Design with Energy in Mind

Toward a low-load and high-satisfaction civic architecture in the Great Lakes Basin

by

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Author’s Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

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Abstract

This study demonstrates how much impact an architect can have on the environmental loads imposed by a building, through fundamental choices of building form, proportion, orientation, and enclosure design. It also offers certain insights about energy flow in mid-sized, non-residential civic buildings that are essential to making the most effective decisions, early in the design process.

The research rests upon an assumption that a "new normal" is required, urgently, in civic architecture in North America. This "new normal" would impose very low loads on natural systems, while being richly satisfying to human interests. The design approach may contrast substantially, to the standard approach taken during the last 50 years. To achieve an architecture that is both low-load and high-satisfaction, new information is needed by an architect in consulting practice.

Research into the study questions proceeds through a series of complementary exercises. First, an inquiry is made into current issues, from the point of view of a consulting design practitioner. Next is an examination of best practices in relevant case studies, in northeastern regions of North America. This illustrates the range of approaches being taken, and the type of results being realized. The "new normal" designs reveal synergies and risks when "low load" and "high satisfaction" goals are present in the same project. Following this, there is a study of the energy flow that results from the manipulation of fundamental parameters in an office building, or headquarters of a civic administration agency. Here, the power of each parameter – including form, orientation and façade design – is measured. Finally, to reflect upon the lessons learned, suggestions are made with respect to needed interventions in everyday practice, in the Great Lakes Basin.

In the course of this research, several design aides have been developed and tested, such as the Questions of Design Quality, the Intensometer, and the Strategy Grid. Any of these might be re-tailored to any building type in any climate. Here, they are applied in the design of non-residential civic buildings in a cool-humid climate.

The observations made in this study comprise a reference handbook - offered for use by students, consulting architects, and building owners, during the earliest stages of design.

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Some years ago, I trained with the late Dr. James Marston Fitch, who wrote about some of the issues investigated here. It is troubling that still they are not so well, or so widely, addressed. To spur me on, I needed to draw upon the commitment and energies of the students and faculty at the University of Waterloo School of Architecture. May Brittany Hanam be blessed for her long hours verifying the energy models in Chapter 5. May our Director, Rick Haldenby be forever thanked for affording me the time to pursue this research thoroughly and, to date, more than 200 new reasons to do so. May Bill Schwarz, and Professor Larry Smith know how happy I am when they appear in Cambridge, to keep talking me through the critical hurdles.

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Dedication

To the memory of my parents, Marian Wight and Alan Campbell Ross,
whose practical support, caring guidance and encouragement made
this work possible - and of my grandfather, Edmund James Wight,
whose curiosity and respect for natural systems made it necessary.

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List of Abbreviations

ACH	- air changes per hour
AIA COTE	- American Institute of Architects Committee on the Environment
APEC	- Association of Petroleum Exporting Countries
ASHRAE	- American Society of Heating Refrigerating and Air-conditioning Engineers
BOMA	- Building Owners and Managers Association
BREEAM	- British Research Establishment Environmental Assessment Method
BUR	- built-up roofing
CASBEE	- Comprehensive Assessment System of Building Environmental Efficiency
CBECS	- Commercial Building Energy Consumption Survey (US)
CBIP	- Commercial Buildings Incentive Program
CIBIUS	- Commercial and Institutional Building Energy Use Survey (Canada)
CMHC	- Canada Mortgage and Housing Corporation
CMU	- concrete masonry unit
CO_2	- carbon dioxide
DOAS	- direct outdoor air system
DX	- direct exchange
EER	- energy efficiency rating
EIFS	- exterior insulation finishing system
EPDM	- ethylene propylene diene monomer (artificial rubber roof membrane)
eQUEST	- the QUick Energy Simulation Tool
ERV	- energy-recovery ventilator
EW	- east-west (axis of building spine)
GHG	- greenhouse gas
GTA	- Greater Toronto Area
GOC	- Government of Canada
HRV	- heat recovery ventilator
HDD	- heating degree-days
HVAC	- heating, ventilation and air-conditioning
IPCC	- Intergovernmental Panel on Climate Change
IEA	- International Energy Agency
iiSBE	- International Initiative for a Sustainable Built Environment
iGBC	- International Green Building Challenge
kBTU/sf-yr	- one thousand British Thermal Units per square foot per year
kWhr/m^2-yr	- kilowatt-hours per square meter per year
LEED	- Leadership in Energy and Environmental Design
LPD	- lighting power density
MJ/m^2-yr	- megajoules per square meter per year
M/E/C	- mechanical, electrical and communications (systems or rooms)

MIT - Massachusetts Institute of Technology
MNECB - Model National Energy Code for Buildings
NESEA - Northeast Sustainable Energy Association
NAFTA - North-American Free Trade Agreement
NRCan OEE - Natural Resources Canada, Office of Energy-efficiency
NS - north-south (axis of building spine)
OAA - Ontario Association of Architects
OBC - Ontario Building Code
o/a - overall
Pa - Pascals
POE - post-occupancy evaluation
PWGSC - Public Works and Government Services Canada
PV - photovoltaic
PVC - polyvinyl chloride
QDQ - questions of design quality
R- - thermal resistance, ft^2-°F-h/BTU
RSI - thermal resistance, m^2-K/W
RCMP - Royal Canadian Mounted Police
SDP - Study of Design Parameters
SA - surface area
SC - shading co-efficient
SCADA - supervisory control and data acquisition (monitoring and display system)
SHGC - solar heat gain co-efficient
TBL - triple bottom-line
TPO - thermoplastic polyolefin (roof membrane)
U value - conductance, or overall heat transfer coefficient, W/(m^{2}K)
U_{imp} - conductance, BTU/(hr °F ft^2)
UFAD - under-floor air distribution
US DOE - United States Department of Energy
US EPA - United States Environmental Protection Agency
USGBC - United States Green Building Council
US GSA - United States General Services Administration
VAV - variable air volume
VLT - visible light transmittance
WWR - window to wall ratio
WC - washroom

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INTRODUCTION

How much can architectural design lower the primary loads that a civic building imposes on the natural environment? In this study, a practicing architect pursues the question. At mid-career, after consulting to nearly forty client groups, there was a sense that the old familiar approach was due for an upgrade. This research is an effort to define a "new normal" for the design of non-residential buildings in the lower Great Lakes Basin, in the coming years.

As the study commenced, the marketing of "green" products and services was rampant, and there was an abundance of emerging advice about how to realize an "environmentally-friendly" building. However, probing questions were answered in contradictory ways. Surely "sustainable design" implied energy-efficiency, yet waste in the operation of buildings continued to be the norm - in both "green" and "non-green" cases. Also, in a design practice whose focus was public agencies, more than mere efficiency was expected. Regrettably, the over-specialization of architects and engineers made enhanced collaboration challenging. The time had come to step back, and to reconsider the fundamentals in a deliberate way.

This research has sought to free an interested practitioner from the marketing hype. Rather than rely on an easy recipe - which may be here today and gone tomorrow - the aim here is to present some of the core principles of environmental design. This study fills a gap in training that many a consulting designer, now at mid-career, may be reluctant to admit in public, but may confess privately. It shows how much impact architects can have on the energy use and greenhouse gas emissions of their buildings, through the choices that are made at the schematic design stage.

The study examines several completed buildings, in which very interesting results have been accomplished. In a careful analysis of these case studies, and in a more abstract study of typical office buildings, the research has identified patterns in the interaction of the primary design parameters - including building form, solar orientation, and skin design. The subjects are everyday civic buildings, ranging in floor area from 10,000 to 200,000 square feet.

To visit the case study buildings is to experience an architecture that imposes low loads on natural systems without sacrificing the qualities that normally are desired in a public building – that it be meaningful, enjoyable, beautiful and at least a little bit clever. By treating the environmental and human-centred attributes as interlocking, this study aims to advance the routine discourse that takes place in the offices of architects who care about both. Surely, more effective problem-solving will happen more often, if the question of realizing a balance is faced head-on, and if the issues are integrated within the architect's imagination.

By demonstrating real success, and then analyzing how it is achieved, this study aims to blaze a clear path that can be followed swiftly, toward effective solutions. The document can help an architect to choose an overall approach, and to select key strategies and, hopefully, to avoid some of the risks that arise, as the shift towards a "new normal" proceeds. The civic non-residential buildings of interest include those that are used for administration, public assembly and education; the lower Great Lakes Basin is a particular type of cool-humid climate, about which more is said in the following pages.

While the results presented in this study are geared to a particular family of building types in a particular locale, the tools and approaches may be translated to other building types, beyond the study area. It is hoped that the information in these pages will help to enhance the researcher's own future practice, and the practice of interested colleagues, interns and students.

1.1 ABOUT "SUSTAINABLE" DESIGN

This study began hopefully, amid growing evidence that environmental stewardship was emerging as a characteristic spirit of the current age. A sea change in worldwide awareness was palpable in the fall of 2007, as the Nobel Prize for Peace was awarded, jointly, to former U.S. Vice-President Al Gore, and the Intergovernmental Panel on Climate Change (IPCC). * During the months prior to and just after this event, the major English language news services presented headlines concerning climate change, fossil fuel resources, or alternative energy schemes – often all three – every day. In the same year, within a four-month period, nine public opinion polls in Canada demonstrated that concern about the impact of human activity on ecosystems had penetrated the public consciousness. †

The discourse, during this period, was distinguished not by the newness of the issues – but by the pervasiveness of all things "environmental". Old foes formed new alliances, and the idea of common interests seemed to have entered almost every realm of human activity, including politics, business, art and everyday life. A concern about the natural world, and about climate change in particular, was rising to the fore.

A conviction is assumed here, that the design of a single building can benefit a community – in a substantive way, as well as a symbolic one. The researcher, other architects, and members of many communities believe that this is one of the roles of a civic building that is funded, and then occupied by a public agency. As the power of architecture is used to express a growing public interest in the environment, new technical, practical, and conceptual design possibilities may emerge.

On the heels of the recognition that climate change and energy scarcity were becoming serious problems, rode the possibility that 21st-century architectural design might contribute some solutions. From the perspective of a practicing architect at mid-career - who

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* For articles announcing the 2007 Nobel prize to Gore and the IPCC, see Figure 3.2.5.

† In a four-month survey of over 9,000 headlines, in the English-language press, in Canada, U.S. and U.K., the daily proportion ranged from 3 to 15%, and the average, for the 15-week period, was 7%. This survey as well as the Canadian public opinion polls are discussed in Section 3.2 and documented in Appendix 1.

values environmental stewardship - the groundswell of public interest in sustainable design was a very welcome development. Yet, if taken seriously, this surge would place new demands on designers, to get it right, making genuine improvements in their thought processes, demanding valid information, and preferring real achievements to "green-speak propaganda".

A host of initiatives had the potential, during this period, to influence architectural practice. New goals were proclaimed, such as the 2030 Challenge (Mazria 2007). Green building rating systems were promoted, such as the US Green Building Council's Leadership in Energy and Environmental Design (LEED) checklist (USGBC 2003). Public policies were developed, such as The U.S. Conference of Mayors Climate Protection Agreement (USCM 2006). These goals, systems, and policies stood against a backdrop in which worldwide projects, such as the Kyoto Accord, went through a politically-charged cycle of commitment, denouncement, and re-negotiation.*

Several of the new programs professed to help architects and their clients to assume leadership in environmental design. Yet the contradictions and gaps in these programs created considerable confusion. The ongoing marketing of "green" building ushered to the fore all manner of claims, related to the environmental, economic, and health impacts of "more sustainable" genre of architectural design. Meanwhile, the gross proportions of the wastes inherent in the design of a typical building of this era became obvious – a waste that was consistent with prevailing attitudes to land-use and transportation. So which of the claims were valid? And how much impact could a single building have? If a civic agency were to chose to "go green" – for philosophical, economic, or practical reasons - how could an architect give reliable, balanced advice as to the best way to realize this ambition? Was "going green" appropriately defined? †

Designers received – willingly or not – a deluge of exhortations that advocated an holistic approach to environmental design. Yet, many of the strategies for "going green" that were easiest to adopt involved little more than specifying a new product for a particular piece of a building. For instance, if one were to add a green roof here, some bamboo flooring there, then intentions toward "sustainability" were implied, whether or not they actually were realized. Thoughtful architects knew, instinctively, that real change would require a deeper level of inquiry.

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* Some of the relevant headlines are presented in Section 3.2 and Appendix 1.

† The green building rating tools are compared, in detail, in Section 3.4.

Despite the hopeful tenor of the times, a more immediate sense of trouble and dissatisfaction spurred on the research. If the design defaults that had been serving civic clients well for several decades were to be altered, in favour of better environmental stewardship, then several practical questions would have to be answered. The immediate opportunities to take a "green" approach in a real project involved acute frustrations and real risks (Hackett 2006; Vyas 2007; Gifford 2009). While hoping to make a tangible improvement by design, an architect searching for reliable information found, instead, a mass of hollow polemic and very little that could be applied in practice.

Meanwhile, many clients remained risk-averse, and disinclined to pay a premium for innovation. Some perceived that a "green" building would cost too much, during the initial construction phase, and that insufficient payback would be available, during the operating phase. Others perceived that the process of "green design" would be too complicated and time-consuming. Still others were concerned that new policies would require multi-agency consensus, before real change could be implemented. And, as is shown in Section 3.3, there was evidence that few consultants were sufficiently knowledgeable, or experienced, to offer competent advice in this area.

Architects and engineers felt new professional pressures, as well. If they were accustomed to concerning themselves mainly with qualities, architects found it very difficult to formulate appropriate questions to put to their consulting engineers, who excel in measuring quantities – and vice versa. A tendency had been growing, for at least a generation - to consider efficiency separately from effectiveness. This meant that the two often were perceived as competing purposes, pursued by separate disciplines. Where the borderline between the two concerns was rigid and impenetrable, and where a common language about "green building" was absent, architects and engineers found collaboration difficult (Ross 2009).

Towards the end of the study period, the connexions between environmental sustainability and economic sustainability were beginning to be discussed in the political arena, in both the U.S. and Canada. In the U.S., the potential creation of "green jobs" was seen as one solution to the downturn in the North American economy.* However, many noted that what had been transpiring, in the months just prior, was far from a "green revolution". One observer commented that the abundance of talk, and the absence of action, characterized this era as more of a "green hallucination". The statement, "moving from

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* See, for instance, Alex Kaplan "Green jobs" at heart of Obama's Earth Day push on Energy", April 22, 2009, in Greenwire, New York Times online, accessed 7 July, 2009

the symbolic to the substantial is not easy", applied in many sectors, as it did to the construction industry. (Friedman 2008, 203-209).

In architecture, what does "low environmental load" mean?

In North America, several different ways of defining what a "low load", "high-performance" or "green" building might be, were gaining traction during the study period. Some, such as Canadian architect Peter Busby were arguing that the most important effects would occur in infrastructure, at the scale of a whole neighbourhood (Boddy 2007). Nevertheless, this study examines the effects within a single building, as a precursor to understanding larger, even more complex systems.

Within a single building, the energy used for ongoing operations arguably is the most significant environmental load of all. There other significant loads that stem from the act of construction. For instance, there is the clearing and excavation of land, and the resulting disruption of the habitats of non-human species. Also, there is the consumption of materials, and the consumption of energy to extract, combine, refine, and deliver them to the construction site for installation. Water is another concern, as it is taken into a building, consumed or contaminated, and then either wholly or partially treated on the way out.

The need for fuel – to ventilate, heat, illuminate, and cool a building – is, however, the load that is most closely associated with greenhouse gas emissions, and other air pollution effects. The American architect Edward Mazria goes so far as to say that "it's the architects who hold the key to turning down the global thermostat" (2003). Whether this level of hyperbole is warranted by the facts is a question that is explored in Chapter 3; still it is clear that North American buildings use energy and emit pollution in significant quantities.

The focus of this study, then, is the energy used to operate one building – not land-use, resource use, or water management. Whenever the term "low load" is used, it is intended to remind the reader of the two major loads that a single building places upon natural systems, both related to operating energy, namely: fuel consumption (from all sources) and greenhouse gas emission.

The amount of fuel used in a building may be influenced to a significant degree by the choices made by its architect. By focusing on operating energy as the most significant indicator of environmental load, this research clarifies one of the key principles that underlie the current prescriptions, about how to design a “green building”. Without such an understanding, there is a severe risk that an architect, who does not appreciate the significance of operating energy, may, in all candour, raise the expectation that a building is “green”, while it is, in fact, a “guzzler” and a polluter.

Balancing “low-load” with other concerns

As important as environmental loads may be, many architects consider the attainment of mere efficiency as a rather narrow purpose. Climate-change mitigation – even for a client-architect team that believes the issues important - cannot dominate the agenda in a public project to the exclusion of all other concerns. Many a public agency invites its architect to meet a host of competing goals, within a single project, and architects sometimes consider the client who presents the most complex array of challenges to be the most interesting. The Vitruvian ideal of “durability, utility and beauty” still is expected in a civic building (Morgan 1914).*

Architects are trained in the art and science of integrating aesthetics, construction technology, cultural messages, and occupant needs – all within the constraints of a budget, a physical site, and a project schedule. Each concern may present a unique set of potential hazards, when it is considered in terms of environmental loads, and practitioners vary in the emphasis they place on each concern. Within a single project, the idea of turning all of the potential hazards into opportunities constitutes a formidable goal.

Concerning aesthetics, architects who wish to lower the environmental impact of their designs must, even today, overcome prejudices about the look and feel of a “green” building. Both outside and inside the profession, there are lingering associations between environmental design and a woodsy or un-imaginative appearance. For some, the word “efficiency” conjures up an image of the very banal or the downright unhealthy. In contrast, many of the most architecturally interesting buildings of recent years are made of futuristic materials, assembled in gravity-defying ways. Some may ask whether a low-load building necessarily looks like the narrow-windowed, poorly ventilated office building of the late 1970s, that spawned “sick building syndrome” in its efficiently sealed and darkened corridors (see Vince 1987). Others may hope that the glass tower of the late International Style - emblematic as it remains, of

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* Vitruvius’ “firmitatis, utilitatis, venustatis” was translated by Henry Wotton, in 1624 as “firmness, commodity, and delight” for which see http://en.wikipedia.org/wiki/Architecture).

financial prosperity and cultural advancement – can be turned into something "eco-friendly".

Developments in construction technology, during the late 20th century permitted wide experimentation with new formal possibilities. Expressing a globalizing, post-modern culture, blobs, crystals, and the ultra-tall are understood, by many, as "the cutting edge", and are seen as something other than environmental design. Some consider this a more stimulating avenue for design exploration than questions of environmental fit. Prejudices such as this add an extra burden to the challenge of realizing a large, "low-load" building.

Many North American architects were not educated about the environmental impact of even the most "normal" building types. An architect who was trained during the first oil crisis of the 1970s may have taken a course or two in "solar design" - but the focus, at that time, was mainly on small residential buildings. Unfortunately, the lessons rarely were applied in practice during the decade that followed, when oil prices returned to more affordable levels, general affluence increased, and development was rampant (Fitch 2006). During this time, the climate control systems that had been established in the early 1960s (albeit with improvements in efficiency) were applied in large non-residential buildings as defaults.

With the rise of interest in "green building", a wide palette of new or enhanced technologies is entering the frame. From "green roofing" to ground source heat pumps, architects now face an uphill learning curve; the alternative climate control systems alone take some time to fathom. The need for re-training was acknowledged, in late 2008, when the American Institute of Architects (AIA) declared it mandatory that a portion of an architect's required continuing education, over the period 2008-2010, be dedicated to "sustainable design" (AIA CES 2008). *

Several new "green building" rating systems also have entered the frame, to demand the attention of consulting designers and their clients. While some suspected these tools might not measure all that one would wish, others enthusiastically enrolled in courses to obtain accreditation in their use. Internationally, extensive work is ongoing, to try to bring "green design" to a common measure. Locally, various "green labels" are put forth, under the banner of "value-added branding" to both property developers and municipal legislators.

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* During the 1980s and 1990s, the practicing architects who engaged in continuous re-education were focused on other matters. Major changes in the profession in North America during that time included, for example: new construction procurement methods (such as design-build), new legislation (related to issues such as barrier-free design), and the advent of the desktop computer.

Sadly, the few architects, who have realized truly energy-efficient civic buildings, have characterized these tools as grossly distracting.

Finally, contradictory messages abound, concerning the cost of “green building”. As Chapter 3 will show, several of the most popular studies were funded by agencies with vested interests. An architect might well ask - which study was undertaken using the most reliable methods, and how would any of the results translate to the current market conditions in the Greater Toronto Area?

It is challenging to justify a capital cost premium for a “green” design, if the argument relies on an externality that is difficult to predict (such as employee productivity), or if it fails to appeal to the “gut feel” of the client representative who makes the decisions (Ellingham and Fawcett 2006). In many situations, there also are gaps in accountability, in which the department that operates a building is separate from the department that is responsible for the initial construction, and its adherence to its budget. Even for a civic agency that acknowledges the rising public expectations with respect to environmental stewardship, when project-delivery circumstances are challenging, it is all too tempting to reach for an easy answer – to expedite (or appear to expedite) the “going green” process, without causing delays or cost increases. Also, if a client does not acknowledge its responsibilities - in the design process, and for the careful long-term operation of its new “green” building - then the situation may become a very risky one for the consultants involved. This is particularly true, with respect to the ever-present challenge of managing capital costs.

Architects and clients who remain skeptical about some of the current approaches to “sustainable design” may, therefore, do so with good reason. In a new civic project, if the immediate benefits of “going green” are poorly described (during design) and difficult to prove (after occupancy), and if the up-front costs are unclear, then it should be no surprise that a prudent client might try to keep an emerging “green building” agenda, however well-intentioned, under tight control.

In spite of the considerable challenges so-far described, some design teams have managed to realize a shift to a “new normal”. Several of the case studies examined here will show how to improve occupant comfort inside, revitalize the public realm outside, reduce energy use, and stick to a budget. The 21st-century version of environmental design looks and feels very different from the 1970s version.* This time around, "going green" is seen to offer hope for better design, generally; and it often entails a deeper, more meaningful shift in mindset than any shift in surface style (see Section 3.2). When the goal to live more lightly on the land meets the expectations of design quality, teams such as those that envisioned the case study buildings are proving that the results can be wonderful indeed.

How do these architects accomplish both low load and better design quality? One common approach is to consult additional specialists, from emerging professional disciplines. The advice of building scientists, energy simulation experts, and construction commissioners is contributing in a very significant way to improving the performance of buildings. This is abundantly evident in the "new-normal" cases studied here. However, it is important to note that these specialists do not take the lead role of the co-ordinating designer. If an architect is to work effectively with any of these new disciplines, then he or she must learn how to communicate well with them. At best, the architect will learn to nurture any synergies that exist between the interests of the specialists and the broader goals of the project.

This study is directed to the kind of project in which the architect is in a position to help a client define priorities, and manage the expectations of all participants in the design process. This role is familiar to many in Ontario, where goal-setting is a routine aspect of the services required of architects whose practices are based on publicly-funded projects. It also is the role with which the researcher is most familiar. Particularly on a project that requires an array of technical specialists, whose focus tends to be relatively narrow, this is a role that someone must fulfill. It may seem an easy step to extend the architect's goal-setting role to the new subject area of environmental loads. For a client, it also is easy to assume that the architect has the necessary skills to advise in this area.

How this study is intended to help

It is no small challenge to balance this extensive array of concerns – but it is the goal of this researcher, and other architects, who are serious about achieving an optimal environmental fit, today. Such an architect is obliged to consider both energy-efficiency and aesthetics, and to overcome prejudices inside and outside the profession. He or she must communicate effectively with a new breed of engineering specialist,

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* The belt-tightening of the "Oil Crisis" proved that a "less bad" approach, if pursued exclusively, rarely endures. In the era of relatively cheap oil that followed, the concern for conservation fell by the wayside, whether the subject was a civic building, or an automobile (Friedman 2008, 14).

help clients set reasonable goals, and manage the expectations of all parties. In spite of a lack of specific training about the environmental impacts of design, this architect needs to synthesize overall quality, cultural values, and emerging construction technologies, within the real constraints of a budget and a site. To do this well, while continuing to provide advice to the public, requires new, good-quality information, careful deliberation and relentless follow-through.

To be able to set the beat, an architect must first get the beat. These terms are applied to the study of many realms of human work, beyond architecture, by systems analyst Donella Meadows (2001). When applied to architectural design, "getting the beat" entails understanding how energy flows in buildings, and identifying the best practice approaches that yield maximum human satisfaction at minimum environmental expense. The observations in this research should help an architect to better appreciate, and begin to be able to manipulate, the complex interaction of factors.

Setting the beat entails applying specific technical methods, in design practice. To design smarter, the architect must acquire a working understanding of the impacts of primary design decisions at small, medium, and large scales. This research will show the range of possible design solutions and the breadth of potential for architectural expression.

As a growing global human population continues to consume a finite supply of resources, it appears as though human society - if it is to be sustained – will have to address the question of balance. If this is so, then the old quip "if our input exceeds our output, then our upkeep will be our downfall" surely applies to the design of buildings in the 21st century in North America. A degree of humility is in order – as not all environmental challenges can be met through the design of a single building (Simon 2000). However, an architect can, over the course of a career, make a contribution. Also, a civic agency that owns and operates a portfolio of buildings can make a contribution – both symbolically and substantially.

1.2 METHODS AND INSTRUMENTS USED IN THIS STUDY

Three different research methods are employed here. Each is chosen to suit a different purpose, and to answer different types of questions.

First, to examine some of the current theories about why or how to design with energy in mind, a series of essays have been written, from a practitioner’s point of view. These essays answer questions such as whether a profound change in the design of civic buildings in the Great Lakes Basin truly is warranted, given what currently is understood about climate change and the future supply of fossil fuels. The extent of support for an integrated “low-load + high-satisfaction” design is explored, and four of the architect’s principle roles are considered, in light of evolving public expectations. One essay scrutinizes the helpfulness of the current green building rating systems, and another compares the conclusions of several recent cost studies.

The next exercise aims to learn from the real-life practice of architects and engineers, in the Great Lakes Basin and on the Atlantic coast, who have proven that it is possible to achieve a high-quality architecture that runs on very little fuel. In this Analysis of Case Studies, a first-hand visit was considered essential - to experience, and to appraise the qualitative aspects of each design. Such a visit is made to seven highly successful buildings. Alongside each appraisal is a record of the technical choices that the architects made, and the amount of energy actually used, since the buildings have been occupied. A comparison of best practices in an additional twelve buildings, drawn from published literature, also is presented.

Since the case studies only hint at the relative influence of building form, orientation and enclosure design, a third, and different research method was required. To understand even more about the techniques that might be employed in future design practice, an experiment is conducted, using generic office building types in Toronto as test subjects. This phase of study involves a large matrix of variations – in plan shape, orientation and enclosure specification. A computer simulation of the energy used annually by each building type shows how much each of the primary architectural design parameters influences energy use.

Some of the traditions used to analyze case studies, or to conduct energy-optimization studies, are discussed in Chapter 2. The strengths in earlier studies are acknowledged, but so are some of the gaps – and both are used to inform the procedures used in this research.

One instrument that is used extensively is “eQuest”, a software program for energy simulation, developed with the express purpose of being used by architects during the schematic design stage. The reasons for choosing eQuest, in preference to other alternatives, are described in Chapter 2. In addition, a few new instruments have been developed as part of this research. The Questions of Design Quality (QDQ), a gauge of “satisfactoriness”, the Intensometer, a yardstick of energy use, and the Strategy Grid, a checklist of design approaches, also are described in detail in Chapter 2.

1.3 THE SCOPE OF THIS STUDY

Non-residential civic buildings in cool-humid climates are the focus of this study, in part because this building type and location have been the focus of the author's professional practice to date. More importantly, both the building type and the location have, so far, not enjoyed as much attention in research as have other building types or other climate zones.

Non-residential buildings have escaped the careful research that residential buildings have been receiving, ever since Victor Olgyay's Design with Climate, was published in 1963.* For instance, the Government of Canada has given continuous research support to encourage advancements in house construction, through programs such as R-2000. Agencies such as Canada Mortgage and Housing Corporation and, in the U.S., programs such as Building America, provide extensive advice to homeowners, about how to build or retrofit single-family dwellings to lighten their burden on the environment (CMHC 2008; US DOE 2008). In Canada, the research into non-residential building at the Federal level is scant. Meanwhile, prescriptive guides for "more environmental" design in this sector have become the object of intense focus, from interest groups in the commercial realm.

In Ontario, roughly 33% of the dollars spent on new construction starts in 2007 were for commercial and institutional buildings (Kelleher 2008). Residential buildings occupied a slightly larger portion of the overall spending pie - approximately 40% of the dollar value of new construction starts. This pattern has been consistent for many years. While financial incentives for retrofitting existing buildings of all types are increasingly offered by the Province, the minimum code requirements, for new, non-residential construction in Ontario, did not evolve substantially between 1986 and 2008.

What is emerging to fill the regulatory gap? Some North American municipalities have enacted policies to stimulate more "green" or "high-performance" building initiatives. Some of these cities have looked to green building rating systems, such as LEED, for an easy recipe to follow. A discussion of the track record of these systems, from a technical perspective, is contained in Chapter 3.

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* V. Olgyay's research at Princeton University is discussed in Section 2.3.

The cool-humid climate of the Great Lakes and St. Lawrence River Basin also is under-represented in the "green building" literature. From Olgyay (1963) to the US DOE (2008), the research about residential design shows a need for a unique design approach to suit each of at least four distinct climate zones exist in North America – if the goal is to lower environmental load. Yet, the majority of buildings currently celebrated as "green" emanate from either the temperate coastal climates in the west, or the hot-arid and hot-humid climates in the extreme south (see Section 2.2). Case studies in from North American climates that are unlike the conditions in Great Lakes Basin are interesting - but they may also mislead architects, and public clients in this region, as to which approaches truly are effective here.

This climate presents a fairly extreme set of challenges to a designer. Neither purely "hot", nor purely "cold", it is sometimes described as "the worst of both worlds". Winters are long and cold - lasting from December through April, with average of -10°C and extremes as low as -30°C. Summer brings periods of high humidity, with average temperatures of 25-32°C, occasionally peaking to 38°C. Average precipitation is 830 mm. – including 700 mm. of rainfall and 130 mm. of snowfall (Environment Canada 2008). Design strategies employed from Illinois to New York to Montreal and Toronto have consequences that are quite distinct in this region – as compared to, say, California, Miami, or the colder regions of Canada. By focusing on one climate, but searching for essential principles – rather than simple prescriptions – this study aims to clarify, specifically, how this climate may be understood – and addressed – by an architectural designer.

1.4 ORGANIZATION OF THE THESIS DOCUMENT

In Chapter 2, Approach, the study methodology is introduced, and the relationship between the various research stages is explained. There is an overview of the most relevant research, by others, that has informed the methods employed here. This section also introduces the new research instruments, and identifies where they are used in this study, and how they may be applied elsewhere.

In Chapter 3, A Practitioner's Inquiry into the Current Issues, there is a series of essays that examine key ideas surrounding the impulse to design with energy in mind. The researcher finds a personal position, amid the current, often hyperbolic and conflicting extremes. The essays are:

- a summary of the findings of the climate scientists,
- a survey of recent press coverage of "green" issues,

- a discussion of the need to make adjustments in the consulting architect's role,
- a critical review of the green building assessment tools that are available to architects today, and
- an overview of the range of existing opinions the capital cost implications of "green design".

Chapter 4, Analysis of Case Studies, contains a comparison of several cold climate non-residential buildings. This part of the study articulates the issues in lowering environmental loads, while continuing to satisfy human desires. By comparing the approaches employed by each architect, one can discern how to mitigate the risk that efficiency might over-ride effectiveness (or vice-versa), and how to capture potential synergies - to achieve both low-load and high-satisfaction. Through the case studies, the reader will begin to appreciate the power of design approaches such as: load reduction through enclosure design, the capture of "free energy", and the on-site generation of renewable energy.

In Chapter 5, Study of Design Parameters, numerous simulations, using publicly available computer software (eQuest), compare the annual energy consumption and pollution effects of a series of simple, typical office buildings. A comparative overview of several simulations makes it possible to discern general patterns, with respect to the power of the primary architectural parameters.

In Chapter 6, Places to Intervene in Practice, common threads are traced through the previous research. Lessons learned from the Inquiry into the Current Issues, the Analysis of Case Studies and Study of Design Parameters are used to identify several initiatives that could be taken in consulting design practice. Their potential efficacy to leverage tangible benefits to the environment is discussed.

In closing, in Chapter 7, Conclusions, the study findings are summarized. This section also points toward potential applications – in other climates, and for other building types - and suggests several ideas for further study.

2

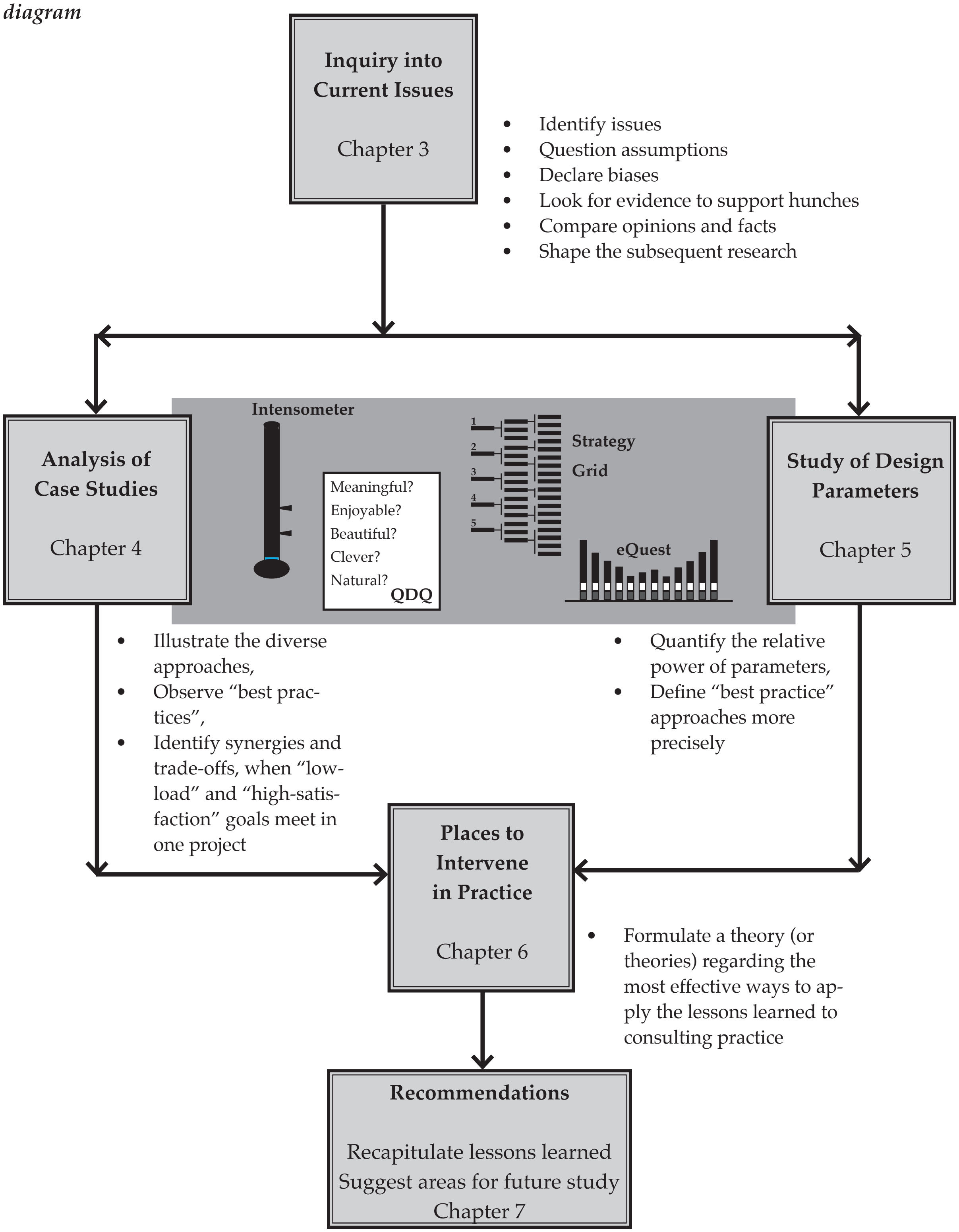
APPROACH

2.0 TOWARDS A "LOW LOAD, HIGH SATISFACTION" ARCHITECTURE

As described in Chapter 1, a fairly tangled web of challenges faces the consulting architect who would aim to realize a "new-normal" design. This research employs several approaches to organize the strands of this web, in a way that answers the central question - how much can an architect's choices, in the earliest stages, influence the environmental load of a building?

The "environmental load" of primary interest here is operating energy. Although there are other important loads imposed by a building, such as water pollution, land-use, and the energy embodied in construction materials, the focus of this study is the load that is easiest to measure and most closely associated with climate change.

Figure 2.0.1
Research exercises - flow diagram



The “earliest stages” of interest are the schematic design phase and the “project definition” phase that immediately precedes it. The principal concern is with the way in which an architect’s choices “deal the cards” to the rest of the design team, throughout the phases of more detailed design development – either multiplying, or limiting their options.

The “architect’s choices” of interest are of two kinds. First, there are the more tangible choices - the physical elements, systems, and materials employed in the building. Second, there is the underlying “architecture” – that is, the choice of overall approach, and the arrangement of major elements in the design.

Major Research Exercises

The central research question is approached from several different angles. This Chapter describes each exercise in this study, in contrast to previous studies of similar nature. The relationship between the exercises is shown in Figure 2.0.1.

The study begins by surveying, documenting, and discussing the most significant issues, as they appear in the recent public discourse. Within the profession, and in other arenas, some messages are consistent, and some contradict one another. Also, there are plenty of competing agendas. A review of the literature highlights the points most relevant to architectural consulting practice.

To find out what the issues are, in lowering environmental loads, while continuing to satisfy human desires, the second stage of the research is to analyze selected case studies. Enhanced methods of analysis are used here, and the ways in which these fill gaps left by earlier studies are discussed in detail in Section 2.2.

To appreciate the relative power of the primary architectural design parameters - such as overall form, building orientation, and skin design - the third exercise entails a series of computer simulations of the annual energy use of typical office buildings. In Section 2.3, the approach used for this analysis is compared to previous efforts.

Each of the research exercises offers clues about how to advance the thought processes and practices of an architect, toward a “low-load + high-satisfaction” civic architecture, in the Great Lakes Basin. The following pages offer an introductory glimpse at the scope of each research exercise. The results are contained in Chapters 3 through 6 – each of which is devoted to one of the sub-questions.

Instruments

In the course of this study, three research instruments were developed, to elaborate earlier theory. In this Chapter, the Questions of Design Quality (QDQ), the Intensometer, and the Strategy Grid are introduced in detail, each with a description of what it yields, why it was chosen, what is needed to use it, and where in the research it will be deployed.

The Questions of Design Quality (QDQ), introduced in Section 2.4, defines “satisfying design”, from the researcher’s perspective. It is a list of twenty-one plainly-worded questions that can be answered with a “yes” or a “no”. It is used mainly in the Analysis of Case Studies.

The Intensometer, introduced in Section 2.5, is a frame of reference about energy use in buildings. This graphic shows the expected range of energy-use in building types relevant to this study. It can be used to compare the performance of any building to another, whether or not it is considered “green”, or labelled as such.

The Strategy Grid, introduced in Section 2.6, is a checklist of energy-saving strategies, operations, and tactics that may be employed in a design. It is used throughout all phases of the research.

Finally, the software program, eQuest, introduced in Section 2.7, allows an architect to predict the absolute annual energy use of a design, in kWhr/year. By performing quick simulations of a series of options, eQuest can help a designer understand which decisions have the greatest impact - at the schematic stage, or in later stages. The eQuest software is used exclusively in the Study of Design Parameters.

Any of these instruments may be used alone, or in tandem with the others. Each supplies information that the others do not. Also, they are all suitable for use in future design practice.

Application

The methods used in this study yield specific data about form, orientation, and enclosure design - within the confines of the Great Lakes Basin. The research exercises, and all of the instruments, are tailored here to study “civic” building types, in this region. However, any of these could be adapted for wider application – to other building types in other climate zones.

2.1 HOW A PRACTITIONER MAY LOOK INTO THE CURRENT ISSUES

The first step in this research involves clarifying assumptions, disclosing biases, and identifying contradictions in the relevant and recent discourse.

This review takes a snapshot of the condition of the relevant discourse in North America, as it evolved during the study period. It compiles a portion of the current deluge of information about "green design", as it pertains to non-residential buildings in a cool-humid climate. In this investigation, the researcher is in accord with some commonly reported opinions about "green design", and takes issue with others. Some ideas that were understood, at the outset, to be "fixed knowledge" are shown to fit better into the category of "emerging opinion". By distinguishing one from the other, this exercise helps to refine the subsequent research approaches. The Inquiry into Current Issues is presented in Chapter 3.

The discussion follows the following line of inquiry:

- Is a "new normal" in architecture truly necessary? (How much of an impact can be made, by civic buildings in North America?)
- Is there support for the researcher's bias toward design that is both low environmental-load and high human-satisfaction?
- Of the many roles that a consulting architect assumes, which are likely to be affected by the quest to achieve a "new normal"?
- Do the existing "green building rating tools" help architects who wish to realize low-load and high-satisfaction in their designs?
- What sources suggest that overall building form, orientation and skin design are powerful parameters?
- What might the "new normal" cost?

2.2 WHY CASE STUDIES … AND HOW?

To understand the reasons for approaching case studies in a particular way, a look back at previous efforts by others is helpful. Gaps in the prior research may then inform the approach to be taken here. The Analysis of Case Studies aims to answer the question - what are the issues in lowering environmental loads, while continuing to satisfy human desires? It is based on field observation, as well as extensive reflection, and it employs all of the new research instruments.

Architects and engineers enjoy case studies, because we can "read" buildings in ways that others cannot. From our earliest days, design students, of all stripes, spend long hours watching our teachers model the activity of "reading" a building, or a bridge, or a system: the professor shows a picture and tells a story. By looking and listening, students learn how to interpret the ideas in a design. This activity is inspiring, and it takes us out of our narrow realm. Reading buildings is "what we do".

Today's "green" building case studies conform to the conventions that are used traditionally, with respect to "non-green" buildings. According to custom, these studies show pictures and tell a story, and the observer tries to read certain things through the design – the building may appear to be "low load" and it may meet a number of other prerogatives, including relevance to the culture and place for which it was designed.

However, in much of the recent presentation of "green" design, there is a considerable range in the reliability of the telling, and an even bigger range in the quality of understanding that results. For a practicing professional, who owes a duty of care to the public, the stakes in interpreting a case study are high. This research includes case studies - not only because "reading" buildings is "what we do" – but also because it matters a great deal how an architect bases decision-making upon a reading. The following survey of existing green building case studies shows both important strengths and some critical flaws in the stories told to date.

Figure 2.2.1
Case Study:
St. Gabriel's Passionist Church, Toronto, ON

(Larkin Architect Limited)

note: for a complete list of the design teams at this and other cases, see Appendix 4

How the case studies were selected

Each candidate for inclusion in this research is located in a cool-humid climate, accommodates administrative offices and/or public functions, offers energy-use data, and is near enough to Toronto that it could be visited during the study period. The cases in this study were selected with some care, because, early in the research, it became evident that very few projects claiming to be "green" are located in climates similar to Toronto. Fewer still offer hard evidence of both low environmental loads and high user-satisfaction.

In Chapter 4, nineteen buildings are examined. Of these, seven "new normal" and three "GTA default" designs are appraised thoroughly – that is, both quantitative and qualitative analyses are made. (These are depicted in Figures 2.2.1, and 2.2.2 through 2.3.8.) An additional nine buildings are studied, in the search for "best practices" toward lowering energy use.

Catalogues, monographs, critical reviews

The recent widening of the discourse about "low-load" design – including both facts and opinions - is advantageous to the researcher, but, in some ways, it creates confusion. Figure 2.2.2 (overleaf) presents a summary of the variation in emphasis, among eleven existing collections of case studies. Several classes of study are examined here, including catalogues, monographs, critical reviews, and post-occupancy evaluations. Every collection celebrates "green design" as more than "merely efficient". Every collection of case studies has certain strengths and weaknesses; none of the studies comprehensively covers all of the aspects of interest in this research. A few of the strongest exemplars of each class are examined; but, for the sake of brevity, many other studies belonging to each class have been excluded.*

All of the collections of case studies argue that "green design" offers greater scope for creativity – and is suitable to a far broader range of buildings - than previously imagined. This argument has been necessary, because of impressions that are held over from an earlier era. One of the case-study editors describes certain prejudices that linger, this way:

> *"A stereotyped notion of green buildings conjures up images of muesli-eating inhabitants with beards and sandals, and rudimentary forms of back-to-nature lifestyles … as well as of crude and ugly buildings with which no urbane sophisticate or academic would wish to be associated." (Buchanan 2005)*

An exhibition at the National Building Museum in Washington D.C., *Big 'n Green,* by its very title, argued that 21st century "green" design is far more "sophisticated" than earlier versions (Gissen 2002). The show featured very large, urban buildings such as Commerzbank

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* For instance, the U.S. DOE High Performance Buildings Database represents parallel lists, on the websites of the USGBC and AIA.

Figure 2.2.2
Variation in emphasis in previous collections of case studies

	Gissen 2002 *Big 'n Green*	Ferrara 2006 *Canada Innovates*	GOC 2007 *Selected Case Studies website*	US DOE 2007 *High Performance Bldgs*	Mendler and Odell 2000 *HOK Guidebook*	Thierfelder 2003 *Transsolar Climate Eng'g*	Passa and Rompf 2007 *E-effic sustainable schools*	Lloyd-Jones 1998 *Arch're & the environment*	Buchanan 2005 *Ten Shades of Green*	McMinn and Polo 2005 *41 to 66*	Torcellini et. al. *Lessons Learned from 6 H.P.*
Catalogue (OG), monograph (MH), critical review (CR), post-occupancy evalu'n (PO)	OG	OG	OG	OG	MH	MH	MH	CR	CR	CR	PO
General relevance:											
Number of non-residential projects	39/ 50	34/ 56	14/ 19	83/ 99	22/ 24	28/ 30	4/ 04	36/ 44	7/ 13	22/ 32	6/ 06
Number of non-rescases similar in use and size to the cases in this study	28/ 39	23/ 34	10/ 14	59/ 83	21/ 22	19/ 28	3/ 04	29/ 36	5/ 07	20/ 22	5/ 06
Number of above, in which the architecture appears to address environ'l loads	26/ 28	19/ 23	8/ 10	45/ 59	14/ 21	14/ 19	3/ 03	24/ 29	4/ 05	16/ 20	5/ 05
Number above, in cold climate with large annual temperature differential	9/ 26	14/ 19	8/ 08	29/ 45	9/ 14	14/ 14	3/ 03	8/ 24	0/ 04	12/ 16	4/ 05
Percentage of the above, that are relevant to this study	18%	25%	57%	29%	38%	47%	75%	18%	0%	38%	67%
"High-satisfaction" design:											
Argues that "green building" offers wide scope for creativity (explicit or implied)	●	◐	◐	◐	◐	●	◐	●	●	●	●
Suggests "green design" may have a consistent architectural language (implied)	◐	◐	○	○	◐	○	○	○	○	○	○
Shows how "green building" is related to societal culture (explicit or implied)	◐	○	○	○	○	●	●	●	●	●	○
Discusses bioclimatic regionalism	○	○	○	○	○	●	○	●	◐	●	○
Includes an appraisal of the building from users' or neighbours' perspective	○	○	◐	◐	○	○	○	○	○	○	○
"Low-load" design:											
Identifies climate change as an important issue, and links it to energy use	◐	○	○	○	○	●	○	●	●	○	●
Reports the energy intensity (predicted and/or actual) of each case	○	○	◐	●	◐	○	◐	◐	○	○	●
Describes the climate control systems	◐	◐	●	●	●	◐	●	◐	◐	◐	●
Suggests there is an ideal "order of operations" in design (explicit or implied)	○	○	○	○	●	◐	◐	○	○	○	○
BOTH load AND satisfaction:											
Offers a comparative analysis of the cases presented	◐	○	○	○	○	○	○	◐	●	●	●
Discusses energy-management in relation to other aspects of design	◐	◐	◐	◐	●	●	●	●	◐	◐	●

● Yes, in most cases ◐ Yes, in some cases ○ No, or rarely in Frankfurt, Swiss Re in London, Conde Nast in New York and Manulife Financial in Boston – with not a hint of macramé in view. A high level of interest in commercial, educational, and institutional buildings also is evident *in The HOK Guidebook to Sustainable Design*, (Mendler and Odell 2000) and *Canada Innovates* (Ferrara 2006). The intent of these studies is to inspire discussion and further inquiry by architects who work in the commercial and institutional realms. However, the three collections so far noted risk leaving an impression that a "green design" can be realized using the architectural language of a typical suburban office block of the 1980s. This idea is at odds with others that are put forth elsewhere, particularly the critical reviews.

As the catalogues take a stab at the old woolly stereotype, architectural critics study how "green building" might be related to other elements of culture, past and present. For instance, *41 to 66 – Regional Responses to Sustainable Architecture in Canada,* shows connections between traditional ways of building and contemporary "green" architecture - in six regions of Canada that have quite distinct natural systems (McMinn and Polo 2005).

A few other studies place "green design" within the history of architectural ideas, tracing back to the proto-modern era of Ruskin and the Arts and Crafts movement (Lloyd-Jones 1998, Buchanan 2005). These studies trace the footprints of environmental consciousness through the Modernist era. In some, the architect's interest in natural systems is placed within a wider discourse about what is most important in design (Fitch 1999; Banham 1969). For instance, in *Fire and Memory,* the philosophies of Frank Lloyd Wright and le Corbusier are used as emblems of contrasting ideas about the relationship between architecture and energy (Fernandez-Galliano 2000).

Figure 2.2.3
Case Study:
SAS Institute (Canada), Toronto, ON

(NORR Limited Architects & Engineers,
image Steven Evans Photography)

Mixed messages & missing information

The latter-day critical reviews celebrate buildings that vary considerably with climate and site. (e.g. Lloyd-Jones 1998, Buchanan 2005, McMinn and Polo 2005). The designs chosen for study use are inflected with a variety of material traditions, are washed in daylight and have a transparency that is not typical of the suburban office block of the 1980s. This shows one way that the "sustainable building" literature presents mixed messages. According to some of the catalogues, it is "normal", but newly "enviro-friendly" (Mendler and Odell 2000, Gissen 2002). On the other hand, according to some of the critical reviews, it must be imbued with a renewed sensitivity to place, being "locally relevant, culturally rich".

Another flaw is that many "green building" case studies fail to show how much load a building is placing on natural systems. If operating energy is the largest load (see Section3.2), then a case study that purports to be about a "green building" ought to show how much energy the design uses, or is intended to use - even if the emphasis of the study is on design quality. (If actual end-use data is available, it is preferable to the predictions of an energy model. If both are available, a comparison should be noted.)

Technical detail is included in some of the catalogues, monographs, critical reviews and all of the post-occupancy evaluations. Everything from heat recovery systems to rainwater-fed cisterns is featured. Yet, in making a strong case that "low-load" can also be "high-satisfaction", many neglect to report how "low" the environmental loads really are. Too often, a building is presented as "energy efficient", but the claim is not backed by evidence as to the degree of success. Among the critical reviews, *Architecture and the Environment, Bioclimatic Building Design* is the only exception (Lloyd-Jones 1998). It provides the absolute energy use figures, for nearly half of the cases presented in its pages.

A few studies offer comprehensive factual information for all projects - notably the online "catalogues" of "green buildings" (GOC 2008; US DOE 2009, AIA 2009). These present energy data, alongside an outline of the project goals, site constraints, capital costs, and notes from the design team, regarding "lessons learned". These databases, by their nature, exclude qualitative appraisals of design success, and avoid critical comparison of one project to another. But the consistency of the format, and the fact that the format is harmonized in Canada and the U.S., provides the primary data upon which more comparative analyses could be based.

Figure 2.2.4
Case Study:
The Adam Joseph Lewis Center (AJLC) at Oberlin College, Oberlin, Ohio

(William McDonough + Partners Architect, image Robb Williamson, courtesy of DOE/NREL)

The need to consolidate quantitative energy-use data with a qualitative appraisal is met, in the Analysis of Case Studies made here. The data about each design is placed on the Intensometer, alongside the answers to the Questions of Design Quality (QDQ).

Another weakness is that many studies list particular physical elements of a building, in such a way that the element alone might be interpreted as the reason why the design is considered "green". (For instance, a green roof, an exterior sun-shade, or a double-skin façade may be taken as an emblem of "green building", even if it is stuck on an otherwise fairly generic design.) At the same time, other studies hint that the fundamental architecture – meaning the form and organization of a building - determines its environmental load. Without in-depth analysis of how much is achieved by either the elements or the architecture, it is very difficult to appraise the overall approach in a particular project. Buchanan has a word to say on this point:

> *"It should be clear by now that green design, though not dauntingly difficult, cannot be achieved by a simplistic or formulaic approach … Green design goes far beyond merely specifying efficient 'green' products … and beyond also using replenishable, recycled and recyclable materials … Green design both influences the basic design parti of a building … and transcends mere energy efficiency … it must attend to a whole range of matters from the technical and ecological, to the economic and social, including even the cultural and spiritual." (2005)*

This review of the existing case studies highlights a need to identify best practices that favour energy conservation within designs that are satisfactory in many other ways. Only by juxtaposing qualitative and quantitative analysis, is it possible to appreciate the potential synergies and risks, when load-reducing and satisfaction-enhancing strategies are taken up in the same design.

This suggests a gap: the relative power of the various features appearing in several of the buildings is left up to the imagination, where it easily may be over-estimated. For instance, all of the case studies describe climate control systems, but few event hint at the relationship between formal choices and equipment choices. When analyzing any design, it is essential to distinguish a design strategy (e.g. manage heat losses and gains) from a feature or tactic that accomplishes that strategy (e.g. incorporate external sunshades). In this way it should be possible to avoid the potential traps identified Buchanan – and to approach a deeper understanding of the principles of "green design", beyond simplistic prescriptions. This need is met, in the case studies in Chapter 4, by comparing design approaches, using another instrument, developed in this study, called the Strategy Grid.

Figure 2.2.5
Case Study:
Wind NRG Office & Warehouse, Hinesburg, VT

(William Maclay Architects & Planners)

Climate and client - two essential factors
The climate context is yet another element that is not consistently represented in previous studies. In some, an interest in tailoring design to climate is coming to the fore. Climate may be described by a list of statistics (as in Lloyd-Jones 1998; Thierfelder 2003; Buchanan 2005). Or, the description may be more qualitative, and experiential – in which the air and sky, terrain, and quality of daylight are depicted (as in McMinn and Polo 2005).

Cases from temperate, hot-arid, and hot-humid climates dominate the case study collections, by a wide majority (i.e. the west coast – from Vancouver to California, the U.S. southwest, Texas and Florida). Looking overseas, it is difficult to determine what is most relevant, without knowing offshore regions well. For instance, the northern climates in which many cases have been studied – such as Germany, the U.K., and Japan – have winters that are relatively short, summers that are relatively dry, and less temperature variation year-round.* Cold-climate cases represent only a third of the case studies in any of the collections surveyed (see Figure 2.2.2 for an account of the proportions in each resource).

The Australian architect, Glenn Murcutt, tells the story of his experience, immediately after being awarded the Pritzker Prize, for his environmentally-sensitive designs. Suddenly thrust onto the world stage, he received numerous invitations to work outside his country of origin. He declined every one of them, and cautioned interested colleagues that, in his opinion, an architect must not only observe objective, scientific measurements of climate - but also, he must learn to understand its demands, by reflecting on direct experience (Murcutt 2005). Murcutt's position stands in stark contrast to the position of many renowned architects, who celebrate global mobility, and who do not focus their professional energies on just one region.

Figure 2.2.6
Case Study:
Artists for Humanity, Boston, MA

(Arrowstreet, Inc. Architects, image credit unknown, from usgbc.org, October 2006)

One outcome of the current interest in climate is the development of a new term - "climate engineers" – and their recent production of architectural-style monographs (e.g. Thierfelder 2003). But the quid-pro-quo seems to be missing. A search for detailed, peer-reviewed case

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* For the purposes of this comparison, cases in Germany are included in the "cool climate" count, cases in the U.K. are excluded, and cases in Japan are included or excluded, depending on their location (north and west locations are included, and south or Pacific coast locations are excluded).

studies, by architects, revealing challenges encountered in advancing towards "new-normal" practice, yielded very scant results. Perhaps most practitioners are too busy to write about it, or perhaps more is on its way, in resources such as the *Journal of Green Building*. There is a very pressing need for study by architect - who regularly deals with the challenges of integrating client needs, practical constraints, and environmental concerns - to present a discussion of the real hurdles encountered in practice. Other than the *HOK Guidebook*, and miscellaneous presentations at green building conferences, very few studies present these issues in a way that allows others to approach key questions more swiftly (see Passa and Rompf 2007). In one paper, the authors complain of:

> *"experience in trying to get 'lessons learned in operating high performance buildings' into the professional literature to speed up solving the operational challenges that arise … there are growing perceptions of problems due to the lack of transparency about operating experiences, but little data to have real discussion about how green buildings actually perform and work in practice."* *(Hinge et. al. 2006)*

Another important voice, very rarely heard in the case study literature, is that of the building user or neighbour. Strangely, many of the authors - who promote the sustainability movement as one with a special concern for social benefits – do not report the opinions of the people for whom the building was designed. If "green design" is to be credible in its claim to result in better working environments, then evidence of this must be presented. Otherwise, there is a real risk in the North American construction industry, of *"frustration from clients and potential backlash from certain segments of this large marketplace"* (Hinge et. al. 2006).

In practice, many architects that work repeatedly for the same institutional client do re-visit their buildings, once occupied – and lessons learned feed the design process in the next project (examples are given by Bordass 2003, 2005 and Gonchar 2008). The fact that the results rarely appear in widely published case studies suggests there is a need to be very careful to compare the real experiences of a "green" building with the intentions inherent in its design. This need is met, in the case studies in Chapter 4, through the application of another new instrument, the Questions of Design Quality (QDQ), which are used to reflect on the field visits.

Figure 2.2.7
Case Study:
The Gilman Ordway Building at Woods Hole Research Center, Falmouth, MA

(William McDonough + Partners Architect, image Alan Orling, from US DOE)

How this research differs

The primary strengths of the case study literature published to date are the enthusiasm expressed for "green building", and the breadth of potential presented. Regrettably, amidst all of this "good news", clarity is sorely lacking. Perhaps this literature is poised to move across a threshold to a second phase, in which certain issues will be resolved. Taken as a whole, the discourse raises the following questions:

- Can a building look like a "typical" building of the late 20th century, and be truly "low-load" ?
- What is the actual rate of energy use in these cases?
- Do the most effective design responses to a "green agenda" have to do mainly with the physical elements - or does arrangement matter?
- Does climate context matter?
- Are "green" buildings truly more comfortable than "new normal" buildings? What are the experiences of building users?

Figure 2.2.8
Case Study:
Provincetown Art Association & Museum (PAAM), Provincetown, MA

(Machado and Silvetti Associates Architect, image Anton Grassi/Esto)

The gaps identified above are filled in the Analysis of Case Studies, in Chapter 4, where "load" data is never neglected, and the focus is on cases in the Great Lakes Basin. The distinction between a "green design" and a "green element" is made clear. This research asks the following questions, about a select group of "green" or "high-performance" designs:

- What is the actual annual energy-intensity of the occupied building?
- What does the design have in common with others of similar use, size, and performance level?
- Is there an architectural language that is used most often?
- Is this "green" building designed with a "contemporary sensibility"?
- Do energy-saving strategies compete with strategies that contribute to other aspects of "good design"?
- Does a high degree of energy-efficiency correlate to the use of particular forms, orientations, or skin designs? and
- What is it really like to experience these buildings?

Limitations

Using a "case study approach", one can only speculate, not measure, how much the fundamental architectural choices – of form, orientation and enclosure - contribute to the overall lowering of environmental loads. The selected designs are sufficiently diverse that they preclude exact comparison. No two are sufficiently alike to analyze along the lines of "this worked here, but it didn't work there … why?"

Also, the field visits did not include in-depth post-occupancy evaluations. The appraisals here rely on anecdotal reports from brief conversations with the building occupants. In some cases, unpublished, rigorous post-occupancy studies of the in-service performance of the design were made available. Significant findings in these are noted in the detailed appraisals, presented in Section 4.2. Despite the limitations of this method of research, the case studies help refine the questions to be posed in the study of design parameters, and they begin to demonstrate what design can do.

Applications in practice

The pursuit of case studies as an academic exercise involves activities that are transferable to consulting practice, including: recognizing a range of emerging technologies in the field, seeing buildings as entities through which energy flows, thinking about the unique demands of the cool-humid climate, and micro-regions within it, talking to building occupants, and taking note of the whole experience of a building.

How case studies will proceed, in this research

This research establishes a model for future case studies, by consistently presenting the major environmental load, operating energy, alongside a qualitative appraisal of design satisfactoriness. The design strategies that contribute the most to a "low-load + high-satisfaction" architecture are brought to the fore, and synergies between "low-load" and "high-satisfaction" are discovered. The discussions of "satisfaction" include the opinions of regular occupants or neighbours, and draw on a direct experience of the building. Viewing each building in a more comprehensive way than previous case studies have, the focus remains on the very challenging climate in the Great Lakes Basin.

While the case study method cannot draw conclusions about the relative strength of design parameters, it can identify the strategies used most often by the most successful designs, and it can show how wide the range of design alternatives there are. Under real conditions, with an owner and a budget, on a site with particular soils, boundaries and topography, the buildings studied here show the potential for actual, not theoretical, success.

2.3 WHO HAS STUDIES THE "DESIGN PARAMETERS"? ... HOW?

Next is an abstract study of how energy flows in buildings. It uses typical office buildings as test cases – because these can be compared more easily to one another than the case studies can be. Its focus is the influence that is exerted, by architectural decisions, upon the overall energy use of civic buildings. At issue are the overall shape, the solar orientation of the building mass, the amount of external glazing, and the thermal resistance of the enclosure.

Figure 2.3.1
A selection of green design "how-to" manuals

Schematic designs were developed here for a series of generic office buildings. Three size classes are represented: small (two stories, 11,000 sf in gross floor area), medium (four stories, 50,000 sf), and large (eight stories, 154,000 sf). Within each size class, the plan shape and building orientation were varied, creating several sub-types. Within each of these sub-types, the skin design was varied further, by specifying three levels of transparency in the facades (20%, 40%, and 60% window-to-wall ratio) and four levels of thermal resistance in the solid enclosure (characterized as "market", "institutional", "high-performance", and "exemplary" levels). As each parameter is changed, its influence on the energy-intensity of the whole building is estimated, using the "eQuest" simulation program. A discussion of the associated impacts on design quality follows.

This experiment was planned after reviewing several previous studies concerned with how energy flows in buildings. Some studies focus on the use of advanced material technology, such as high-performance glazing. Others emphasize "heliothermic planning", or passive solar architecture. Energy-use studies will soon require a critical, comparative review, as many show valuable conclusions, from varying perspectives. Here, a brief discussion highlights the important strengths and the significant gaps in the literature as a whole.

Two types of relevant literature

Within the "energy-study" genre, there are general "how-to manuals" and more case-specific "optimization studies". Both types are directed toward architects in consulting practice, and both types have been published in North America as well as Europe (see Figure 2.3.1).

The "how-to manuals" for non-residential buildings present an array of building types, in many climates, and they illustrate a very wide gamut of interesting design strategies. A few hint at the relevance of each approach to particular climates (e.g. Yeang 2006). However, the "how-to manuals", as a group, put less emphasis on the relationship of design to climate than appears elsewhere in the literature. Also, as in the case studies discussed earlier, there is a striking under-representation of the design approaches suit cold climates.

The "how-to manuals" directed toward residential buildings outnumber those for larger non-residential buildings by a substantial margin.* Among the manuals that are intended to guide institutional and commercial design, few distinguish further, between large and small buildings or between high-energy uses and low-energy uses. It is left up to the reader to try to understand the relationship between individual design tactics and the energy-use of the whole building, through trial-and-error of a number of designs.

Some of the "how-to" manuals emphasize building elements that are seen as "green", because they are unusual in "mainstream" commercial buildings. For instance, tips abound regarding techniques such as how to locate an exterior sunshade (Brown and deKay 2001), or how to size a solar collector (Lechner 2001; Kwok and Grondzik 2007). If the plan and volume of a design are already established, an architect may find some practical help in the "how-to" manuals with the refinement of certain elements.

But what if an architect wishes to know whether it would be worthwhile to adjust the orientation of a large civic building toward the sun (hoping to increase solar gains), or to "slenderize" the plan form (hoping to lessen the need for artificial lighting)? Some of the manuals show architectural strategies, such as the orientation of courtyards and atria, the placement of thermal collector walls, or the organization of a building around wind-catchers (e.g. Brown & deKay 2001). Such strategies may lower energy use, in some circumstances, but the manuals do not present estimates of how much energy conservation is likely to be accomplished, nor do they explian how to estimate the savings for a particular case.

The "how-to manuals" reviewed so far, are effective in displaying alternatives to standard design. However, from the perspective of a consulting architect, the manuals are not suitable to be consulted actively during the design of a real project for a real client. There is not

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* See, for example: US HUD 1976; Argue et. al. 1978; Mazria 1979; Strong 1987; Hasting et. al. 1997; Vale & Vale 2000; Wilson 2006; Hastings and Wall 2007.

enough focus on climate-specific solutions, not enough representation of non-residential cases, insufficient information relevant to the schematic design stage, and very little hard data about the overall effects of the proposed tactics.

"Optimization" of form, through "heliothermic planning"

The second type of research, under the overall energy-study umbrella, tests alternatives in relation to a given design challenge. In this type of study, greater emphasis is placed on tailoring design responses to climate than in the "how to manuals". In a few studies, the question of building form and orientation is addressed. Office buildings and schools are popular test cases for "optimization", and these studies conclude with quantitative estimates of the effects of the particular design strategies, or groups of strategies, that they examine. This suggests the order of priority of design strategies in similar cases.

Some "optimization studies" test alternate building forms. The idea that form ought to be modified to suit climate is not new. In the 1^{st} century B.C., the Roman architect Vitruvius advised,

> *"If our designs for private houses are to be correct, we must at the outset take note of the countries and climates in which they are built. One style of house seems appropriate to build in Egypt, another in Spain, a different kind in Pontus, one still different in Rome, and so on with the lands and countries of other characteristics. This is because one part of the earth is directly under the sun's course, another is far away from it, while another lies midway between these two." (Morgan 1914)*

A similar idea is put forward in the landmark optimization study entitled *Design with Climate* (Olgyay 1963), which is prefaced with an observation about "modern times", noting that 1950s North America was a time of rapid spread of communication and population, and that the accompanying architectural patterns seemed to ignore the wisdom that had been known since Vitruvius, about the influence of climate on building. Olgyay saw the central issue in architectural design, in any era, as a challenge to help a human body to maintain equilibrium, and to fulfill the requirements of "comfort" or "livability". He argued that the feeling of thermal balance is essential to any definition of comfort.

Olgyay tested the concept of "heliothermic planning", for which there were various European theorists at the time. The objective was to "utilize natural possibilities to improve conditions without the aid of mechanical apparatus" (1963, 126). This would take into consideration both temperature and solar radiation effects. Olgyay was interested in learning (or re-learning) how to "correct" a design for a typical North American house. In his study, he asked:

- How much does the pattern of heat flow vary, if a house is situated in "cool" Minneapolis, "temperate" New York, "hot-arid" Phoenix or "hot-humid" Miami?
- What are the most effective combination of design strategies to "balance" conditions in each locale?
- How much do the architectural (i.e. non-mechanical) strategies matter? That is, as Olgyay put it, "How much can the physical architectural features alter the actual thermal situation?" (126)

Olgyay's test case is a one-storey, single-family house, of insulated wood-frame construction that is 1,225 sf in floor area. The study shows the heat loss and heat gain in the house, in its typical or "orthodox" plan form (square), on two days of the year that represented the most extreme conditions (21 January and 21 July). The Winter and Summer diagrams show the total heat loss and heat gain for the orthodox house in a "cool" climate, over a 24-hour period, in each season (see the upper left quadrant of Figure 2.3.3).

Olgyay speculated that the variety of forms found in nature might contain lessons for architects. For instance, he observed that leaves seem to be related to the management of heat (or energy) in trees. Figure 2.3.4 is his illustration of this idea. It shows that the northern pine needle is a dense, compact structure that withstands extreme cold, drought and winds, and that leaf forms in other climates are different. The deciduous leaf of the temperate zone is able to open to a considerable size, in the relatively "friendly" climatic conditions, from San Francisco to the Carolinas. The cactus growing in hot-arid Phoenix is a massive structure, which conserves water. Finally, in the "hot-house" tropics of Miami, under a protective canopy, leaves expand into quite "liberal" shapes.

Olgyay and his team then "balanced" the house to create the most comfortable interior environment, using the least intervention of heating and cooling equipment. He developed variations on the design to suit the various climates (see Figure 2.3.3, right side). *

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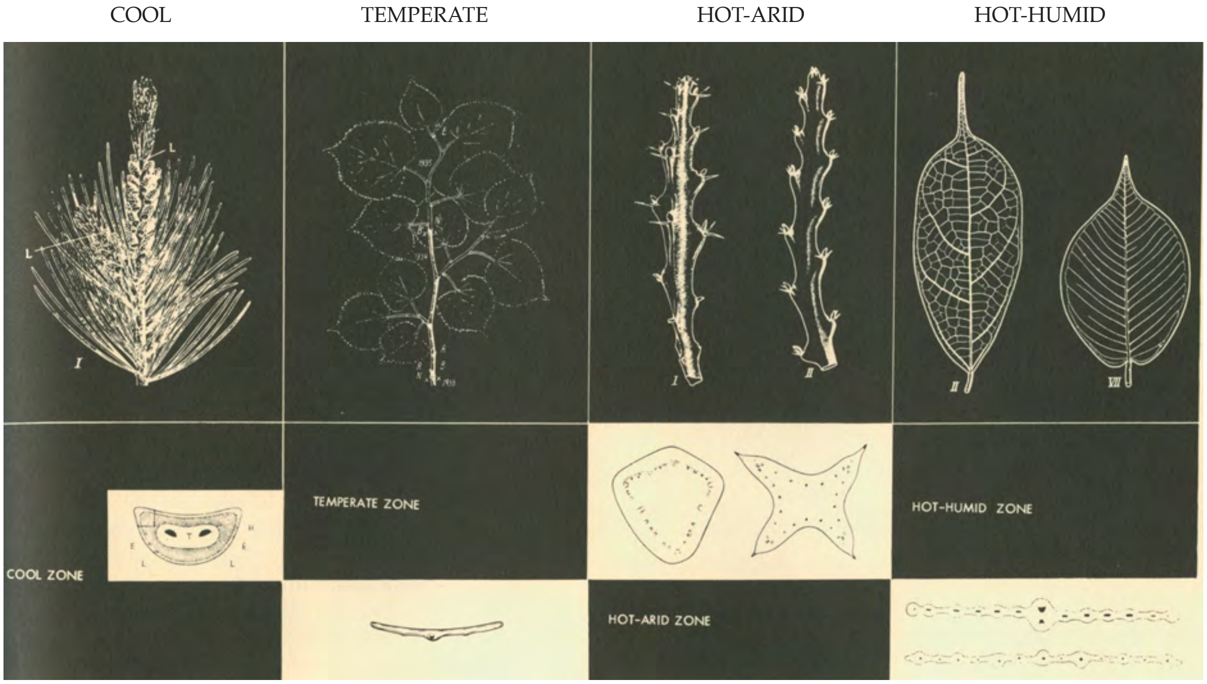
* The values for the two extreme days are extrapolated to yearly values, by applying factors to represent the duration of each season and a factor for human stress in summer. The proportions of underheated season/overheated season were 75%/25% in Minnesota, 72%/28% in New York, 37%/63% in Phoenix, and 0%/88% in Miami.

Figure 2.3.2
Plant morphology in various climatic environments (Olgyay 1963, 85)

Olgyay speculated that the leaf forms of dominant species may contain a lesson to architects about building form

Figure 2.3.3 (opposite)
A "balanced" house takes on different forms in Minneapolis and Miami (Olgyay 1963, 140, 149)



"ORTHODOX" house
(standard practice)

"BALANCED" house
("corrected" by Olgyay's team)

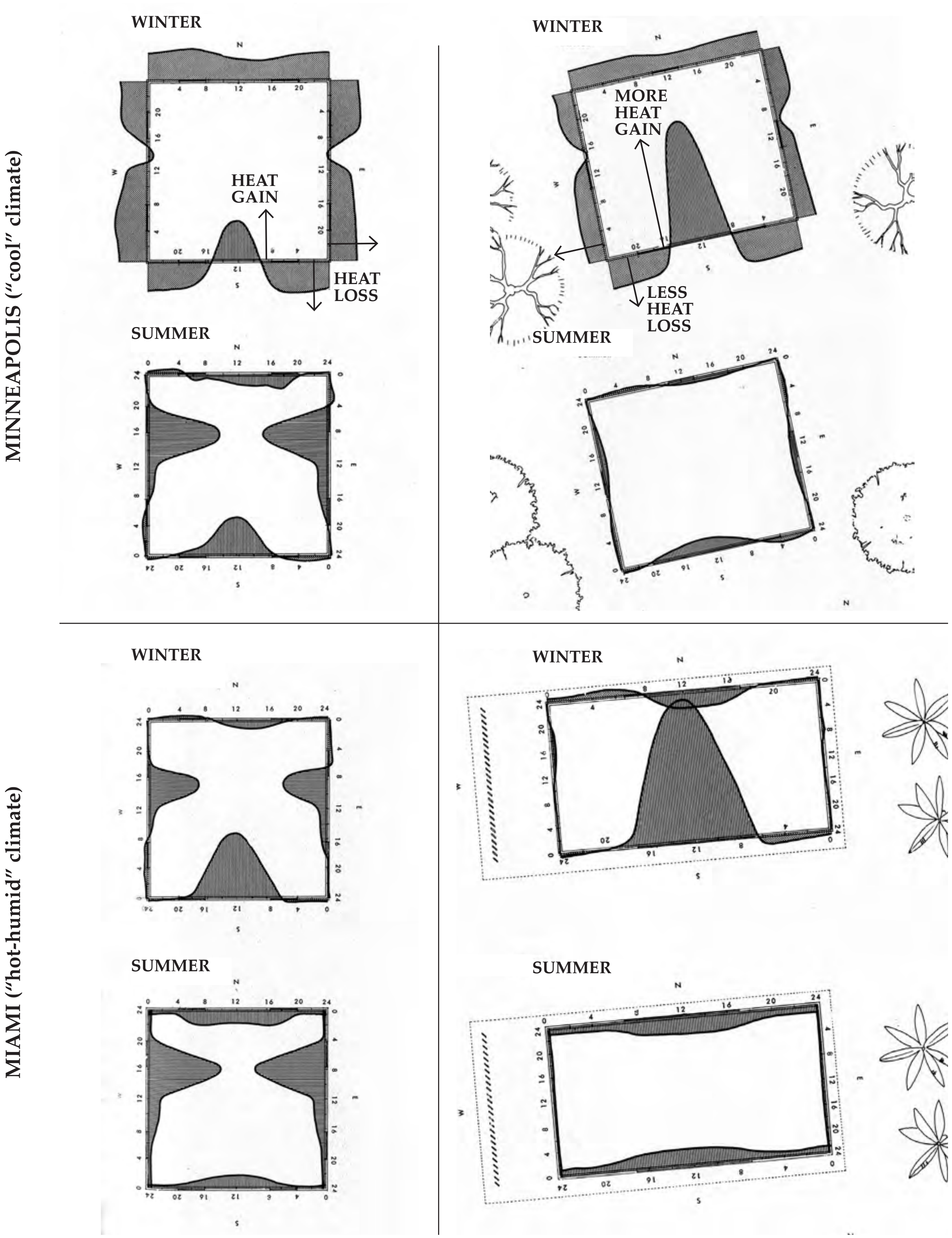
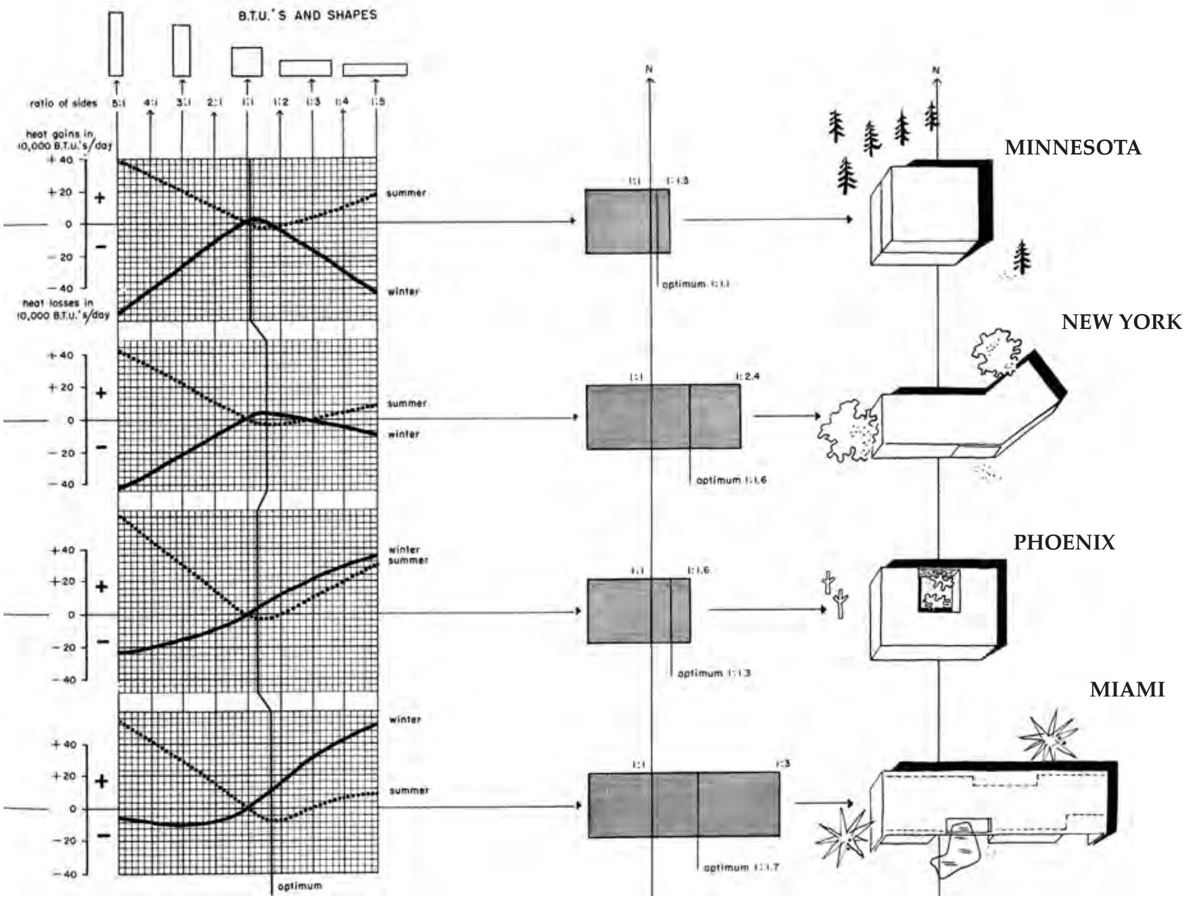


Figure 2.3.4
"Ideal" plan forms for houses (Olgyay 1963, 89)

East-west plan forms are preferred in small houses in hot-humid climates. Does this strategy apply as well to larger buildings in the Great Lakes Basin? The Study of Design Parameters, in Chapter 5, examines the question.



Like the needles of the northern pine trees that surround it, Olgyay's optimum house form in Minnesota is compact, near-square plan. Like the leaves of the tropical plants that surround it, Olgyay's optimum house form in Miami is long and narrow, and dependent on shading from adjacent structures (see Figure 2.3.2 and 2.3.4).

The principles that Olgyay describes remain significant for designers of small houses, decades after the book was published. However, if designers assume that the strategies presented by Olgyay can be applied, literally, to larger, non-residential buildings, there may be a problem. There is nothing in Olgyay's published work to suggest that the patterns observed in a single-family house are replicated in larger, commercial or civic buildings. He did not study large buildings – perhaps due to limitations on computing capability, or perhaps because there was so much residential construction ongoing at the time. Nowhere does Olgyay claim that heat flow in every building type is the same as it is in a small house.

Unfortunately, to date, there has been no study like *Design with Climate* to assist architects who are involved with non-residential buildings. The only speculation in Olgyay about larger buildings is parenthetical, as in the following comment, made within the context of conclusions about the southern hot-humid region:

> *"Some calculations show that, while in houses more than 90% of the cooling load is due to weather factors, in large buildings the same effects amount to less than 60%. In such cases the form and orientation is of secondary importance." (90)*

Design with Climate is one source of the present-day understanding that the overall form of a building has a significant impact on the amount of energy consumed in a year. The principals discovered in this study may be applicable to the cold-climate civic buildings that are the focus here - but only in the very broadest sense. "Heliothermic planning", a term that Olgyay coined to express a fundamental idea that he espoused is widely applicable. However, he recommended design strategies for a specific building type of limited size, that used specific construction systems. Because the wood frame house differs so dramatically from the larger civic buildings studied here, Olgyay's conclusions may not be so applicable. If the research in Chapter 5 can claim a heritage in the work done at Princeton in the early 1960s, it can also aim to go further, testing how much climate matters, and showing how much particular design strategies matter, to non-residential civic buildings in the Great Lakes Basin.

Heliothermic planning applied to non-residential buildings

In the Study of Design Parameters, in Chapter 5, the findings that Olgyay made are not contested. The idea that the same building, if situated in different climates, will experience very different patterns of energy flow, throughout the year, now is well-accepted (see ASHRAE 2004). In Chapter 5, the pattern of energy use in a Toronto office building is contrasted to that in four very different North American climates. The idea of selecting particular design strategies to suit a given climate has gained consensus in the literature, if not in active practice (see Section 2.6). The Analysis of Case Studies shows the strategies used most often in the Great Lakes Basin (Section 4.5). Also, various prescriptive guides have been published, for specific building types, that recommend the strategies best suited to the various U.S. climates (e.g. ASHRAE 2004).

This study re-examines, in depth, the third question that Olgyay asked, regarding how much influence is exerted by particular architectural choices on annual energy use - this time in a large office building, rather than in a house. Technical developments, during the decades since *Design with Climate* was published, permit and demand that the current research reaches further than the earlier work. First, the advent of desktop computing capability allows swifter and more comprehensive simulation of energy use than Olgyay could perform. Second, advancement in the manufacture of glazing units and window frames has expanded the range of performance that is possible today. The latter development makes it necessary to study more alternatives than in earlier years; the former makes it possible to do so.

In 1963, it would have been difficult, if not impossible, for Olgyay and his team to simulate the annual energy use of a town hall, school or office building. Even for the study of the small house, he could not model conditions for all 365 days of the year; instead, he approximated the gap between the daily values and the overall annual sum. Today, an energy model of a complex building can be made - with publicly available software, and a personal computer. The software has reached a stage that allows a non-expert to attain results swiftly, after a short learning curve. During the early stages of schematic design, an architectural design team can study several alternatives. Various software programs exist for this purpose; the reasons for selecting eQuest for this study are presented in Section 2.7.

In 1963, Olgyay used single glazing in his “orthodox” house and proved the use of double-glazing to be one of the most significant contributors to energy use reduction. In the intervening decades, the use of double-glazing became common practice, in residential and

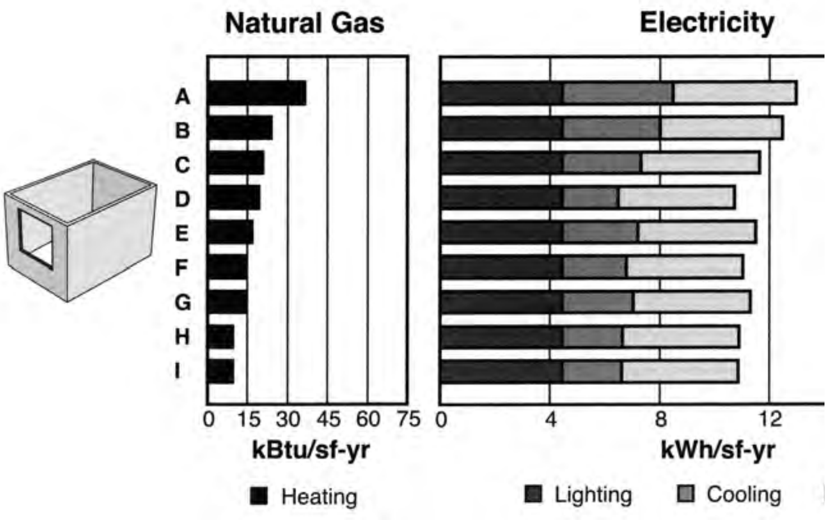


Figure 2.3.5
Annual energy use comparison for nine window types

south facing, no shading 30% WWR, Chicago (from Carmody et. al. 2004, 33)

non-residential construction in the GTA. Now, forty-five years after Olgyay's landmark publication, another study explores eight levels of thermal performance of glazing units – six of them commonly applied in the design of medium-sized office buildings throughout the U.S. and Canada (Carmody et. al. 2004). The application of advanced window technologies, such as coatings and seals, can have a dramatic impact on the annual energy use of a building. However, in the literature to date, this impact has not often been compared to the impact of architectural measures, such as building form and orientation.

Optimizing the building skin

Carmody et. al. devote an entire textbook to the study of the impact of a window specification on the overall energy intensity of a commercial office building (2004). Their test case is a 3-storey building with a square floor plan and a total gross floor area of 48,000 square feet. The building is consistently oriented with the facades facing the four cardinal directions. Nine different glass specifications are modelled in the DOE-2.1E energy simulation program. Without changing the form or orientation of the building, five window-to-wall ratios (WWRs) were modelled for each window specification, and all of the permutations and combinations were tested in six locations. * Figure 2.3.5 is one of a series that shows the impact on whole-building energy intensity; window types "A" through "I" range from single, clear glazing in non-thermally-broken aluminum frames to quadruple glazing in insulated aluminum frames.

The study also shows, for the various locations, where energy is needed (heating or cooling) and from what source (gas or electricity). Carmody et. al. argue that windows are one of the most important

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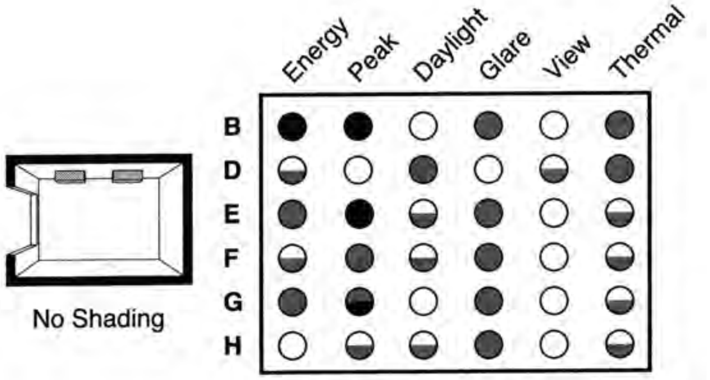
* Minneapolis, Chicago, Washington D.C., Los Angeles, Houston, and Phoenix

Figure 2.3.6
Comparison of multiple attributes of six window types

(same scenario as Figure 2.3.5, from Carmody et. al 2004, 137)



	Energy	Peak	Daylight	Glare	View	Thermal
B	●	●	○	◍	○	◍
D	◒	○	◍	○	◒	◍
E	◍	●	◒	◍	○	◒
F	◒	◍	◒	◍	○	◒
G	◍	◓	○	◍	○	◒
H	○	◒	◒	◍	○	◒

○ 8–10 Best
◒ 6–8
◍ 4–6
◓ 2–4
● 0–2 Worst

elements in the design of any building - because they are key to both technical and human comfort concerns. Figure 2.3.6 is one of another series of diagrams that rate each window type according to qualitative as well as quantitative criteria.

This raises the question of how far is it necessary, or reasonable to go, with these advanced material technologies? An early issue of the *Journal of Green Building* presents an optimization process that could be followed in consulting practice. (Werthen and Navvab 2006). Its test case is a 2-storey office building, with a square floor plate, and a gross floor area of 25,000 sf. It is located in the heart of the Great Lakes Basin, in Detroit. A process of finding the "optimum" enclosure specification is illustrated, using the eQuest software and simple analysis of the operating costs associated with major climate control systems.

This study begins by simulating the annual energy use of the building, with a "baseline" specification, compliant to ASHRAE 90.1 prescriptive path. * The functions that consume the most energy are (in descending order): lighting, heating, and cooling. Starting with the most energy-intense function (in this case, lighting), the researchers identify measures that would reduce energy consumption. The first is to introduce daylight sensors, to reduce the energy needed to run area lights. Later, to reduce the energy needed for heating and cooling, the window-to-wall ratio is adjusted and the window specification is improved. Several measures are taken to "optimize" the design. Unlike the Olgyay study, these do not include changes to the shape of the floor plan, or to the solar orientation of the building as a whole.

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* For this building type in this location, the ASHRAE 90.1 standard prescribes a minimum as follows: R-13 wall assembly, R-15 roof assembly, double-glazed, thermally broken aluminum window units with U-0.47 (imp), and a 45% window-to-wall ratio, distributed equally on all four facades.

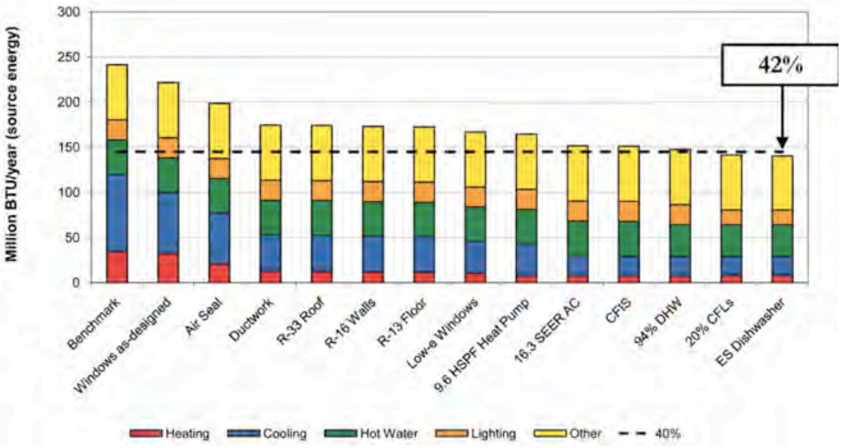

Figure 2.3.7
Sample report of a Parametric Study

presented to the US DOE in relation to a house constructed with funding from the Building America Program (BSC 2009)

To adjust the window specification, Werthen and Navvab plotted the increased performance of the glass vs. the resultant annual cost savings for operating the building as a whole, and determined the point of limited additional return. The researchers chose this point as the “optimum” for each aspect of the window specification. Like Carmody et. al. this study shows the impact of the window specification on the performance of the whole building, and points out the practical limitations on the application of advanced technology. *

The particular parameters that Werthen and Navvab choose as “optimum” for this case might be incorporated into another design for an office building, somewhere in the Great Lakes Basin. But the intention of the journal article was to *“encourage designers who may not have known how to approach an energy study to do so.”* So - more importantly than the specific findings - the method could be applied to another design in another location without external, “specialist” assistance.

Optimizing other parameters

Two more studies show different approaches to illustrating the influence of several parameters, from windows to climate control systems. Figure 2.3.7 shows one way of illustrating the impacts: one by one, the contribution of each adjustment to the design is linked to the overall performance of the building.

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* In Werthen’s Detroit example, the final energy simulation, using all of the optimized parameters, predicts a reduction from the 191 kWhr/m2/yr (60.64 kBtu/sf/yr) that would be consumed by the baseline building to 130 kWhr/m2/yr (41.3 kBtu/sf/yr) in the optimized design. This would result in an annual savings of approximately $6,000 – roughly 25% of the baseline expectation.

Figure 2.3.8
Variations in emphasis & methods in the existing studies of design parameters

	Olgyay 1963 *Design with Climate*	Brown and DeKay 2001 *Sun, Wind & Light*	Carmody et. al. 2004 *Window systems for H-P*	Hausladen et. al. 2006 *Climate Skin*	Werthen and Navvab 2006 *Building Design Strategies*	Yeang 2006 *Ecodesign*	Lerum 2008 *High-Performance Buildg*	Ross 2009 *Design with Energy in Mind*
"Optimization" study (OS), post-occup. eval'n, or "how-to" manual (MN)	OS	MN	OS	OS	OS	MN	OS & PO	OS
General relevance:								
Type of building used as subject	1,225 sf HOUSE	VAR. non-res	48,K sf OFFICE	OFFICE	25,000sf OFFICE	VAR. non-res	civic OFFICE	S, M, L OFFICE
Number of distinct climates tested	4 U.S.	many	6 U.S.	6 world	Detroit	many	7 world	Toronto
Measures whole-building performance in…	BTU/day	-	kBTU/sf/yr	kWhr/m^2/yr	MBTU/yr	-	kWhr/m^2/yr	kWhr/m^2/yr
Methods used:								
Starts with climate data from…	AIA	NOAA, EnvCda	US DOE	no ref.	eQuest	?	var. local	eQuest
Tests one (or more) whole-building design(s)	●	◐	◐	○	●	○	●	●
Tests a typical, repeated, small unit (eg perimeter office cell)	○	○	●	●	○	○	○	○
Software used for energy models	by hand	n/a	DOE 2.1E	TRNSYS	eQuest	n/a	E-10/actual	eQuest
Shows how much energy use is influenced by…								
...whole-bldg shape	●	○	○	○	○	◐	◐	●
...whole-bldg orientation	●	○	○	○	○	◐	◐	●
...the orientation of glazing	●	○	●	●	○	◐	◐	●
...the thermal resistance of the enclosure	●	○	●	●	●	◐	◐	●
...various window-to-wall ratios	●	○	●	●	○	○	◐	●
Also includes:								
Case studies (or real examples of particular design strategies)	○	◐	◐	◐	○	◐	●	●
Case studies with post-occupancy info	○	○	○	○	●	○	●	●
Whole-building cost info (capital & LCC)	○	○	○	○	◐	○	○	◐
Discussion of daylighting	○	◐	●	●	◐	●	◐	◐

● Yes, primarily ◐ Yes, to a degree ○ No, or in a very minor way

Another way of illustrating the impacts is found in *Climate Skin*, a textbook *“intended to support architects and engineers in producing energy-efficient concepts”* (Hausladen 2006). An office building of unspecified size and shape, located in Wurzburg, Germany, is used as a test case. Graphs, charts and diagrams illustrate the effects of decisions at the concept stage, such as: the effect on heating energy demand of increased insulation, air-tightness. Figure 2.3.9 is one example. Yet again, trends are not shown for overall building shape and orientation, although numerous statements allude to the impact of surface area to volume ratio on heating demand.

Asking “what if…?” after occupancy

Another, very different approach to optimization is taken by Lerum, who visited seven buildings well after occupancy and interviewed occupants, measured on-site conditions, and studied utility records (2008). In all cases, the reports reveal a pattern of performance that is quite different from what was expected during the design stage. Lerum goes on to ask various “what if” questions, in the hope that the answers may inform designers who face similar circumstances in the future. In one case the question is - what impact would re-orienting the building exert on the overall annual energy use? Lerum’s work, which aims to learn from thorough post-occupancy evaluation, stands out as unique amidst all of the other research surveyed here, which deals in predictions and relies heavily on computer simulations.

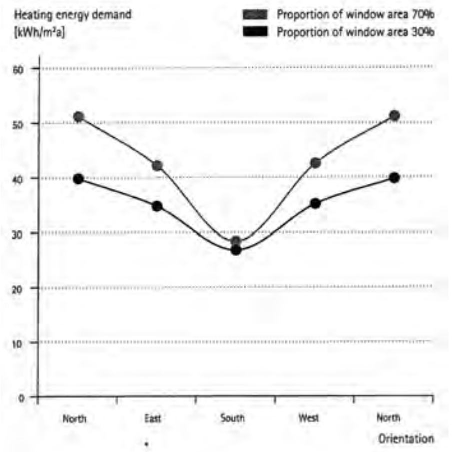


Figure 2.3.9
Influence of orientation and proportion of window area on heating energy demand

(from Hausladen 2006, 35)

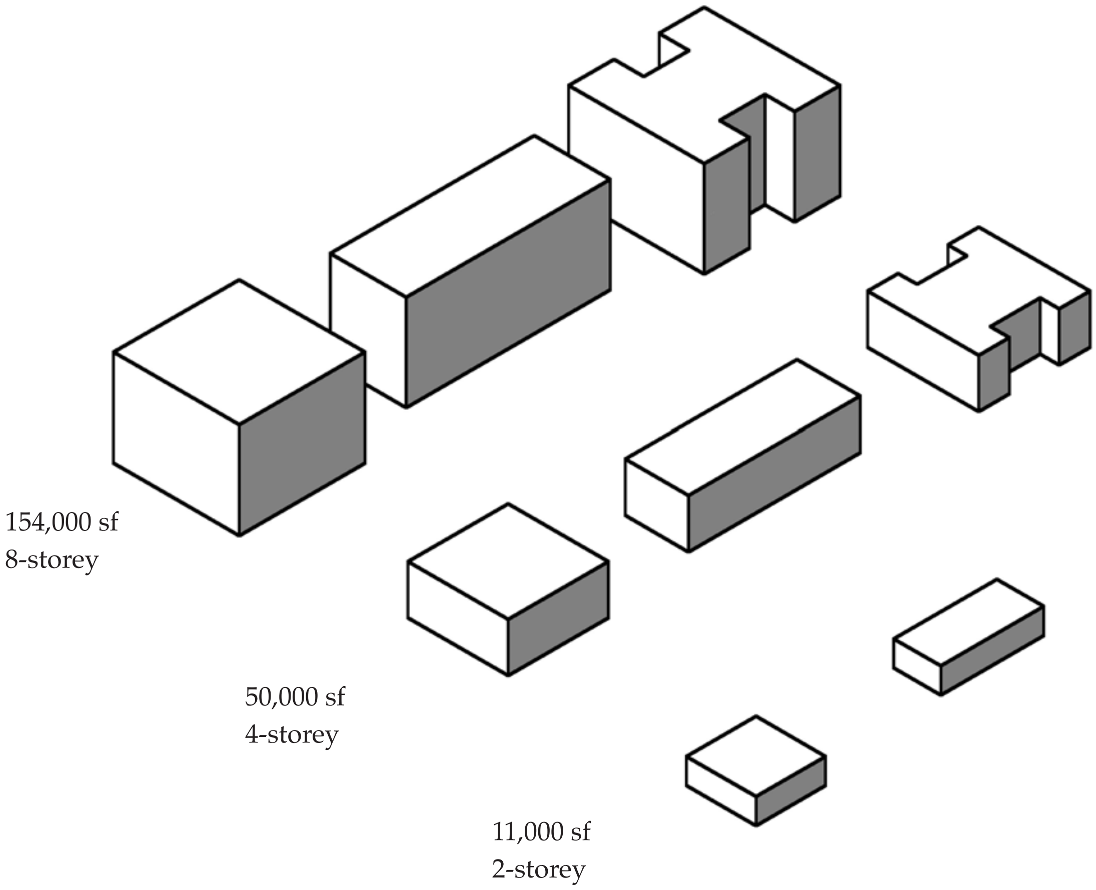
How this research differs

The research to date has established that design priorities ought to vary with climactic zone, and that building shape, building orientation, glass orientation, and the thermal resistance of the enclosure interact in complex ways. Both the “how-to manuals” and the “optimization studies” leave questions about whether the principles are consistent at all scales. A comparison of the emphasis in key examples of the “energy study” genre is presented in Figure 2.3.8.

The “optimization studies” examined here have assumed various points of departure and then employed different methods of research. Olgyay started with a hypothetical, typical house as a test case. Believing that nature provides a model for architects and that comfort correlates to least mechanical intervention, *Design with Climate* “balances” a design, using form, building orientation and skin

Figure 2.3.10
Building types used in the Study of Design Parameters

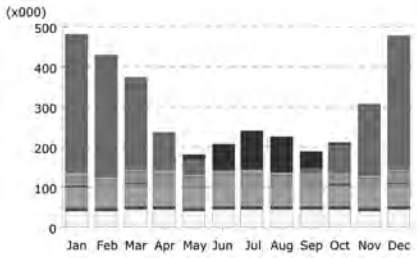
The annual energy use in small, medium-sized, and large office buildings (centre) is estimated (lower right) as parameters (top left) are adjusted one at a time (see Chapter 5).



ANNUAL ENERGY USE (kWhr/m2/year)

enclosure type

window-to-wall ratio	A	B	C	D
60%	?	?	?	?
40%	?	?	?	?
20%	?	?	?	?



attributes (1963). Werthen and Navvab started with a hypothetical office building, as a test case. Believing that the limiting factor that establishes the "practical optimum" level of performance is today's cost of fuel and electricity, the study optimizes a window specification for an office building in Detroit (2006). Carmody et. al. acknowledge that energy performance must be balanced with considerations of view, glare, daylight and thermal comfort, and provides a comprehensive resource for specifying windows and allocating window are to building facades (2004). Two other studies show different ways of illustrating the impacts of several parameters (BSC 2009, Hausladen 2006). Lerum asks "what if" some aspect of a completed design were varied (2008). This last study highlights important lessons that reside in the gap between an energy simulation and the real-world performance of buildings.

The Study of Design Parameters in Chapter 5 aims to shed light upon the relative power of building shape, building orientation, overall size, and the thermal resistance of the enclosure of an office building in Toronto. It will link the variation in each of these parameters design strategies to whole-building energy-use impacts. It offers new perspective on the potential of searching for the optimum architecture rather than simply specifying an "optimum" building component.

The Study of Design Parameters assumes a different point of departure and follows a course that is distinct from, yet informed by, all of the earlier studies. Like many of the studies, this research uses hypothetical, "typical", buildings as test cases, and relies on a computer program to "model" annual energy use in a building. Unlike many of the earlier studies, it does not try to "balance" a particular design. Rather, it shows the effects of the major architectural strategies, by predicting the energy-use of each permutation within a matrix of building types.

The office buildings tested here contain business suites with open plan and private offices, conference and copier rooms, a typical service core (elevators, washrooms and equipment spaces), and an entrance lobby on the main floor. (Schematic plans of the small, medium, and large buildings, showing the allocation of space on a typical floor, are presented in Chapter 5 and Appendix 5.) The proportion of floor space dedicated to each function, and the hours of operation, are set as constants for all simulations. The impact of three window-to-wall proportions (20%, 40%, and 60%) and four levels of thermal enclosure is estimated, for each variation in plan configuration. Simple variations, with square, "skinny", and "H-shaped" plans are put to the simulator. A summary of the building types is presented in Figure 2.3.10.

Since the objective is to test the architecture, an effort was made to neutralize the effects of the climate-control systems. The matrix of building types includes a wide gamut in which real-life mechanical systems design would vary. Since heating, lighting and cooling are the largest loads, it is important to treat them consistently at all scales. Rather than simulating the energy use under "normal" design conditions, this method yields a reflection of the loads passing through the building. Here, the heating system is an all-electric resistance, 100% efficient.

The gap between the results obtained using the "neutralized" HVAC system and the real-life energy use of a similar building is not a concern. No simulation is matched exactly by the actual performance of the completed building, as the Analysis of Case Studies will show. The important observation is how the energy use differs as the architectural parameters are altered. The Study of Design Parameters will address the following questions:

- How does the pattern of energy flow in an office building in Toronto compare to the pattern in the same building, located in a different climate?
- How much does each primary architectural parameter influence the total annual energy use of a building?
- Does one parameter out-perform the others in a building with a floor area of 10,000 sf -to the same degree as it does in a building with more than 100,000 sf?
- Is the guidance (increasingly present in "green design" checklists and manuals) to apply certain "rules of thumb" – such as "align the building east-west" or "specify R-30 in the roof" - always correct in every circumstance?

The results were verified by an independent researcher, working at a second location separate from the author. The two researchers used the same inputs, the same software, and different hardware. The initial runs were compared, to make slight adjustments to the inputs on both ends. After that, the second researcher completed all runs before seeing the results of the first. The results from the first researcher are in Chapter 5, and those from the second are in Appendix 5.

Limitations

The designs used in this phase are not inflected by the features of real sites, such as topography or nearby buildings, nor are they tailored to the demands of real users. They are free-standing buildings in a suburban context, because this is most controllable scenario with which to begin. Hopefully, the knowledge derived in this series of cases will be informative for other cases, in more densely built-up urban contexts, where the viable design options may be fewer.

Also, each estimate of energy use that is presented here is a "model" figure. These are meaningful in the context of this study, relative to the other figures. However, they are a function of the specific inputs used in this experiment. There is considerable abstraction inherent in these designs; for instance, the type of climate control systems selected for the experiment would not likely be selected in a real building. Moving from the "laboratory" into the "real world", the actual energy use - even in a building that resembles one of the types very closely – will be different than the figures presented here.

Nevertheless, the designs are very realistic in plan, form, and space allocation. Also, they use components that are available to builders of commercial or institutional projects, today. Choosing and documenting the "typical" parameters here paves the way toward future exercises, in which the inputs to the simulation software would be tailored more closely to suit each future design challenge.

Application in practice

In the researcher's consulting practice, to date, the study of the energy-use consequences of early design decisions has been a rare occurrence. Because energy use has not, in the past, been a key design goal, designers' minds have not been focused on the relationship between building form, orientation, and energy. Also, other priorities have occupied the foreground; especially in civic buildings, where the demands of site, functionality and image tend to be quite complex.

In a select few recent projects, an estimate of energy use has been made – usually to assist in obtaining a government grant, or satisfy the demands of a green building rating system. On these occasions, the simulation task was delegated to a specialist "energy consultant", working outside of the architect's office. The "upside" of this practice is that the architect was not unduly inconvenienced. However, two serious problems were noticed. First, the chance to improve the project at hand was lost. Because they required detailed inputs, the energy models were done long after the primary form, orientation, and plan layout were established – leaving very limited opportunities to revise the design, when the results of the energy model became available. Second, the architect learned almost nothing in the process. The specialist's report crossed the desk, on its way to the grant provider, but no meaningful connection was made between the design decisions made earlier and the array of numbers presented in the energy model. As the lessons about the present project were lost, so too went any hope of using the experience to inform the next project.

By taking up a simple version of the tools previously used only by "energy specialists", an architect may begin to appreciate the issues in managing energy flow. The advice of mechanical and electrical engineers still is needed, to establish realistic inputs to the simulator, and to suggest alternative design approaches. The energy specialist also still has a role, in finalizing a credible estimate, especially on more complex scenarios. Yet the process pursued here could be useful to an architect, during the stage in which the formative concepts are being established.

How design parameters will be studied here

The literature reflects ongoing efforts to understand the whole-building energy-use consequences of primary design decisions. Recent studies emphasize the use of renewable energy devices, or the application of advanced material technologies. These studies are needed, because of the wide array of choices available to architects today. However, there is a need for an energy study emphasizing "heliothermic planning", or the manipulation of architectural form.

Now that computer simulation software has advanced, it is possible to estimate the energy use of large complex buildings. Nevertheless, the parameters interact in a complex ways. To guide a diversity of projects "on the boards", an architect needs more than a simple "one-size-fits-all" recipe for success. She or he needs to learn a few basic concepts, and then to acquire the tools and skills that can be applied to suit unique circumstances as they are encountered.

The Study of Design Parameters examines a large series of cases, under controlled conditions, so that patterns may be detected. It is expected to yield information that the Analysis of Case Studies does not. It also models the practice of simple design analysis, using "beginner-level" energy-simulation software. Through this exercise, free of the peculiarities of site and client, an architect may start to understand the impact of those fundamental choices that "deal the cards" to the rest of the design team.

2.4 APPRAISALS, USING THE QUESTIONS OF DESIGN QUALITY

The first instrument, developed within this study, describes the various aspects of “design excellence”, from the researcher’s perspective. In it, fundamental conditions of “sustainability” mingle with traditionally recognized conditions of “satisfying design”. As a personal compass, it suggests an emphasis for future design practice. It is used, here, as a “standard of expectation” when critiquing the case study buildings.

The issues encompassed by this instrument are in the normal purview of an architect; they are present in consulting practice, and regularly are discussed from various, informed perspectives within the profession. However, the preferences, emphasis, and biases belong to the author of this research. As such, the Questions of Design Quality (QDQ) might ***not*** be adopted exactly “as-is”, by another architect. Every successful architect learns how to perform for an audience – emphasizing the aspects that are known priorities to the recipient, and using language that is most likely to lead to approval of the design. It is essential to become adept in applying this skill. However, after a quarter-century of “performing” in practice, the researcher has had the opportunity to reflect, in an academic setting. For once, it has been possible to ask, where is the balance in my priorities? And how best can I discuss the aspects of design that are most satisfying to me?

Also, this research is directed to those architects whose practices occupy the vast middle ground, between the more extreme stereotypes within the profession. It may not appeal to the architect, at one extreme, whose attention is focused on a select few aspects of satisfying design. This type strives to realize the highest quality in a chosen few areas – often failing to realize quality in others. An architect who “pushes” for a “singular vision” - of beauty or anything else - while ignoring the comfort of building occupants is one example of this type – and this research will not cure such an affliction. Likewise, this research may not motivate the type who has an awareness of a broad spectrum of issues, but is disinclined - either by attitude or circumstance - to strive for very high quality. This research does not aim to engender a wholesale change of direction in the practice of an architect who will not – or cannot - find a way to express architectural concepts to an uninformed client. It is not meant to rehabilitate anyone.

Figure 2.4.1
The Questions of Design Quality (QDQ)

Meaningful

It "speaks"

What is the strongest message of the design?

Does the design express belonging to the local community?

Does it imply renewed community vitality?

Does it say "welcome" and/or express stability and sound governance?

Is there a future vision - about energy or ecology - implied by this design?

Enjoyable

It works superbly and elevates the spirit

Does the design suggest that the owners care for the occupants?

Is it comfortable (thermally, acoustically, visually)?

Does the space planning work superbly?

Does the design lift the spirit?

Beautiful

Surface, light and space

Does the design extensively employ daylight?

Are materials, lighting and space arranged in a way that is interesting, appealing, and memorable?

Is the design a strong exemplar of the sensibilities prevailing at the place and time in which it was created?

Clever

Innovation and integration

Is unusual technology – emerging or re-emerging – applied in this design?

Do technical strategies drive the form?

Does the design attain a measurable superlative?

Are the key design tactics well integrated with one another?

Natural

It fits

What does this place allow us to do? …help us to do? …need us to do?

By satisfying human desires, does the design help a natural system gain an advantage?

How would nature solve this problem? (Is it durable, replicable, adaptable, fecund?)

Will the design be good for the community?

Are the inputs low, for a given amount of output?

The research question - “how much can an architect do, to really lower the loads of a design?” is addressed to a third type of architect. That this type represents a large proportion of the overall is taken as a matter of faith, rather than statistical evidence, because the researcher has worked, for years - with reasonable success and in relative happiness - among this group. Throughout this study, whenever the term “an architect” is used, the reference is to one who is both fully aware of a broad spectrum of goals that are considered “reasonable” for civic buildings, and also cares enough to try to realize high quality, in as many aspects as humanly possible, in a single design.

Every architect who consults for some time develops a personal menu of favourite tactics to use repeatedly. This menu may include any number of disparate elements – for example, a specification for exposed concrete, particular paint colours, or proven handrail details. This sort of “style” preference - which relates to physical components of a building - is not the subject of the current analysis. The Questions of Design Quality (QDQ) comprises rather more fundamental ideas - those that rise from the conceptual underpinning of a design to influence the whole experience one has of a completed work of architecture.

Finally – and importantly – there are the clients. As collaborators in the complex process of developing the design for a new civic building, architects and non-architects must articulate their predilections and, hopefully, arrive at consensus. An important aspect of an architect’s role is to lead the discussion about an emerging design, in terms that are understood by all stakeholders. Having reflected and re-established one’s personal priorities, it is essential to find a way to take them back out into the public realm – expressing architectural concepts in plain language, so that non-architects might appreciate the issues clearly, and feel comfortable forming their own good-quality responses. A list of twenty-one questions was developed to meet this need. These form the backbone of the “Questions of Design Quality (QDQ)” – and are presented in Figure 2.4.1.

Applying the Questions of Design Quality (QDQ)

This Questions of Design Quality (QDQ) is expressed with civic administration and assembly buildings in mind (e.g. town halls, libraries, courthouses, police stations, recreation centres, schools and churches). Much of what is expected of a civic building also may apply to an office building designed for a private-sector owner-occupier. A variation of this list could be developed to suit another building type – such as a single-family, or multi-unit residence. (Such a variation would be quite similar, but some of the questions, particularly in the "Meaningful" category, would be re-cast to relate more closely to the design of private space.)

Any design – with or without explicit "sustainability" goals – is highly satisfactory if it is meaningful, enjoyable, beautiful and clever. The questions in each of the first four categories are not new; and a "well-designed" public building is generally recognized as one that displays all four of these attributes, in a balance appropriate to the circumstance. The Tea House in Portland, shown in Figure 2.4.2, is an example of such a building.

Figure 2.4.2
Meaningful, enjoyable, beautiful and clever: The Tea House in the Japanese Garden in Portland Oregon

(Tono, 1964, image Ron Cronin, from Hamilton 1996)

In the QDQ, the attribute "Meaningful" is listed first, because it is the most important. If the design of a civic building "speaks" about an issue that is important to its community, then it is "satisfying". Vying for greatest importance is that a design be "enjoyable". This is to say that it doesn't just "work", but "it works superbly", and that it elevates the human spirit. A challenging attribute to photograph, "enjoyability" involves all of the senses other that the visual. Some aspects of "enjoyable" – such as comfort and convenience - are the focus of today's "post-occupancy evaluations". To be fair in appraising this attribute, there is no substitute for the direct experience of a building.

To say that a design is "beautiful" is to focus on the visual sense. Although subject to ever-shifting cultural preferences, "beauty" can be described - both in terms of today's sensibilities, and in terms of more lasting fundamentals. Finally, to say that a design is "clever" is to say that it is innovative in some way. About "beauty" and "cleverness", there will always be a wide gamut of opinion within the profession, and outside it. In the QDQ for civic buildings, beauty and cleverness are valuable, but a little less so than meaningfulness and enjoyability.

As expectations turn toward a "new normal" in design, "sustainability" criteria may be added to the description of "design excellence". A close review of selected literature from the canon of sustainability philosophy yielded the five remaining questions in the last category - “Natural”. Listing these criteria last does not mean that they are least important. However, these questions are “newcomers” to the list; each presents a challenge and an opportunity, when considered in tandem with the questions in the first four categories.

No aspect of design quality is submitted – in this study - to measurement on a precisely calibrated numerical scale. By choice, making this appraisal in qualitative terms is deemed both sufficient and appropriate. In this way, certain challenges may be avoided – such as those encountered by the green building rating systems that have tried to “put a number to” design quality (as described in Section 3.4). Also, the attributes within the list of Questions of Design Quality (QDQ) are not entirely discreet; there is some overlap between some issues. Finally, the avoidance of a numerical scale allows the relative importance of each category to shift slightly, according to the design challenge at hand.

With very few exceptions, the questions in the QDQ are constructed to be answered “yes or no”, with limited qualification (i.e. “yes, clearly”, “yes, to a degree”, “no, not really” or “no, not at all”). A detailed appraisal, using all of the questions, was made of each case study building, during a field visit. After that, a comparative analysis of the case studies was made (see Section 4.2).

In the following pages, a few examples illustrate each of the attributes, with reference to buildings other than the case study subjects. The Questions of Design Quality (QDQ) could be applied to public spaces; but here, the discussion is limited to the design of a single building. Hopefully, this discussion will advance the art as well as the science of developing a “low-load, high-satisfaction” architecture.

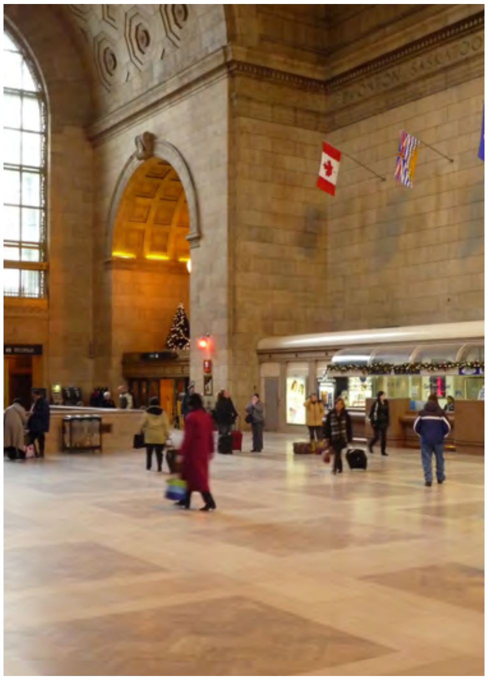


Figure 2.4.3
A meaningful threshold of the City - in the Great Hall in Toronto’s Union Station

(Lyle, 1931; images in this section Barbara Ross unless otherwise noted)

Condition #1: Meaningful
This design speaks to an important community issue
A meaningful public building is one whose design has captured the values and aspirations of the people who caused the building to be made - and can communicate these values to any witness.

The study of cultural history shows the power of buildings to convey messages of many kinds, each relevant to conditions prevalent in a specific time and place. An architect, like any other type of artist, communicates emotions and human experiences by transmitting ideas through a physical medium – in this case, that of construction - to an audience. Yet an architect has a few challenges that other artists don't have. For instance, this medium is in the public domain, and it is strong enough to hurt people. Caution is required in the creation of an artistic work that people must inhabit. And courage is needed - to consider the many ways that such a creation may be treated over time. An architect must work within these challenging realities, and at the same time inspire, delight, and capture the imagination of her audience. In civic architecture, this "audience" includes both the regular occupants and the visiting public.

The messages of concern in this study are civic messages. Often they have to do with arriving, gathering, sharing, or witnessing. In some cases, the message is a declaration of ownership and responsibility; in others, it is a comment on the state of society in general. In the Questions of Design Quality (QDQ), negative civic messages are eschewed. For instance, a design that seeks to express the violence of our times might be considered, by another standard of expectation, to be successful – if it gets its violent message across. However, the researcher considers it neither valuable nor honourable to propagate or celebrate violence through a civic building. Here, the preference is, instead, for a civic architecture that speaks of positive ideals.

So, in appraising the case study designs, the first question must be, *"what is the strongest message of this design?"* The questions that follow pertain to the positive messages that usually are wanted in a civic building - such as a sense of belonging, a celebration of community vitality, or an offer of welcome.

A clear exemplar of *"belonging"* is the Church of St. Martin in the Fields, in London, U.K. This design does much more than accommodate Christian worship in its 18th century English Baroque hall. Through a condition of its architecture, the building tells the story of its community. This church is known worldwide, through its association with chamber music, and religious broadcasts. But, since it was consecrated (under the reign of Henry VIII), the central idea of the place has been compassionate care. Originally, it was situated to quarantine tuberculosis patients. It has been known as "the church of the ever-open door", ever since it offered shelter to soldiers en route to Europe during World War I. And its front door has not been turned on its hinges since then. It is said, "architecturally, spiritually, culturally, and socially, St. Martin's has helped to form the world around it". To the question, "does the building express belonging to the local community?" the response, would be "yes, clearly".

A common expectation of a civic building is that it *sings out proudly of the vitality of its community.* The great hall in Toronto's Union Station does this, as it accommodates much more than purely efficient arrival in and departure from the city (see Figure 2.4.3). It is a high-vaulted space, made of stone, carefully crafted in neo-Classical architectural language. The names of major Canadian cities are inscribed in a frieze, at the top of every wall. At certain times of day, a shaft of sunlight burns across the vaulted space, and falls as a spot-light upon the name of one city or another. The space and its articulation say that this place is connected to each of those other places, and passing across this threshold is an important moment. To the question, "does it imply community vitality?" the great hall at Union Station, in the years just after it was built, would earn a response of "yes, clearly". Decades later, even in a state of somewhat "faded glory", it still speaks of the stability of Toronto, in a way that also elevates the spirit.

Another natural expectation of civic government itself – and also to businesses, both large and small - is *a high degree of transparency and accountability.* To the taxpayer or the customer, this equates to "good governance". Toronto's "New" City Hall is one example of a civic building that embodies these values (see Figure 2.4.4). It has two elements that speak: the council chamber and the skating rink in the forecourt (both of which have served as models for other city halls, in other Ontario cities, such as Kitchener, North York, and Welland). Toronto's council chamber, round in form, speaks of consensus. Protruding from the mass of the building, and showing its form to the street, it also speaks of accountability to every passerby. Also, the large pool in City Hall Square provides cool respite to passersby in summer and a skating rink in the winter, and a constant reminder of the changing seasons. This design says "welcome" just as it tries to communicate "good governance" to the citizens of Toronto.

Figure 2.4.4
Intended meanings: transparency and accountability, at Toronto's New City Hall

(Revell 1965, image John Gordon Ross, private collection)

Figure 2.4.5 a (top)
The Aldo Leopold Legacy Center, Baraboo, Wisconson

(Kubala Washatko Architects Inc., image Mark F. Heffron, from AIA COTE 2008)

Figure 2.4.5 b (bottom)
An alternate vision - The Yale Sculpture Building & Gallery

(Kieran Timberlake Associates LLP, image Peter Aaron/Esto)

The cases studied here were selected because it is obvious, at first glance, that each one is an effective "speaker". The message is particular to each circumstance – and therefore, each design is unique. In several instances, the message is related to a future vision about energy use, or ecology, or the relationship between human activities and natural systems. The winners of the American Institute of Architects (AIA) annual Top Ten Green Award demonstrate this sort of message (see Figure 2.4.5a and 2.4.5b). It has been said that every building may imply a city (Kuwabara, 2007). These designs are deemed worthy of celebration, because the "green agenda" in one may suggest new possibilities in future designs by any architect.

By applying the "meaningfulness" questions from the QDQ, each design is appraised – according to how well it succeeds in getting its particular message across. Having focused the discussion on positive community aspirations, there is no need to try to assess whether one aspiration is more valuable than another. The evaluation is based on the premise that expressing - and sometimes guiding - the values of a community is one of the most important functions of architectural design.

Condition #2: Enjoyable
The building is comfortable, convenient and enlivening

This condition relates to the experience, first-hand and full-scale, of people who walk past, enter, and "live in" a building. An enjoyable building is comfortable, convenient to assemble and work in, and enlivening. Many architects have tried to describe the qualities that people universally find satisfying in buildings (e.g. Alexander's 1977, 1979; Susanka 2001). To realize the qualities of "enjoyability", a designer must care about the occupants of her building. Among the Questions of Design Quality (QDQ), Condition #2 is not secondary to Condition #1. Comfort, convenience, and elevation of the spirit are as crucial to a satisfying design as is the conveyance of meaning.

Comfort has various aspects – both tangible and perceived. To be comfortable in a building, a person must be *warm, dry, and able to breathe fresh air.* There must be *appropriate levels of light and sound.* For example, if there are noisy or hazardous activities in one space, then the design must include protection for occupants in adjacent spaces.

Tangible comfort is nearly - but not perfectly - measurable, on a numerical scale. During the field visits to the case study buildings, each building owner was asked if a structured, rigorous post-occupancy evaluation (POE) had ever been conducted. In six of seven case studies, the owners closely monitor ongoing energy use. In two more, there have been limited surveys of user-satisfaction. Yet, in only one case, was a full POE conducted by a third party, to assess the responses of all building occupants to the design (i.e. the Baird 2006 study for Wind NRG). In a thorough POE, both actual and perceived comfort can be assessed by comparing responses in a single building to average responses in buildings of similar type. In this way, the number of complaints of, for instance, too little cooling in summertime, or too much glare from windows may be assessed as "no worse than usual", or "significantly more common than usual".

The perception of comfort, on its own, is much more subjective - difficult to describe, and nearly impossible to measure. To increase it, a designer may introduce symbols, such as an easy chair, or a fireplace. A sense of orientation (that is, not being "lost") is part of the perception of general comfort, and is greatly helped by providing views to the outdoors.

Space planning contributes greatly to the enjoyment by an everyday user of a civic or office building. To consider a building convenient, a person must be afforded enough space of a suitable type, which is arranged to suit the functions imagined and which is accessible. Attainment of a design about which the occupants say "it works superbly" is the result of careful listening and painstaking work in functional planning. The detailed POE surveys at Wind NRG asked questions about this issue. In the other buildings, opinions have not been sought - in any manner other than anecdotally – or they have not been documented. During the field visits, some indication of the success of the space planning was sought, by asking about adaptations to the building interior, made by occupants. (Relevant adaptations included: using rooms for purposes other than what was intended, adjusting furniture layouts, and occupants introducing their own equipment, such as local heaters, fans, and so on).

The last question listed in the category "Enjoyable", has to do with *lifting the spirit.* A design may satisfy, in this way, independently of "period style". A lay person might experience a "lifting of the spirit", walking through the arches at Toronto's BCE Place (designed by architect Santiago Calatrava in 1987) just as surely as an architect might, upon entering the Roman Pantheon. The experience occurs as a result of an architectural brand of alchemy – a reaction of the senses, stimulated by light, sound, smell, the temperature, texture and shape of the space, and the memories of the person having the experience. For example, once, upon entering the Church of St. Francis in Assissi, on a frosty autumn day, the sound of the organ burst into the dawn light. The experience of joy was so intense that it involved a near-physical sensation of the heart vaulting out of the body into the air. On this occasion, this "lifting of the spirit" was much more than an appeal - of the cultural significance of the place - to the intellect. It had to do with the entirety of the sensory experience.

Figure 2.4.6
Daylight conveys meaning - The Canadian War Museum

(Moriyama & Teshima and Griffith Rankin Cook Architects in Joint Venture, image from mtarch.com)

Condition #3: Beautiful
This design plays with daylight, surface and space

An appraisal of this condition depends mainly on the predilections – both cultural and personal - of the reviewer. It has been noted that "The path to world domination lies through humankind's shifting ideals of beauty" (Pollan 2001). The irony in this statement is that declarations of "satisfactoriness", where beauty is concerned, are subject to the whims of the viewer, and tend to be swept away by the winds of ever-changing fashion.

However, there are a few constants that transcend time and place – and it is with these that the "beauty" questions in the QDQ begin. *One constant is the entry of natural light into a building interior.* In the cold climates that are the focus of this study, abundant daylight in a building is highly prized, and both the quantity and quality of daylight are at issue. There may be a large overlap between "beauty" and "meaningfulness" –

where talented designers employ daylight of particular qualities, to make a statement or to influence a state of mind. For instance, the tactic of guiding a beam of light to an important location has been used throughout history - from ancient Egypt to the Canadian War Museum in Ottawa (see Figure 2.4.6). This is an example of making a statement with daylight. And a very effective recent example of a designer's use of daylight – for practical, meaningful, and aesthetic purposes - is given by one of the case study buildings, St. Gabriel's Passionist Church in Toronto. (For a full appraisal of this project, see Section 4.2.)

Another constant is reflected in the next question *"are materials and space arranged in a way that is interesting, appealing, and memorable?"* A building is interesting and appealing if it includes a variety of contrasting types of space (e.g. enclosed/expansive, long and skinny/short and wide), and, if it demands a variety of ways of moving from space to space (e.g. along a flat floor, up a stair or ramp, and through an elevator). The contrast and the experience make certain elements more memorable than others. This attribute transcends historic style. Both the late 20th century National Gallery of Canada and the Gothic Revival Parliament Buildings – in Ottawa - are good examples of the deft manipulation of variety of materials and space by designers from very different eras.

Another "beauty" question addressed in the QDQ is the issue of *"contemporary sensibility".* A survey of recent architectural awards, given to public buildings, between 2000 and 2007, reveals four themes that pervade the current design sensibility in Canada: a practice of connecting internal activities and outdoor public spaces, the use of non-rectilinear forms, an interest in contrasting in surface textures, and the incorporation of "found" materials (Chodikoff ed. 2000 ff.). One test of design quality in the case study buildings is the degree to which these themes are evident.

Buildings of the current era are distinguishable from those of other eras, by the way in which they make connections between public space outside and less-public space inside. This is evident in several Toronto projects, such as the Princess of Wales Theatre (Lett Smith, 1993), the Four Seasons Centre for the Performing Arts (Diamond and Schmitt 2006), Canada's National Ballet School (KPMB 2005), and the Wellesley Community Centre / Public Library (Mclennan Jaunkalns Miller 2006), the last of which is shown in Figure 2.4.7a.

Also, there is an intense interest in contrasting surface textures, such as rough vs. smooth, or natural vs. machined, that can be seen in projects such as the Toronto headquarters of McKinsey & Company,

Figure 2.4.7 a (top)
Connections between outdoors and indoors - Wellesley Community Centre

(Jaunkalns Miller 2006, image from mjmarchitects.com)

Figure 2.4.7 b
Contrasting surface textures at McKinsey & Company Headquarters

(Hariri Pontarini 1997, image Mario Carrieri, from The Canadian Architect Feb. 2001)

shown in Figure 2.4.7b (Taylor Hariri Pontarini 1997), and the Pembroke Courthouse (NORR, 2006).

There is a surge, worldwide, in the use of non-rectilinear forms as well (see Figure 2.4.7c). This is made possible by emerging computer capabilities, and is evident in the work of Frank Gehry and Daniel Liebiskind. It is taken to an extreme in “blob” architecture - typified by the Kunsthaus in Graz, known as the “curious mutant bagpipe”, shown in Figure 2.4.7c (Cook and Fournier 2003).

The last of the notable “contemporary sensibilities” is an interest in *“found materials”* - which may be reclaimed from another building, or borrowed from another industry, and which may seem rather out-of-place, or out-of-scale. The current trend, towards using these conspicuously in a design, can be traced from the recycled carnival signage at TOHU in Montreal (Jaques Plante, 2004) to the old-windshields-as-guardrails in one of the case study buildings (Artists for Humanity). Another example is seen at the Canadian War Museum (see Figure 2.4.7d).

In a portion of the design community at least, there is a resurgence of interest in achieving a regionally appropriate appearance. This is a reaction against the message conveyed by the uniformity of latter-day “International Style” buildings. Bioclimatic regionalism is the subject of several recent critical studies, including one profile of the architecture of various regions of Canada, entitled “41 to 66” (McMinn and Polo 2005).

Certain late-20th century critics have complained of “the tyranny of the visual” in architecture (Fernandez-Galiano 2000). It is possible for a building to be perceived as beautiful, without being deeply meaningful. A beautiful building that is only somewhat meaningful may, in the very short term, be enjoyed for its novelty. But it is likely to become a “victim of fashion”, over the long term. For this reason, “skin-deep” beauty is acknowledged, in the QDQ, as one aspect of a satisfying design – but a much less important one than the previous two.

Condition #4: Clever
Innovation and integration are in evidence

A design may be viewed as "clever" if it employs materials or techniques that are new and unusual, if it attains a superlative, or if it is exemplary in its integration of design strategies. The quest to find ever more clever materials and construction methods is both cultural and technical. The current age has often been described as a highly materialist one, and much can be done, now, that could not be done in earlier eras. The pre-occupation with "cleverness" is as evident in the current wave of "green building" as it is has been in any other era or area of design specialty. For instance, *a green roof, a living wall, or a radiant floor may signal "green building" intensions.* Each is a clever invention in its own right, and may contribute positively to a particular environmental condition. However, the simple insertion of one of these devices does not necessarily a "low load" building make.

Attainment of a superlative (e.g. the biggest, the tallest, the first case, or the most lavish) is taken by some as a sign of "cleverness". The recent spate of very tall buildings – such as Taipei 101 (Lee, 2004), the Shanghai World Financial Center (Kohn Pederson Fox, 2008), the Petronas Towers (Pelli, 1998), and the Chicago Spire (Calatrava, estimated completion in 2012) - exemplify this trend. Attainment of extreme heights is possible through the application of advanced technology – including, such innovations as high-performance steel composites, specialized concrete mix designs, impact-resistant glass, and massive stabilizing dampers.

Cleverness of another sort is in evidence when there is a *very close integration of several technical systems, or when the overall form of a building is driven by a technical concept.* The extremely low-load case study buildings are the best exemplars of close integration – enclosure systems and active climate control systems, in all cases, are conceived as a unified whole. Notable examples are found in the work of Transsolar (Thieffelder, 2003), and of KPMB Architects at Manitoba Hydro (Chodikoff, 2006). A few additional examples are shown in Figure 2.4.8a & b.

Figure 2.4.7 c (top)
Non-rectilinear forms at the Kunsthaus in Graz

dubbed "the curious mutant bagpipe" (Cook and Fournier, image from Slessor 2003)

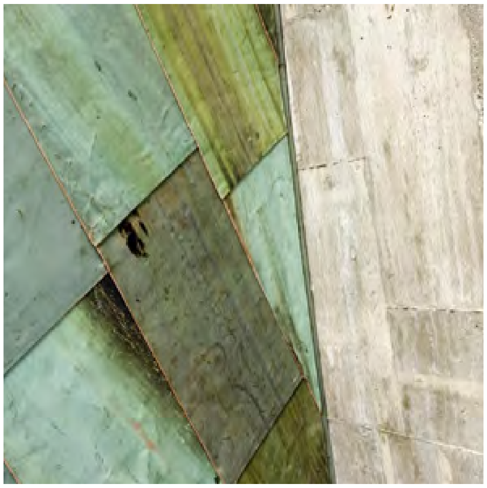


Figure 2.4.7 d
Reclaimed materials - at the Canadian War Museum

(Moriyama & Teshima and Griffith Rankin Cook Architects in Joint Venture, image from mtarch.com)

Figure 2.4.8 a (top)
Cleverness = integration at the Chapel of St. Ignatius at Seattle University

(Holl, 1997)

Figure 2.4.8
Structural innovation at the Canadian Pavilion at Expo ‘67 in Montreal

(Ashworth, Robbie, Vaughan & William, Schoeler & Barkham, Stankiewicz; image from Milne 1967)

It is very satisfying to a designer to spend her days *inventing* (and to see her innovations made real). Yet, from the perspective of a “normal” (non-designing) person, this sort of cleverness is enticing, only for a short while - because of its newness. Once the innovation is understood, it becomes a commonplace. Also, there are many very satisfying buildings that are not very “clever”, in any of the senses defined here. If a building is only clever - and not meaningful or enjoyable - its “satisfactoriness” will be minimal, at worst, or fleeting, at best.

Condition #5: Natural
Five design ideas from other fields

On the assumption that certain thought processes might be universal to all types of “sustainable” projects, a comparative review was made of the thoughts of nine authors, who often are quoted in “green” literature. Emanating from disparate parts of the world, this group includes farmers, educators, research scientists, and a chef, as well as designers. All of the authors were engaged, during the last third of the 20th century, as active participants in projects that aimed to lower environmental loads, while satisfying community needs. In studying their reflective writing, five challenging questions were discovered, that were part of the thought process in most of the projects. In an earlier essay, instances of asking each question were identified, the outcomes of asking them were described, and the possibility of applying them to the architectural design process was considered (Ross 2006). The following is a brief synopsis of what the questions imply, and the extreme conditions with respect to each question are exemplified in Figure 2.4.10.

The first “Natural-ness” question, *“what does this place require us to do?”* was posed in an essay entitled *“Nature as Measure”* (Berry 1990). It has two additional parts: *“what does it (this place) allow us to do?”* and *“what does it help us to do?”* This question underpins most credible yardsticks of sustainable design, and is invoked regularly in the literature of “green” philosophy (e.g. Pollan 2001, Hawken et. al. 1999, McDonough 2002). Within architecture and beyond, it addresses the “fit” between a human creation and the natural systems within which the work is situated. In the literature, in human enterprises as diverse as the cultivation of potatoes in the Andean altiplano and the redevelopment of urban brownfields in North American cities, this question is raised as a test of whether a project "fits" its natural context. The question also is at the root of the concept "feedforward", through which designers are challenged to ask themselves questions about the impact of their decisions upon the future of a natural system. One such question, applied to the design of a detergent for household use – bearing in mind the direction of the effluents - would be "what kind of soap does the river want?" (McDonough, 2002)

An example of this kind of questioning may be seen in Mies van der Rohe's Barcelona Pavilion. The architect applied his preferred aesthetic to design, and also he recognized that he was working in a hotter climate than usual. He added deep overhangs for shade and a pool of water, to provide respite. Perhaps Mies asked these first three questions, as part of his design process. However, his imitators do not appear to have done likewise - imposing glass boxes on Caribbean islands and air-conditioned towers on the deserts of Dubai (see Figure 2.4.9a). The early Corbusian ideal of a standardized architecture, equally applicable in any climate, arose from a way of thinking that is exactly antithetical to the approach suggested by this first question (Fernandez-Galiano, 2000).

The life work of the Egyptian architect Hassan Fathy also was centred on this question. Fathy's mud-brick designs – and his scheme for realizing them in Egyptian peasant communities, were in and of their place (see Figure 2.4.9b). The issue is not old-style vs. au-courant (mud vs. steel). Rather, it is about understanding the endemic instead of importing the surface-image of the exotic (Fathy 1973). There is a potential link between this question and each of the other tests of "satisfactoriness" – particularly to belonging (meaningful), lifting the spirit (enjoyable), using daylight (beautiful), and integrating well (clever).

The second "Natural-ness" question, *"can a natural element gain an advantage, by satisfying human desires?"*

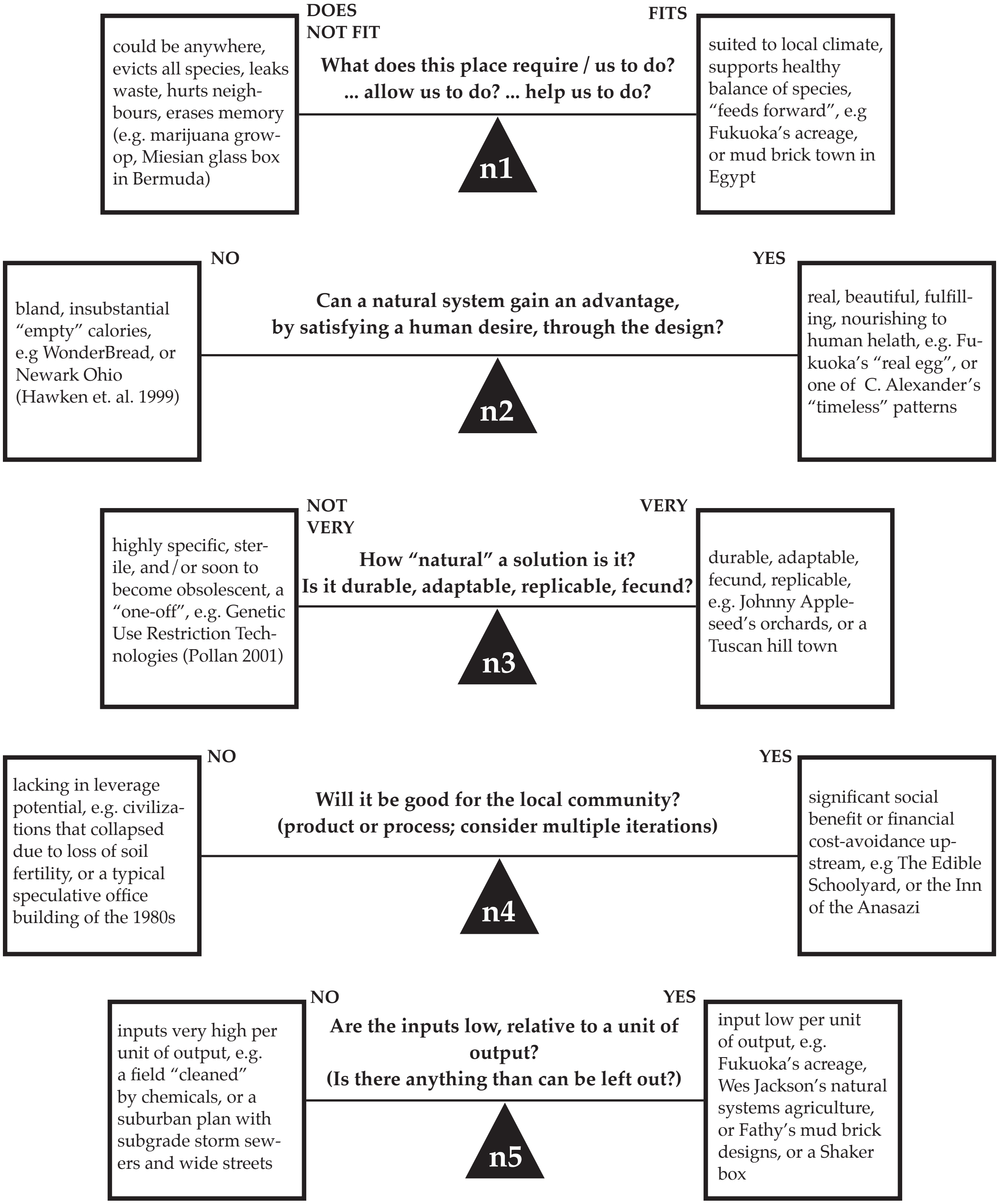
Figure 2.4.9 a (top) Skyscrapers on the desert of Dubai.

(image from The Nerdy Climate Guys at blog.climatsecurity.org 2 Aug. 2008)

Figure 2.4.9 b Asking "what does this place allow/help/need us to do?" - at New Gourna

(Fathy, image Chant Avedissian, from archnet.org, IHF0265, 27 July 2006)

Figure 2.4.10
Examples related to the questions in the "Naturalness" category of the QDQ



What does this place require / us to do? ... allow us to do? ... help us to do?

DOES NOT FIT: could be anywhere, evicts all species, leaks waste, hurts neighbours, erases memory (e.g. marijuana grow-op, Miesian glass box in Bermuda)

FITS: suited to local climate, supports healthy balance of species, "feeds forward", e.g Fukuoka's acreage, or mud brick town in Egypt

Can a natural system gain an advantage, by satisfying a human desire, through the design?

NO: bland, insubstantial "empty" calories, e.g WonderBread, or Newark Ohio (Hawken et. al. 1999)

YES: real, beautiful, fulfilling, nourishing to human helath, e.g. Fukuoka's "real egg", or one of C. Alexander's "timeless" patterns

How "natural" a solution is it? Is it durable, adaptable, replicable, fecund?

NOT VERY: highly specific, sterile, and/or soon to become obsolescent, a "one-off", e.g. Genetic Use Restriction Technologies (Pollan 2001)

VERY: durable, adaptable, fecund, replicable, e.g. Johnny Appleseed's orchards, or a Tuscan hill town

Will it be good for the local community? (product or process; consider multiple iterations)

NO: lacking in leverage potential, e.g. civilizations that collapsed due to loss of soil fertility, or a typical speculative office building of the 1980s

YES: significant social benefit or financial cost-avoidance upstream, e.g The Edible Schoolyard, or the Inn of the Anasazi

Are the inputs low, relative to a unit of output? (Is there anything than can be left out?)

NO: inputs very high per unit of output, e.g. a field "cleaned" by chemicals, or a suburban plan with subgrade storm sewers and wide streets

YES: input low per unit of output, e.g. Fukuoka's acreage, Wes Jackson's natural systems agriculture, or Fathy's mud brick designs, or a Shaker box was posed in "The Botany of Desire" (Pollan 2001), and it is a strong inspiration for this study. In this series of essays, four plant species are depicted as having gained - not lost - by adapting to satisfy fundamental human desires. The apple, it is said, satisfies the desire for sweetness, the tulip for beauty, marijuana for intoxication, and the potato for control. Thirty years before Pollan's book was conceived, and halfway around the world, this second question was at the root of the life work of a rice farmer and philosopher Masanobu Fukuoka (1978). In *"The One Straw Revolution"*, Fukuoka tells the story of his success in realizing yields equivalent to those on "modern" farms, but using "natural" methods. As it applies to food, either Pollan or Fukuoka might re-phrase this question as "how tasty AND nutritious is it?" Makers of pre-packaged "cardboard" sandwiches clearly do not ask this question. Children who learn to grow, prepare, and share their own food, in the middle-school program at Alice Waters' Edible Schoolyard clearly do (Waters 2005). This question also may be linked to the other tests of "satisfactoriness" – particularly future vision (meaningful), caring (enjoyable), and contemporary sensibilities (beauty).

The third "Natural-ness" question, *"how would nature solve this problem?"* was posed in *Biomimicry* (Benyus 1997). Masanobu Fukuoka also asked this, as he turned away from modern theories of agriculture, even though he had considerable scientific training. In agriculture, it is beginning to be clear that the settled rural landscape of the American Midwest (now largely eroded) was more likely to be "sustainable" – over the very long term – than the current mono-cultural practices associated with large-scale "factory farms". In the work of the Land Institute - to re-discover practices that preserve topsoil and yield a reasonable harvest - the third question is conspicuous (Berry 1992, Hawken et. al. 1999).

In architecture, the decisions that lead to the very-long-term durability of, for instance, the Roman Coliseum, are much less well understood. McDonough proposes starting with an examination of materials manufacturing to encourage infinite re-usability. And Stewart Brand (1994) also makes a strong case that architects should learn more about how the use of their designs evolves over time. Whether a design solution is “natural” (i.e. replicable, adaptable, durable, and fecund) could be the subject of an extensive, separate study. For the purpose of the present research, this question will focus on durability, and – because the case study buildings all have been constructed since the year 2000 – the answers can only be highly speculative.

The fourth “Natural-ness” question, *“is the proposal good for the community?”* is called “the Amish question” by Wendell Berry. In the essays that comprise *“Sex, Economy, Freedom and Community”,* this question is explored in relation to matters as diverse as commerce, education, war, private and public morality, and land stewardship (Berry 1992). If one were to appraise Waters’ project at the *Edible Schoolyard,* the answer to this question would be a resounding “Yes, clearly”. By introducing the experience of managing a garden and cooking together, into a middle-school curriculum, children are given a “primary course in civility” - that has reached out to include entire families, encouraging more frequent eating together at home.

An architect who holds urban design considerations in high priority addresses the question of community benefit. The diverse issues associated with this question are raised by Wendell Berry, by chef-philanthropist Waters, and by the economist Hunter Lovins. The community benefits of a design may not be limited to issues of land-use, building form, and traffic patterns. The perpetuation of cultural heritage and the revitalization of local economies are goals into which a particular architectural approach might contribute. A clear example of success, in relation to this question, is the Inn of the Anasazi, a project which “redefines real estate development as more of an art ... that can actively rebuild community” (Hawken et. al. 1999).

The last question, *“are the inputs low, for a given amount of output?”* is worded carefully to include more than a simplistic “efficiency” question - it includes a renewed emphasis on “effectiveness”. For instance, in the so-called “clean” field of Idaho potatoes, described by Pollan, the chemical inputs cost just pennies less than the sale price of the crop. There, the answer will be “No, not really”. In contrast, at Village Homes, in Davis California, described by Hawken et. al., the approach to community planning was efficient in saving construction costs and boosting real estate values, while it also was effective in creating a very enjoyable place for children to grow up (1999). There, the answer to this last “naturalness” question is “Yes, clearly”.

As explained in Chapter 2, in architecture, operating energy is the environmental load that is largest, easiest to measure, and most closely associated with greenhouse gas emissions. Therefore, it is the input of primary interest, in appraising the case study designs. Because it is an ever-present concern in civic projects, capital cost inputs also are recorded.

The conditions of a "satisfying" design

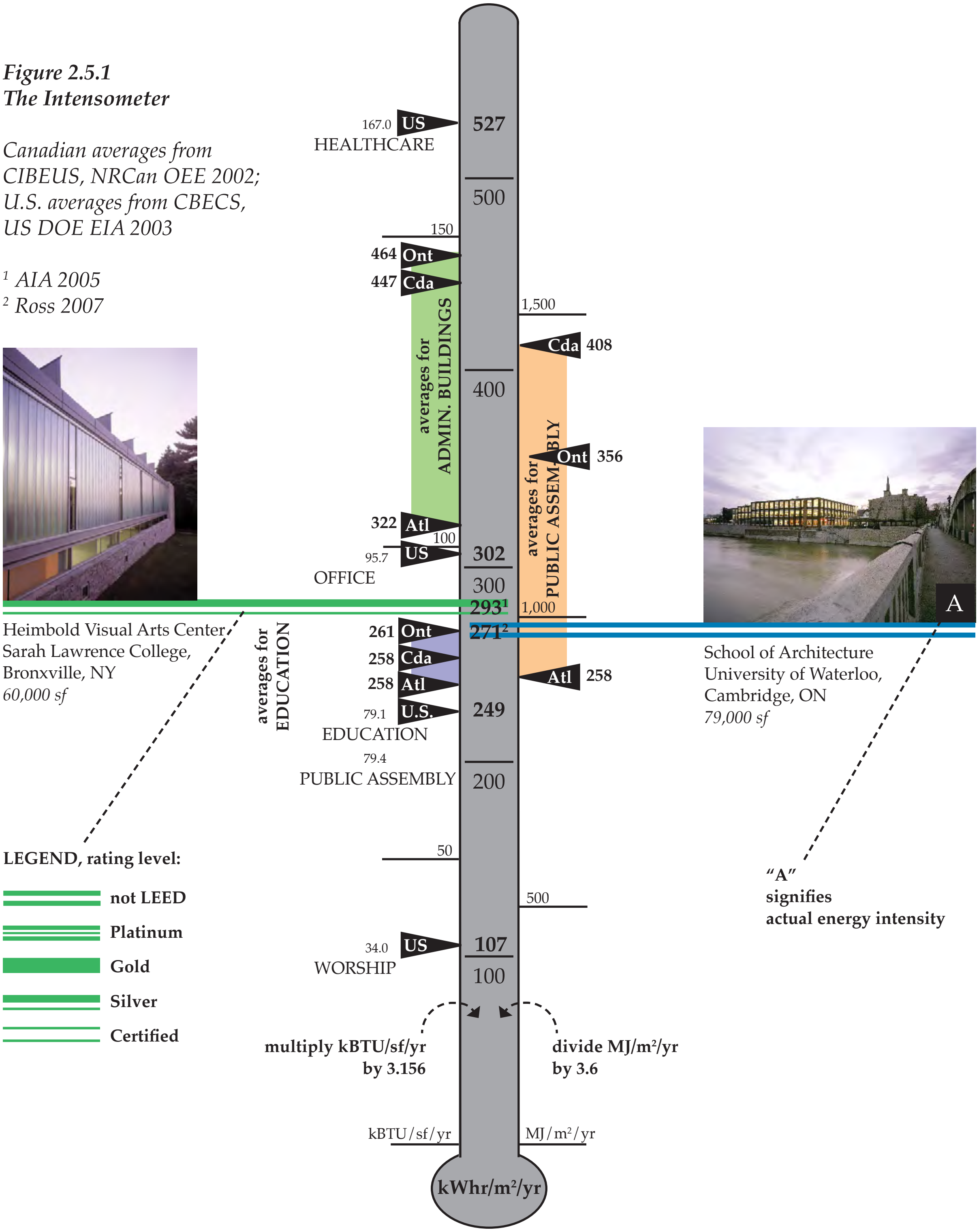
The "artful, elegant frugality" of a Shaker box is an emblem for success in relation to both low load and high satisfaction. Elevating satisfactoriness, in a civic building, always has required a design that is meaningful, enjoyable, beautiful and clever. Now that environmental sustainability is coming to the fore, a "satisfying design" also must fit its environment, offer a "win-win" for natural systems and natural human desires, be durable, give support to the surrounding community, and run on dramatically lowered energy inputs.

The questions in the QDQ are posed to help appraise several designs in a consistent manner. In Chapter 4, the questions in the QDQ are posed, during a visit to the seven, to show the fine gradations of success. Each was selected because it offers evidence of significantly lowered loads as well as compelling reports about the satisfaction of other, important needs of a human community. And each shows an inspiring range of design responses to this rather ambitious list of expectations.

Figure 2.5.1
The Intensometer

Canadian averages from CIBEUS, NRCan OEE 2002; U.S. averages from CBECS, US DOE EIA 2003

[1] AIA 2005
[2] Ross 2007



2.5 COMPARING PERFORMANCE, USING THE INTENSOMETER

This instrument, conceived as part of this study, expresses “absolute energy intensity”, giving architects a frame of reference about energy use in buildings. The advantages of measuring “absolute energy intensity” rather than relative intensity (“per-cent-better-than”) are discussed in detail in Section 3.2.

Figure 2.5.1 shows an Intensometer, for cold-climate, non-residential buildings. Along the vertical axis, three sets of units are aligned to form a conversion scale. The part-metric, part-imperial hybrid, kWhr/m^2/year, is chosen as the main reference unit in this study because it facilitates quick conversion from the other two units, and it is very easy to relate to the utility bills generated in most places in North America.

This Intensometer shows the range of average energy intensities, for three categories of occupancy – administration, public assembly, and education buildings. Statistical surveys provided the data for the occupancy types and regions relevant to this study (NRCan OEE 2002). The cases studies here are in locations where the total degree day figure (18 C basis) is no less than 3,562 and no more than 4,534. Therefore, no attempt is made to adjust the data on the Intensometer to a common location; retention of the original data is preferred.

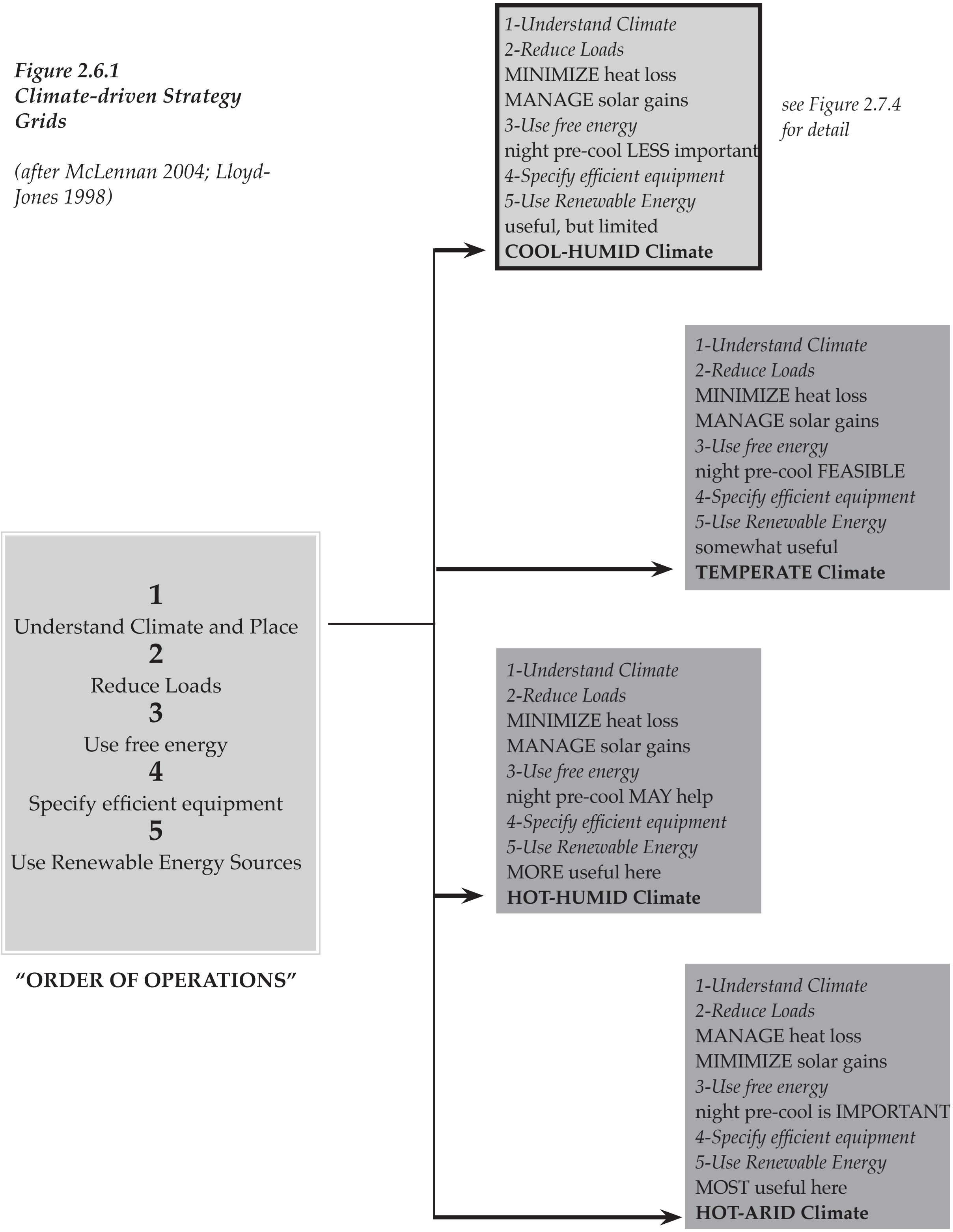
In Chapter 4, several Intensometers present comparisons of the energy use of the case study buildings. Projects that have attained LEED certification are always entered on the left side, with their level (Platinum, Gold, Silver, or Certified) indicated by the type of line under each photo (see Legend in Figure 2.5.1). Non-LEED projects are entered on the right side. Wherever possible, actual energy use is reported, and tagged with the letter “A”.

Each time information about a building is placed in this frame of reference, a designer has the opportunity to gain in understanding. To give a fair comparison, each Intensometer that is compiled in the future should be restricted to one climate zone, and buildings of similar use. The floor areas should be shown, to support further inquiry as to whether the overall size of a building skews the data to a significant degree. Knowing the whole-building energy intensity is the first step in “getting the beat” with respect to energy flow within a design.

Intensometer

Figure 2.6.1
Climate-driven Strategy Grids

(after McLennan 2004; Lloyd-Jones 1998)



see Figure 2.7.4 for detail

2.6 LISTING BEST PRACTICES: THE STRATEGY GRID

The third instrument helps to keep track of the strategies, operations, and tactics that reduce the energy-intensity of a design. The Cool-Climate Strategy Grid was initiated and developed as part of this study, and it is built upon a foundation that has been established in the literature (see Figure 2.6.1).

The Strategy Grid builds on an argument contained in *The Philosophy of Sustainable Design*, about the relative emphasis in the most effective designs. The architect Jason McLennan draws an analogy between architectural design and a mathematical equation, arguing that, in both cases, the order in which the solution is reached determines the degree of success. He states:

> *"Sustainable design has its own order of operations in order to be effective. Without this hitherto unwritten order of operations, the cost of implementing the strategies increases and the effectiveness of the strategies decreases. In some cases, by ignoring the order of operations the result can often do more harm than good."* (McLennan 2004)

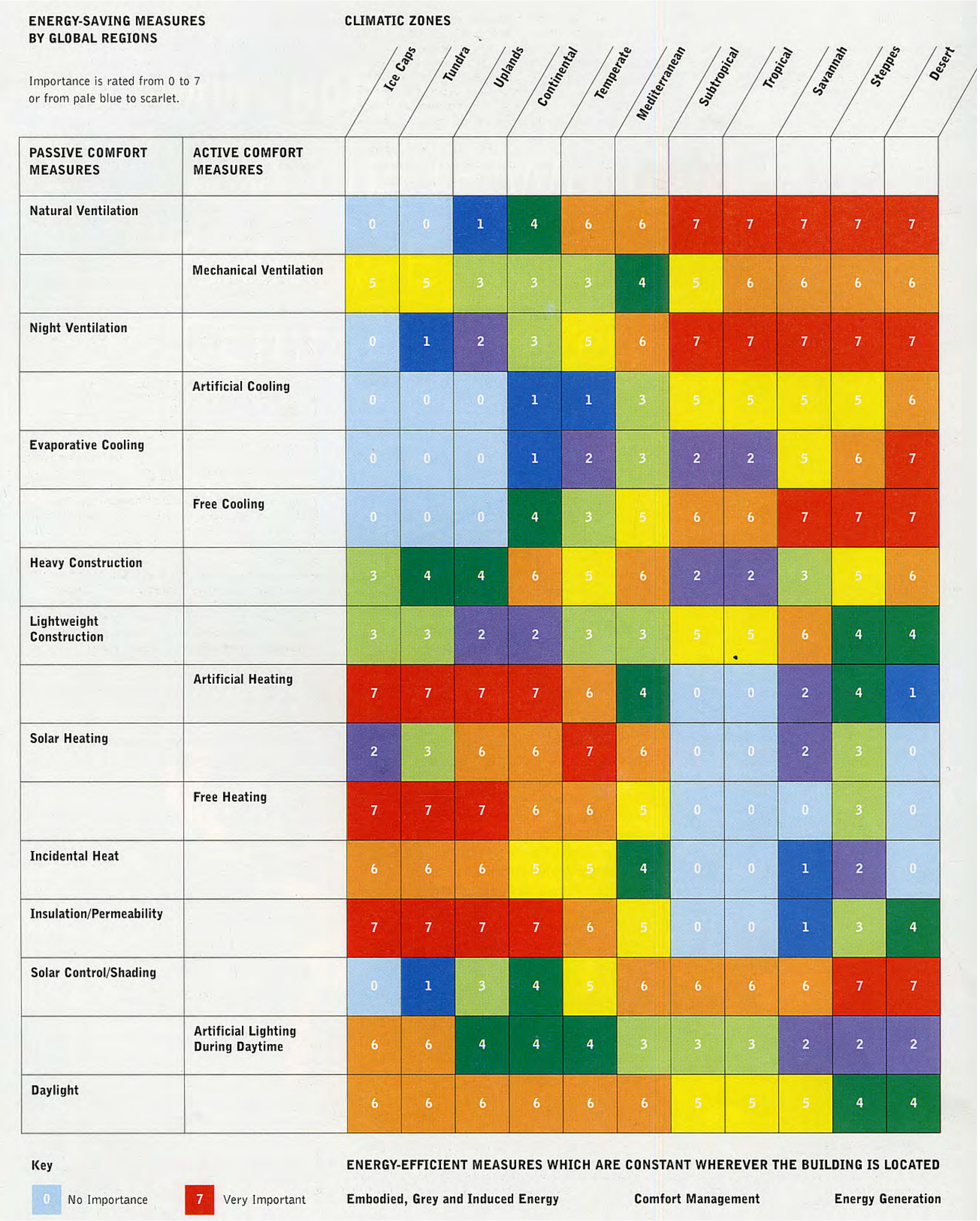
Figure 2.6.1 begins, on the left side, by showing the four categories defined by McLennan, plus a fifth that has been added here. On the right side is an outline showing how McLennan's steps might be tailored to various North American climates. Any of these outlines could be composed as a full "Strategy Grid" to suit a particular zone. Here, the relative potential of heating, night pre-cooling, and use of renewable energy sources is reflected within the conceptual framework so far proposed.

Strategy Grid

The bioclimatic design approach - a brief history
McLennan's "Order of Operations" harkens back to an earlier, somewhat different way of categorizing design strategies, in relation to climate, that first appeared in *Architecture and the Environment, Bioclimatic Building Design*, in which a limited number of energy-saving measures are prioritized in chart form, according to the

Figure 2.6.2
Design priorities for various climates

(from Lloyd-Jones 1998)



ENERGY-SAVING MEASURES BY GLOBAL REGIONS

Importance is rated from 0 to 7
or from pale blue to scarlet.

CLIMATIC ZONES

PASSIVE COMFORT MEASURES	ACTIVE COMFORT MEASURES	Ice Caps	Tundra	Uplands	Continental	Temperate	Mediterranean	Subtropical	Tropical	Savannah	Steppes	Desert
Natural Ventilation		0	0	1	4	6	6	7	7	7	7	7
	Mechanical Ventilation	5	5	3	3	3	4	5	6	6	6	6
Night Ventilation		0	1	2	3	5	6	7	7	7	7	7
	Artificial Cooling	0	0	0	1	1	3	5	5	5	5	6
Evaporative Cooling		0	0	0	1	2	3	2	2	5	6	7
	Free Cooling	0	0	0	4	3	5	6	6	7	7	7
Heavy Construction		3	4	4	6	5	6	2	2	3	5	6
Lightweight Construction		3	3	2	2	3	3	5	5	6	4	4
	Artificial Heating	7	7	7	7	6	4	0	0	2	4	1
Solar Heating		2	3	6	6	7	6	0	0	2	3	0
	Free Heating	7	7	7	6	6	5	0	0	0	3	0
Incidental Heat		6	6	6	5	5	4	0	0	1	2	0
Insulation/Permeability		7	7	7	7	6	5	0	0	1	3	4
Solar Control/Shading		0	1	3	4	5	6	6	6	6	7	7
	Artificial Lighting During Daytime	6	6	4	4	4	3	3	3	2	2	2
Daylight		6	6	6	6	6	6	5	5	5	4	4

Key

0 No Importance

7 Very Important

ENERGY-EFFICIENT MEASURES WHICH ARE CONSTANT WHEREVER THE BUILDING IS LOCATED

Embodied, Grey and Induced Energy **Comfort Management** **Energy Generation**

demands of each climactic zone (Lloyd Jones, 1998). The summary chart from this earlier study is presented in Figure 2.6.2. *

According to Lloyd Jones' system, the Great Lakes Basin falls within the zone labeled "Continental". Therefore, the design strategies for this climate, listed from highest priority (7) to lowest priority (1), are as follows:

- 7: artificial heating, insulation
- 6: heavy construction, solar heating, free heating, daylight
- 5: incidental heat (that may be captured from processes in or on a building)
- 4: natural ventilation, solar control/shading, "free cooling" (e.g. pumped heat exchange with aquifer), artificial lighting (efficiency and controls)
- 3: mechanical ventilation, night ventilation,
- 2: lightweight construction,
- 1: artificial cooling, evaporative cooling

Lloyd-Jones attempts to draw attention to architectural strategies by distinguishing "passive" from "active" measures. However, strategies such as building shape and orientation are mentioned only parenthetically. The depth of a floor plate and the height of a storey is noted as having a role with respect to natural ventilation, and the overall building orientation is noted under "solar heating". Both are given a medium level of importance in the "Continental" climate. Tactics related to the enclosure are not specified in great detail; the reference is only to "solar control/shading". Lloyd-Jones does not break this down into window-to-wall ratio, orientation of glass, or the properties of glass; such details are left up to the reader.

Lloyd-Jones' chart has been reproduced widely (UNEP 2007; Yeang 2006), and the general thrust of its message is an important one. Also, the systems

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* Lloyd Jones focusses on mid- to large-scale buildings, of both non-residential and residential type, and most of the cases presented are between 20,000 and 150,000 sf in gross floor area.

Figure 2.6.3
Design priorities for a single-family house in various North American climates

(Olgyay 1961, 126-152)

	Cool Minneapolis		**Temperate New York**		**Hot-arid Phoenix**		**Hot-humid Miami**	
optimum plan aspect ratio	1: 1.1		1: 1.6		1: 1.3		1: 1.7	
window-to-wall ratio S,N	51%	10%	43%	9%	38%	6%	33%	33%
window-to-wall ratio E,W	11%	11%	13%	13%	32%	8%	0%	0%
Design Measure / order of priority / importance over the year:								
less air infiltration	1	28%	3	23%	2	19%	3	7%
less heat transfer of glass	2	24%	4	18%	-	-	-	-
building orientation	3	22%	1	27%	4	11%	-	-
shading of glass surface	4	22%	2	27%	1	46%	1	64%
roof ventilation	5	2%	5	3%	3	*	-	-
shading of wall surfaces	6	2%	6	2%	5	7%	5	4%
venting appliances	7	-1%	7	-3%	6	6%	4	5%
roof construction	-	-	-	-	3	14%	2	20%
Dominant loads:	temperature				solar		radiation	

for organizing ideas that are proposed by McLennan and Lloyd-Jones are very useful in expressing design operations as higher-order goals, distinct from the numerous ways they may be reached. However, one might argue with some of the recommendations in Lloyd-Jones, such as the low priority put on mechanical ventilation, and the implication that natural ventilation and night pre-cooling might preclude the need for artificial cooling in the “Great Lakes” version of the “Continental” climate.

Like McLennan and Lloyd-Jones, Olgyay tried to prioritize the strategies used to “balance” his house designs, as shown in Figure 2.6.3. Building orientation is listed as priority #1 in the temperate climate (New York), but this is not so in other zones. In all zones, plan aspect ratio and window-to-wall ratio are presented as essential to the “balanced” design solution. Olgyay emphasized the principle that different stresses are placed on structures, depending upon regional thermal and solar variations, saying:

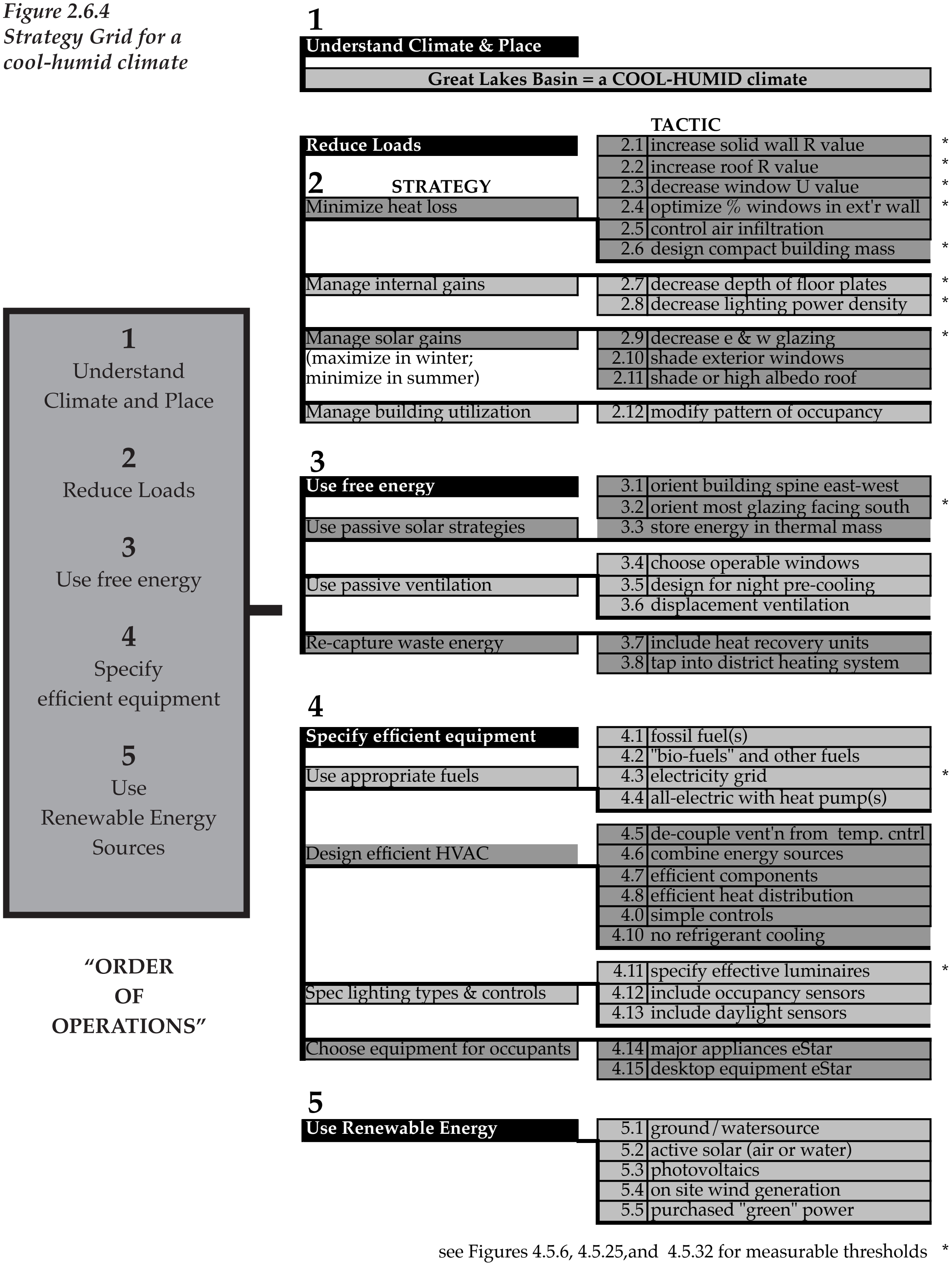
> *“The relative importance of the regional thermal stresses must be clarified to show the part they play in shaping a structure. General low temperature tends to press buildings into a compact form, and heavy radiation impacts tend to elongate the shapes, mostly in the east-west direction.” (87)*

Olgyay discussed, but did not demonstrate the regional effects on large building shapes, and concluded that:

> *“… in the cool zone, closed compact forms are preferable and elongated unilateral (“through”) buildings are not advantageous … in temperate zone, shapes on the east-west axis are preferable … in hot-humid zone, buildings on the north-south axis receive greater penalty than they would in other zones” (90-91)*

Architect Ken Yeang also conveys a typology of design approaches and distinguishes very broad design approaches from specific tactics (2006). He speaks of “all-passive”, “mixed”, “full”, and “productive” modes.

Figure 2.6.4
Strategy Grid for a cool-humid climate



1
Understand
Climate and Place

2
Reduce Loads

3
Use free energy

4
Specify
efficient equipment

5
Use
Renewable Energy
Sources

“ORDER OF OPERATIONS”

1

Understand Climate & Place

Great Lakes Basin = a COOL-HUMID climate

2

Reduce Loads

STRATEGY	TACTIC		
Minimize heat loss	2.1	increase solid wall R value	*
	2.2	increase roof R value	*
	2.3	decrease window U value	*
	2.4	optimize % windows in ext'r wall	*
	2.5	control air infiltration	
	2.6	design compact building mass	*
Manage internal gains	2.7	decrease depth of floor plates	*
	2.8	decrease lighting power density	*
Manage solar gains (maximize in winter; minimize in summer)	2.9	decrease e & w glazing	*
	2.10	shade exterior windows	
	2.11	shade or high albedo roof	
Manage building utilization	2.12	modify pattern of occupancy	

3

Use free energy

Use passive solar strategies	3.1	orient building spine east-west	
	3.2	orient most glazing facing south	*
	3.3	store energy in thermal mass	
Use passive ventilation	3.4	choose operable windows	
	3.5	design for night pre-cooling	
	3.6	displacement ventilation	
Re-capture waste energy	3.7	include heat recovery units	
	3.8	tap into district heating system	

4

Specify efficient equipment

Use appropriate fuels	4.1	fossil fuel(s)	
	4.2	"bio-fuels" and other fuels	
	4.3	electricity grid	*
	4.4	all-electric with heat pump(s)	
Design efficient HVAC	4.5	de-couple vent'n from temp. cntrl	
	4.6	combine energy sources	
	4.7	efficient components	
	4.8	efficient heat distribution	
	4.0	simple controls	
	4.10	no refrigerant cooling	
Spec lighting types & controls	4.11	specify effective luminaires	*
	4.12	include occupancy sensors	
	4.13	include daylight sensors	
Choose equipment for occupants	4.14	major appliances eStar	
	4.15	desktop equipment eStar	

5

Use Renewable Energy

5.1	ground/watersource	
5.2	active solar (air or water)	
5.3	photovoltaics	
5.4	on site wind generation	
5.5	purchased "green" power	

see Figures 4.5.6, 4.5.25,and 4.5.32 for measurable thresholds *

Also, Yeang notes that most of his designs employ a combination of all four approaches, which he calls the "composite mode". Yeang's "all-passive mode" loosely corresponds to McLennan's "reduce loads" step. Yeang's "mixed mode" parallels McLennan's "Use free energy" step; Yeang's "full mode" relates to the selection of efficient equipment, which McLennan identifies as the fourth step in his "Order of Operations". Finally, Yeang's "productive mode" refers to the use of renewable energy.

Yeang discusses some tactics in relation to reliability, buildability, and maintenance requirements. He states that overall shape and plan aspect ratio matter a great deal in large buildings and, like Olgyay he refers repeatedly to the contrast between guidelines that apply near the equator and those that ought to be followed in higher latitudes (185-190). However, he does not list design priorities for a cool-humid climate.

Design priorities in a cool-humid climate

To combine what is established in this literature with observations of the case studies and knowledge from past practice, the Cool-humid Climate Strategy Grid for use in the Great Lakes Basin was developed in detail (see Figure 2.6.4).

This list places specific design strategies and tactics, applicable to this region, in relation to each of McLennan's operations which, on the left, make up the top level of the hierarchy. Strategies to accomplish each operation follow - such as minimize heat loss, or re-capture waste energy.

To realize any each of the strategies, there are several tactics that may be used – either alone, or in tandem. These tactics are shown in the right-hand column. For instance, minimizing heat loss might involve any, or all, of six tactics, from designing a compact building mass to specifying high-performance windows. In Section 4.5, one more level will be added, namely a list of alternative means, each of which constitutes the "stuff" applied when carrying out a particular tactic. This "stuff" will be observed in the Analysis of Case Studies. For instance, to shade exterior windows, one might specify glass with a low Shading Co-efficient, or use awnings, a tree or a nearby structure - or some combination of more than one kind of relevant “stuff”.

In The Strategy Grid, as in Yeang, “use renewable energy sources” comprises a separate category of strategic design approach. This distinguishes renewable energy, which is captured using mechanical devices, from “free energy”, which is defined, here, as energy that can be captured when it would otherwise be wasted. Employing renewable devices does not, in and of itself, cause a reduction in the amount of energy needed by a given design. Also, for reasons of cost and physical scale, renewable energy generation is only practical when all possible measures are taken to minimize the amount of energy required. (The role of renewables, and their correlation to very low energy loads, is well illustrated in the Analysis of Case Studies, in Chapter 4.)

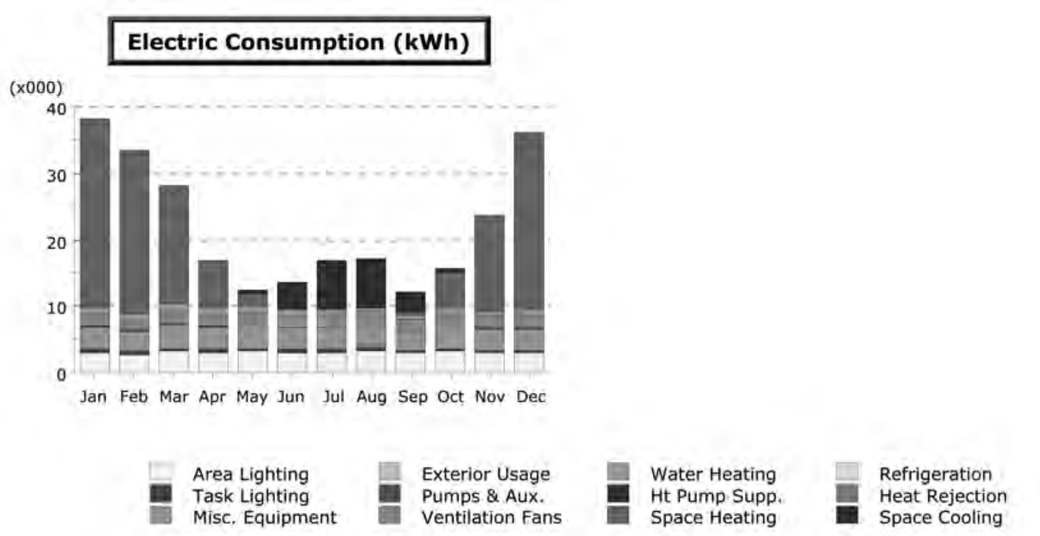
The Strategy Grid addresses a problem that is proliferating, as “green building” grows in popularity. Today, there is wide advocacy of certain tactics that have come to be associated with “green” or “sustainable” design - such as straw-bale construction, under-floor air distribution, exterior sunshades, and so on. These tactics may be presented outside the context of a whole design challenge, and it sometimes seems as though the presence of the tactic, by itself, is enough to define a design as “green”. Too often a lower-order tactic is promoted irrespective of climate, without reference to the higher-order goal. The tactics aren’t “wrong” – in an appropriate context, many of them can help to reduce one type of environmental load or another, to some degree. Yet, “green” tactics very often are adopted without knowledge of what the real effect on the overall energy use of the building will be. There is a growing number of buildings that employ “green tactics” with virtually no reduction in environmental load, as compared to their “non-green” counterparts (see Section 4.3).

In the Analysis of Case Studies (in Chapter 4), the Strategy Grid will be used to discover which operations designers have used most often, to best effect. In Chapter 5, the Strategy Grid will be used as a frame of reference in a discussion of the relative power of the fundamental parameters.

For a designer trying to chose among alternative approaches, it can help to organize incoming messages, including marketing claims. When appraising a design precedent, the Strategy Grid help to weigh where the emphasis in a design lies. In the Analysis of Case Studies, it is used to search for correlations between particular strategies and overall annual performance. In practice, the Strategy Grid may help to identify what is missing, or redundant, in a design. It also may help to communicate which elements of a design take greatest priority – to a client or the members of a consulting team.

Whenever a group of design strategies is placed within this frame of reference, a designer has the opportunity to see what may be missing or redundant, and to consider alternative or complementary strategies and tactics. Organizing the initiatives this way is one way of “setting the beat”, with respect to energy flow in a design.

Figure 2.7.1
Sample prediction of annual energy use, output from eQuest software



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.04	0.70	4.15	7.54	7.17	3.16	0.37	0.07	-	23.21
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	28.24	24.47	17.86	7.06	1.85	0.01	0.00	-	0.44	5.36	14.33	26.52	126.12
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	1.02	0.95	1.10	1.03	1.00	0.88	0.83	0.85	0.72	0.86	0.85	0.92	11.00
Vent. Fans	1.78	1.61	1.82	1.75	1.82	1.75	1.78	1.85	1.68	1.82	1.71	1.75	21.12
Pumps & Aux.	0.37	0.34	0.37	0.29	0.18	0.04	0.00	0.00	0.08	0.23	0.33	0.36	2.60
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	3.24	2.93	3.34	3.20	3.34	3.20	3.24	3.44	3.00	3.34	3.10	3.14	38.51
Task Lights	0.39	0.35	0.41	0.39	0.41	0.39	0.39	0.42	0.35	0.41	0.37	0.37	4.64
Area Lights	3.11	2.81	3.23	3.09	3.23	3.09	3.11	3.35	2.85	3.23	2.97	2.99	37.07
Total	38.15	33.46	28.12	16.86	12.53	13.51	16.90	17.09	12.28	15.60	23.73	36.04	264.27

2.7 SIMULATING ENERGY-FLOW USING eQUEST

This shareware predicts the annual energy use of a building; it can be used alongside design sketches, from the most schematic stage.* Inputs are made using a wizard that prompts choices of material assembly and climate control systems that are relevant to this study. As shown in the sample in Figure 2.7.1, results are displayed graphically with a breakdown of where energy is used on a monthly basis.

The eQuest software was chosen because it is easier to learn, though no less robust than alternatives such as EE4, Energy10, or Ecotect. Canada's EE4, and its American cousin DOE2, were designed to analyze large, complex buildings; however, detailed inputs, of the type that may not be available at the schematic stage, are required. The lack of a graphic interface also is rather unattractive to many architectural designers. Also, eQuest offers a wider array of architectural inputs, and greater transparency than the last the CBIP Screening Tool, and the MIT Design Advisor, which are both online tools.

The "Quick Energy Simulation Tool" (eQuest 3.0) relies on two decades of development of its more robust "parent", DOE2. "eQuest" also is transparent - allowing, for instance, checks on how the software calculates the effective thermal resistance of an enclosure system. It also allows testing of the consequences of using at least a few "green building" tactics, such as heat recovery ventilation and sunshades. The menu-driven framework in eQuest includes materials and equipment that are commonly used in the North American construction industry. It is quick to use and versatile, allowing numerous re-iterations, and its graphic interface, while simple, is re-assuring.

The eQuest software has a few important limitations. It does not model natural ventilation, or the use of renewable energy sources .Since these are not at the essence of the study question, this has not limited this research. More consequentially, eQuest does not yield an estimate of greenhouse gas emissions. However, this can be calculated, on the basis of the eQuest energy estimate, if the emissions at each energy source are known. This instrument is the principal tool used in the Study of Design Parameters.

eQuest

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* Available at http://www.doe2.com

2.8 SUMMARY OF THE APPROACH TO THE RESEARCH

The research approaches used here - to the Inquiry into Current Issues, to the Analysis of Case Studies, and to the Study of Design Parameters - have been informed by gaps in existing research.

This study will begin by inquiring into the recent discourse about "green design" in North America, presenting issues that are relevant to non-residential civic buildings. Issues to be explored include the potential of this portion of the overall building stock to help mitigate climate change, the need to lower loads while continuing to meet quality goals, the impact of the "new normal" on an architect's roles, and the utility of the current "green building" rating systems.

Considerable inspiration is made available to consulting architects and their clients by several existing collections of case studies. However, a deeper probe reveals a glaring lack of hard data with respect to the actual energy intensity of so-called "green" buildings. Also, the voices of the occupants who have experienced these buildings are nearly inaudible in the literature. The quality of the designs presented in the previous case studies should be high, and the environmental loads should be low - but the two are rarely discussed within one study. The studies that dwell on qualitative success tend to ignore quantitative measurement of energy use, and vice versa - surprising, given the claims that green buildings offer greater support to occupant health and productivity than "non-green" buildings (see Section 2.2).

To address the deficiencies in previous case studies, the Analysis of Case Studies involves both quantitative and qualitative appraisals. The diverse qualities that provide satisfaction in each design are discussed in terms of the QDQs – including meaningfulness, enjoyability, beauty, cleverness, and naturalness. The energy use is then documented, on the Intensometer. After a first-hand experience of selected cases, this analysis highlights the issues in aiming to achieve excellence with respect to both energy use and design quality.

In Section 2.3, a review of "energy studies", including both "optimization studies" and "how-to" design manuals, has shown how little research attention has been directed, to date, to non-residential buildings. Also, a pre-occupation with the physical components of a building has distracted the discourse away from the search for an optimum architecture. Step-by-step "how-to" manuals", that assist during the late stages of design development, when refining particular element, dominate this literature. Yet very little exists to advance the architect's understanding at the outset, of the consequences arising from "how the cards are dealt" by the overall design approach.

To address the gaps in the current "energy studies", the Study of Design Parameters will involve calculating the whole-building annual energy use of a series of designs. A simple office building serves as a test case, in which the fundamental parameters are modified, step-by-step. Recent advancements in desktop computing software have placed the necessary tools in the hands of the researcher, so that the impact of the earliest decisions may be better understood. This analysis will yield a clear picture of the relative power of the primary, project-defining architectural choices, such as building form (or "massing"), orientation, and skin specification.

The Analysis of Case Studies, presented in Chapter 4, and the Study of Design Parameters, presented in Chapter 5, are complementary to one another. The former provides information about the range of design approaches and the degree of success that can be accomplished, by an architect, and it identifies the issues when "low-load" objectives meet "high-satisfaction" goals. However, it does not answer the question of which design parameter is most powerful. The latter exercise lacks what the former provides in rich design detail. However, it compensates for what the former lacks - by yielding relatively high-fidelity measurements of the effect of certain key choices on whole-building energy use.

The instruments used in this research draw on existing concepts, and elaborate with details that are currently lacking in the literature. The Questions of Design Quality, the Intensometer, and the Strategy Grid are complementary to one another, adaptable to climates beyond the Great Lakes Basin, and ready to be applied in future research, or in future practice (see Sections 2.5 through 2.7).

In his Chapter, the methods and tools used throughout the study have been introduced. Later chapters will present practical and technical conclusions about how much an architect can do to lower the primary loads that a civic building imposes on the natural environment. But the study begins with an in-depth inquiry into more theoretical foundation of a "new normal" in architectural design.

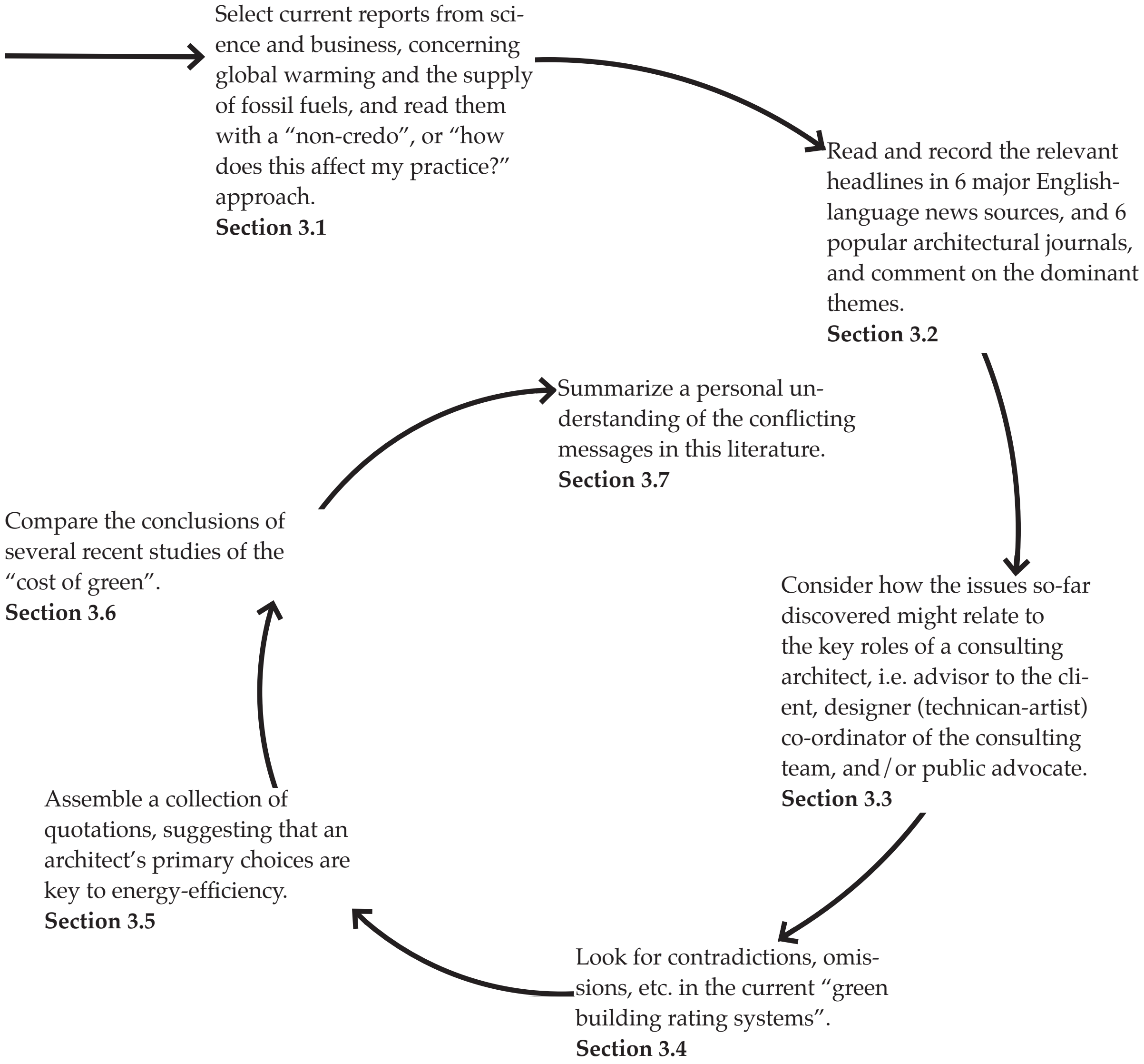
3

A PRACTITIONER’S INQUIRY into the CURRENT ISSUES

3.0 THEORY:
HOW MUCH CHANGE? ... HOW FAST?

From the ice cores taken in the high Arctic, to the pollution effects experienced in settlements around the Great Lakes Basin, the environmental loads emanating from late 20th-century human activity were evident, by the time this study began. During the study period, the public discourse in Canada and the U.S. included regular acknowledgement that these loads were rebounding to the detriment of human society. Yet the deluge of information - about issues such as “global warming”, the future cost of energy, and “sustainability” in general - included many conflicting messages. Thoughtful citizens, including architects, wondered how much action to take, and with what degree of urgency.

Figure 3.0.1
Inquiry into the current issues - flow diagram



Select current reports from science and business, concerning global warming and the supply of fossil fuels, and read them with a "non-credo", or "how does this affect my practice?" approach.
Section 3.1

Read and record the relevant headlines in 6 major English-language news sources, and 6 popular architectural journals, and comment on the dominant themes.
Section 3.2

Consider how the issues so-far discovered might relate to the key roles of a consulting architect, i.e. advisor to the client, designer (technican-artist) co-ordinator of the consulting team, and/or public advocate.
Section 3.3

Look for contradictions, omissions, etc. in the current "green building rating systems".
Section 3.4

Assemble a collection of quotations, suggesting that an architect's primary choices are key to energy-efficiency.
Section 3.5

Compare the conclusions of several recent studies of the "cost of green".
Section 3.6

Summarize a personal understanding of the conflicting messages in this literature.
Section 3.7

The need for a “new normal” in architectural design is assumed in this study. In Figure 3.0.1, several fields of inquiry are identified. Each might be the subject of extended research, and the progression from one to the other is not linear. Through the essays in this section, the researcher has organized diverse opinions in the literature, in many instances carving a “middle path”, between extremes.

In Section 3.1, the research takes an objective stance, and inquires whether the current, widespread and dire predictions of global environmental decline truly warrant a profound change in the design of civic buildings in the Great Lakes Basin. This is not an in-depth, critical analysis of the climate science and the reports of fossil-fuel explorers – for that would surpass the expertise of the practicing architect who has embarked on this research project. However, an inquisitive, open-minded reading of the relevant public reports allows one to come to such conclusions as any informed citizen may.

This review provides a grounding in the fundamentals, as currently understood, that is intended to help an architect who offers advice to the public. It should help one who continues to watch the evolving reportage to ask better questions, and to discern the substantive from the merely rhetorical. Also, it may help the designer to envision, with greater clarity, what one hopes to see in the future, and what one wishes to work towards.

The “new normal” in architecture is defined, in this study, as both “low-environmental-load” and “high-satisfaction”. Section 3.2 presents samples of the words of architects, and others, who support this preference. A content review of selected architectural journals, and another of six major English-language news services is used to outline trends in the debate - both within the profession, and in the wider public discourse.

“Low-load” is defined as energy-efficient and, therefore, low-emission. Operating energy is established as the focus of this study. “Net-zero” or “near-zero” may be the ultimate goal. However, from an architect’s perspective, there is a problem with “zero”. In the Questions of Design Quality (QDQ), “high-satisfaction” is defined as meaningful, enjoyable, beautiful, clever, and natural. Several designers advocate an approach that “dissolves compartments” - working to achieve both “low load” and “high-satisfaction”.

Section 3.3 offers background concerning the potential effects on practice, asking what aspects of an architect’s professional role are at issue, in the shift to a “new normal”. As advisor to the client, co-ordinator of the consulting team, technician, artist, and public advocate, an architect will need specific information and new skills, in order to do this work effectively. A few studies have tried to assess the gap between the knowledge that architects currently possess and the increasing expectations of a public that is gaining in awareness of environmental issues. Some caution that the current stage of rapid change is a very risky one, and that this is an area in which a consultant's words and actions easily may run afoul of reality, or of a client's expectations - or both.

In Section 3.4, the research takes a more detailed approach to determine whether the green building rating systems, as currently constituted, help an architect attest to the environmental impacts of a design. Architects in practice, and their clients, are trying out instruments that purport to appraise whether a design is "better-than-normal" or "green". In many cases, the drive to attain a rating is a client demand - and in only some cases does the client truly comprehend what it is demanding. These rating systems are relatively new; some measure energy use, some try to measure "whole building design" and some refer to "leadership". Here, the question is, how effective, really, are they?

Section 3.5 contains a very brief look at what is said about the way the architect "deals the cards" during the schematic design stage. Several clippings from the background literature are collected, to show that a general sense is emerging, in the literature, that wise choices with respect to building shape, orientation of a building to the sun, and skin design are essential to the realization of a "low-load" building. The veracity of these statements will be tested through this research.

Finally, in consulting practice, there is the persistent question of what might a "new normal" cost? In Section 3.6, a comparison of the conclusions from the major North American studies shows a range of opinion on the subject. One architect, with long experience in "green" design, proposes a way to identify the particular factors that influence the capital cost of a "green" design, as distinct from the factors that are at work with respect to any design.

This chapter records key ideas about climate change, and energy scarcity, in relation to architectural design. This background is presented in light of questions that a practicing architect may have – about the science, the potential of the profession, the instruments that might be used, and the approaches that might be taken, during the schematic design stage – toward the realization of a "low-load + high satisfaction" architecture.

3.1 THE NEED FOR A "NEW NORMAL"

An understanding of the issues related to the combustion of fossil-fuels in buildings - and the resultant climate change impacts – is a necessary foundation for anyone concerned with the environmental loads imposed by a building. Designers in the cool-humid climates that are the focus of this study, have, to date, assumed that combustion is necessary to achieve comfortable shelter, particularly in the winter. The challenges posed by increasing concentrations of greenhouse gas emissions and narrowing access to fossil-fuel resources were identified in scientific studies as early as 1983. As more people feel ready to discuss them, it is useful for an architect to contemplate what the current science actually says – that is, to be clear about where reasonable certainty is established, and where questions remain.

This section will show that, at the dawn of the 21st century, the worldwide rate of combustion caused grave concern to the scientific community. The North American building sector had been a major contributor to the total combustion tally, for decades. Scientific and economic analysts issued the building sector a challenge, to reduce combustion to a "new normal" level, in order to contribute to the mitigation of climate change. Given the magnitude of the gap to be overcome, it follows that, as a matter of everyday practice, each new opportunity to build ought to be approached with an understanding of how much combustion a design will require, and the related environmental effects.

Hitting the wall: climate change and energy scarcity

The idea that human activity is causing the climate to change has reached a level of acceptance in the general public discourse. In extensive scientific study, the observable effects have included: increased global average air and water temperatures, a rising sea level and widespread melting of ice and snow. Local effects - varying in type and severity from one region to another - include changes in the rate of precipitation, the frequency of extreme heat waves, and in the number and severity of storms.

Although skeptical voices continue to debate the causes, the evidence on every continent shows changes in a host of natural systems – for instance, the decline in water quality in warming rivers and lakes, the pole-ward shift in the range of plant and animal species, and the increased instability of thawing ground in polar regions. There is some evidence that additional effects are emerging in particular regions – including heat-related human deaths, irregular forest fires,

Figure 3.1.1 The global impact of fossil fuel use on climate*.*

This graph shows the concentration of CO_2 in the Earth's atmosphere currently, at the lower red dot, and as predicted in 45 years, at the upper red dot (Gore 2006). The source data originally was published in Science Magazine, the Journal of the American Association for the Advancement of Science (Monnin et. al. 2001).

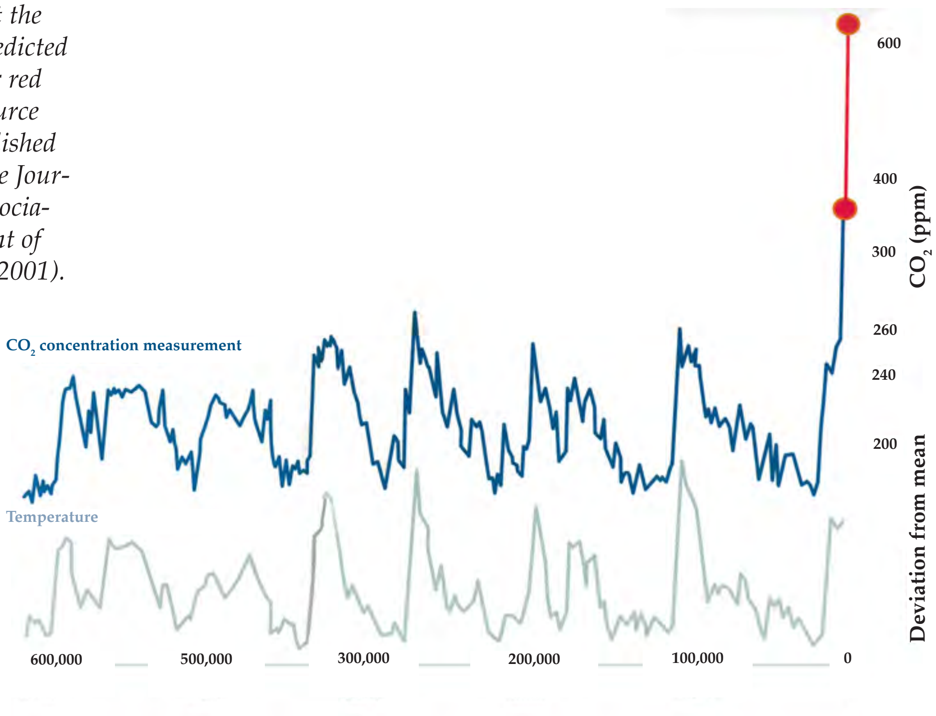
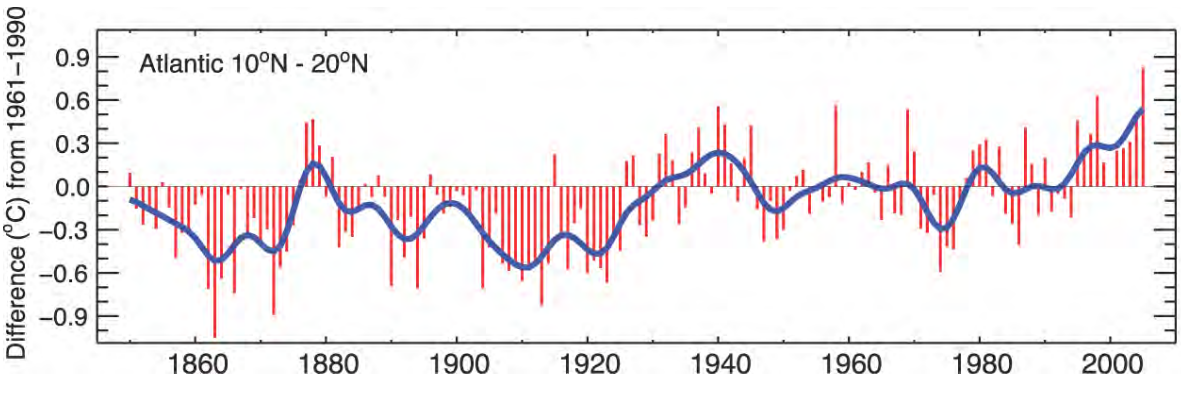


Figure 3.1.2 Sea surface temperature annual anomalies in tropical Atlantic Ocean *(IPCC WG1 Solomon 2007, 42)*

Scientists believe that the warming of sea surface temperatures in the Caribbean and tropical Atlantic are related to the increased frequency and severity of hurricanes on the southeast U.S. coast (Gore 2006; Flannery 2007)



and irregular availability of winter activities, such as hunting and skiing. The Fourth Report of the Intergovernmental Panel on Climate Change, the largest project in the history of scientific research stated:

> *"Changes in the atmospheric concentration of greenhouse gases (GHGs) and aerosols, land-cover and solar radiation alter the energy balance in the climate system. … Most of the observed increase in globally-averaged temperatures since the mid-20th century* ***is very likely*** *due to the observed increase in anthropogenic GHG concentrations." (IPCC SYR SPM 2007, 5)*

"Very likely", in the language of the IPCC, means a 90% certainty. The graph in Figure 3.1.1 illustrates the relationship between global average temperature and atmospheric CO_2 concentrations over the millennia (Gore 2006).

The work of the scientists, captured in this "hockey stick" graph provokes speculation as to the possible future trajectories. The Scientific Expert Group reported to the 15th United Nations Congress on Sustainable Development thus:

> *"Two starkly different futures diverge from this time forward. Society's current path leads to increasingly serious climate change impacts, leading to potentially catastrophic changes in climate that will compromise efforts to achieve development objectives where there is poverty and will threaten standards of living where there is affluence. The other path leads to a transformation in the way society generates and uses energy ... This path will reduce dangerous emissions, create economic opportunity ... and contribute to the sustainability of productive economies capable of meeting the needs of the world's growing population." (Bierbaum et. al. 2007, 11)*

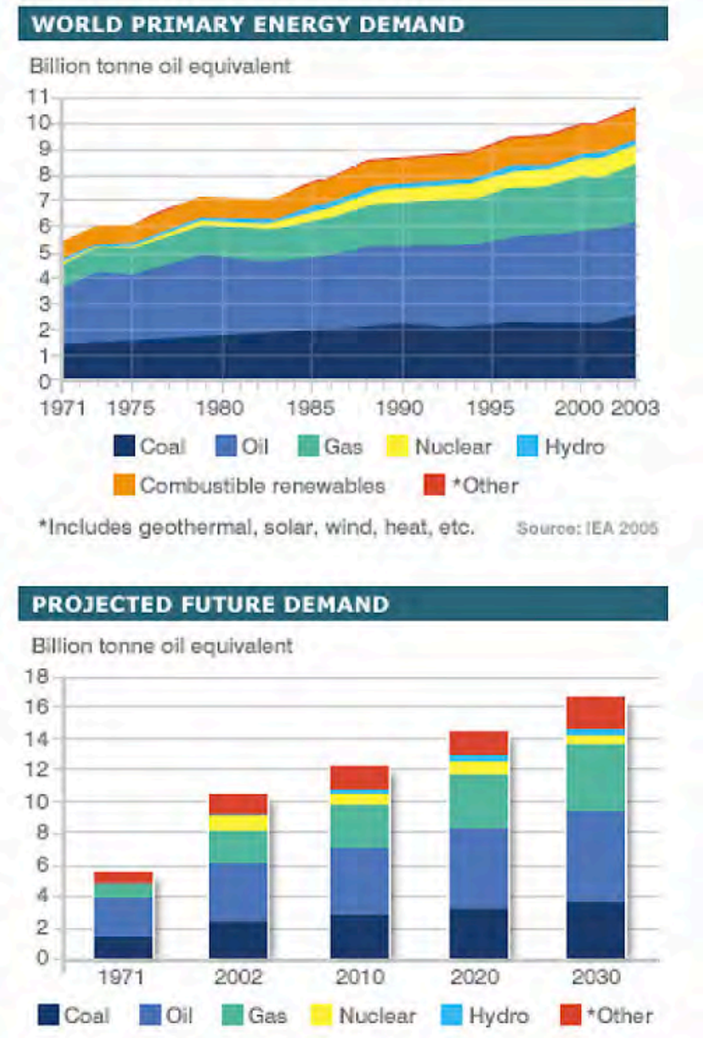
One of the effects of global warming is a rise in sea temperatures, which scientists think may be associated, in turn, with the increased frequency and severity of hurricanes along the U.S. southeast coast. The scientific measurement of this effect is presented in Figure 3.1.2.

It is difficult for an architect, who is not a climatologist, to discern whether the scientific reports are valid. It is impossible for the scientists to say, with irrefutable certainty that the predictions contained in their simulations will come true; the future remains uncertain. However, upstream from the greenhouse effects of combustion, there is a second argument for reducing fossil-fuel use. As the human population surges, so does energy demand. The growth in demand is outpacing population growth, as lifestyles in the "developing" world become

Figure 3.1.3a

World primary energy demand will outpace production of conventional oil

Between 1971 and 2008, world primary energy demand nearly doubled. The use of conventional liquid fuel (oil) increased proportionally, but use of natural gas, nuclear and renewables increased to a greater degree (top graph). Current projections shows demand for oil increasing only slightly, while demands for natural gas, coal, and "other" energy continue to quicken (middle graph). (from http://www.bbc.co.uk, which cites IEA 2005)



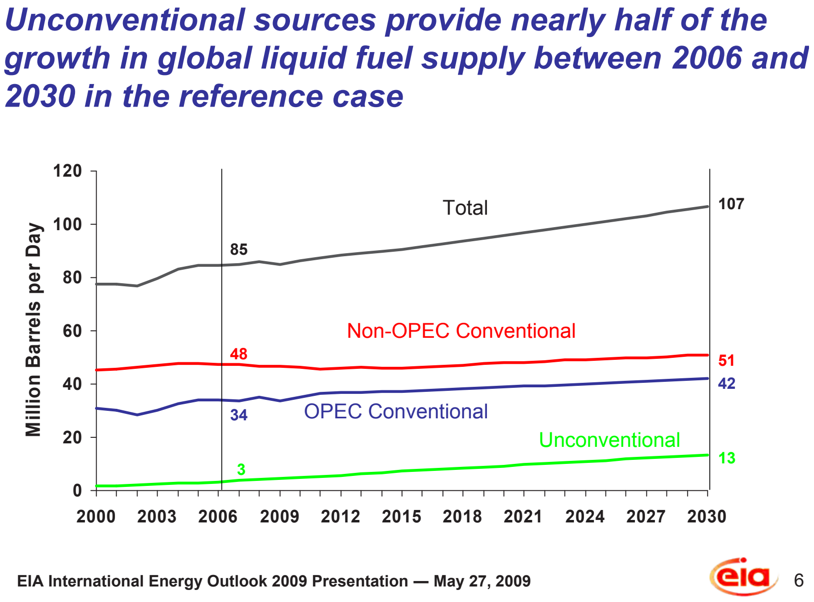
*Includes geothermal, solar, wind, heat, etc.

Source: IEA 2005

Figure 3.1.3b

The production of "easy oil" has peaked (IEA 2009)

"Unconventional" sources of liquid fuel oil include shale oil, gas to liquids, coal-to-liquids, extra-heavy oil, biofuels and oil sands/bitumen.



Unconventional sources provide nearly half of the growth in global liquid fuel supply between 2006 and 2030 in the reference case

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6

more like those in the industrialized world. Fossil fuels (coal, natural gas, and oil) currently meet approximately 80% of the global energy demand. But the supply of "conventional" crude oil has peaked (see Figure 3.1.3a and b).

Much of the future supply of crude oil is located in the high Arctic, in deep water, or in tar sands. During 2007, "easy oil" was declared to be on the decline. And, as oil becomes more costly to refine, the worldwide surge in demand likely will look again to coal. Unless action is taken, CO_2 emissions from fuel processing (at the source) will then rise even faster than energy demand.

These warnings – like the climate change science – have been reported for some time, in the annals of scientific journals. Now they appear regularly in the business and popular press. For instance, in an article published mid-2007, the UK Chairman of Royal Dutch Shell listed "four hard truths" as follows:

- the global energy demand is accelerating,
- fossil fuels dominate the current energy mix,
- the extraction of "easy oil" likely will not keep pace with demand, and
- CO_2 emissions probably will increase even faster than energy demand, because the rising demands, not fully met by oil, will increasingly be met by coal.*

In the event, however unlikely, that future scientific study declares climate change a less serious issue than currently is understood, there is still the question how to supply energy to an expanding world population. In the words of the International Energy Agency (IEA), a body within the framework of the Organization for Economic Co-operations and Development (OECD):

> *"The energy future which we are creating is unsustainable. If we continue as before, the energy supply to meet the needs of the world economy over the next twenty-five years is too vulnerable to failure arising from under-investment, environmental catastrophe, or sudden supply interruption. This has been the central message of the World Energy Outlook for the past several years; and in 2005 at Gleneagles and 2006 at St. Petersburg, G8 leaders endorsed that judgment, making a political commitment to change."* (IEA 2006, 3)

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* James Smith "Firms need clear climate policies", in BBC News Online (Front Page) 8 October 2007, at http://news.bbc.co.uk

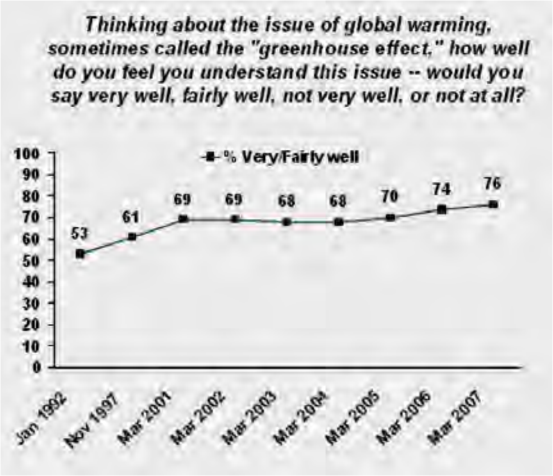


Figure 3.1.4
U.S. public perception of how well the climate change issue is understood

... grew from 53% to 76% between Jan 1992 to March 2007 (Saad 2007)

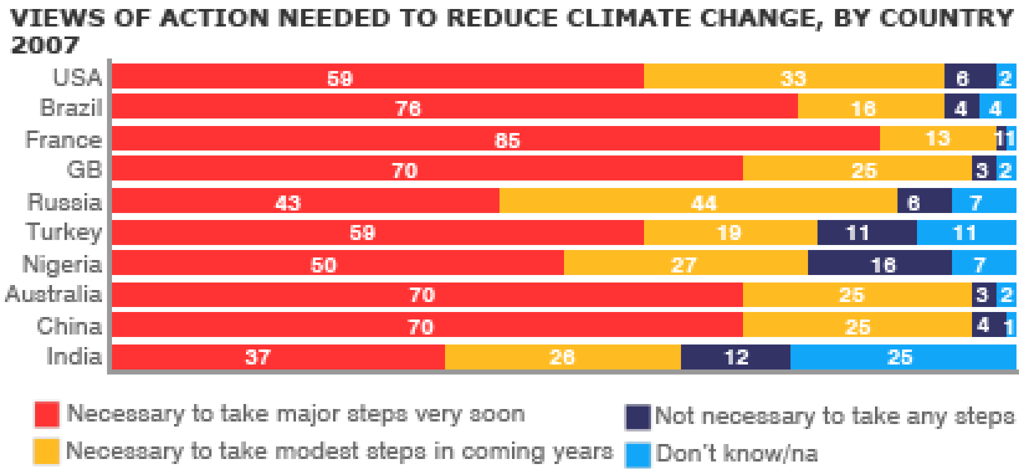
Public appreciation of the issues

The impacts of climate change on North America are illustrated in *An Inconvenient Truth* (Gore 2006). The film, which was headlined by former U.S. Vice President Al Gore, illustrates the human costs of global warming, by presenting several recent examples relevant to the U.S. experience. Droughts in Texas, and the hurricane seasons of 2004 and 2005, which included the devastation in New Orleans, are presented as prime examples of a climate gone awry. The images are convincing because they speak to the human experience, not just to abstract concepts.

The observation that a global warming effect had begun, and was expected to continue, was documented in *Our Common Future* (WCED 1987). Commonly invoked as “the Brundtland Report”, this study made reference to scientific analyses dating back to 1983.

Yet, during the last decade of the 20th century, climate change skeptics argued that temperatures were not rising, or the climate was changing, but the change was attributable to natural variation. From both sides of the debate, accusations were made that vested interests are skewing the science. For instance, in *The Denial Machine*, many of the more activist skeptics were portrayed as beholden to big businesses with vested interests in maintaining the status quo (Flannery 2005; McKeown 2006; Monbiot 2007; Royal Society 2007).

Some have argued that the popular press has given the “naysayers” far more airtime, proportionally, than those who have studied climate science and who can present objective evidence about it. By late 2007, the most vocal skeptics were out-numbered, by a large margin, by stakeholders in the IPCC process. The visual display of ice cores from the high arctic, depicted in *An Inconvenient Truth*, was convincing to many viewers. It provided evidence that previously had been relegated to specialized scientific journals, such as those referenced in the Brundtland Report.



SOURCE: BBC/GlobeScan/PIPA

Figure 3.1.5 Public opinion, in 10 countries, shows support for commitments to climate action.

A poll of 22,000 people in 21 countries, conducted by Globescan, under the guidance of the Program of International Policy Attitudes at U. Maryland, revealed a majority opinion that action is needed to reduce climate change. (See "Man causing climate change - poll" at BBC News Online, 25 September, 2007, at http://www.news.bbc.co.uk))

A number of opinion polls in late 2006 and 2007 indicated that a majority of the public - in both the developed and developing worlds - by that time, acknowledged climate change as real, and favoured immediate action. A poll in the U.S., by the Pew Center, showed that fewere than 50% of respondants perceived global warming as an imminent prolems, and these were equally divided between Liveral Democrats and other voters. At the same time, a 47-nation poll showed rising concern about environmental and pollution problems, and a marked tendency to blame the U.S. for them (Kohut 2007). An outline of the ten-year trend in the public awareness of the issues in the U.S. is shown in Figure 3.1.4. The results of the global poll are in Figure 3.1.5.

In Canada, several public opinion polls taken in 2007-08 are of note. In one, majority of Canadians (61%) favoured moving more aggressively to reduce dependence on fossil fuel-derived energy. In another, a majority (73%) favoured a usage charge for consumers of a higher-than-average amount of energy. In a third, the environment joined the economy and healthcare in the top three concerns of voters (higher than poverty, crime and taxes). * Although practical electoral support fell short of expectations, environmental protection in general, and carbon taxation in particular, were much discussed in the Federal elections, in both Canada and the U.S., during the fall of 2008. Also, the

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* See Bruce Anderson "Pricey oil fuels more, not less, environmentalism" 8 July, 2008, "Tax environmental harm, reward environmental good" 7 May, 2008, and "Environment on the agenda" 4 January, 2007, all at http://www.harrisdecima.ca (all accessed 10 October, 2008). Also see John Wright "Canadians concerned about climate change" 2006 at http://www.impsos-na.com/news/pressrelease.sfm?id=3205 (accessed 9 Oct, 2008).

protection of the environment was the area in which satisfaction with government action (both Federal and municipal) was weakest.*

Amid the continuing refrains of those with opposing views, during the year 2007, the public discourse about climate change took a definitive turn. A common conclusion, by the end of 2007, was as follows:

> *"… there is a growing scientific consensus that, even on top of the natural variability of the climate, something out of the ordinary is happening, and humans are to blame."* †

In the following study, the presence, in the public discourse, of these two issues - climate change and the supply of fossil fuels - is appreciated as part of a mindset that is unfolding, within human culture. The contributors to the IPCC acknowledge there are gaps in the current understanding of the problem of climate change – and even wider gaps in estimating how best to solve it. The intent in this study is not to debate the value of current scientific conclusions, nor to convince the skeptic of their veracity. Rather, the assumption here is that the worldview expressed by the IPCC – and others - has gained considerable traction in public consciousness – and therefore the practice of architecture already is implicated.

A depiction of widespread and irreversible environmental damage – of which the IPCC report is one of the more comprehensive - often is received in the same spirit as Chicken Little's warning that "the sky is falling!" If another mindset is preferred, when it comes to thinking about the future, then it is easy to dismiss a vision of the world - such as that portrayed in the IPCC report - as misguided and untrue. In an article entitled *"Chicken Little, Cassandra, and the Real Wolf – So many ways to think about the future"*, systems designer Donella Meadows outlined various mindsets that commonly are at work when people think about the future (1999). In the "Chicken Little syndrome", the future is wholly predetermined and not the result of human choice. Meadows invokes the work of Garret Hardin, in relation to various kinds of "truth" that appear in the work of prognosticators, saying:

> *"I tend to get especially infuriated by the Truth-by-Repetition Truth when it is articulated with absolute certainty, as if it were an Always-True Truth; especially when it purports to tell me what*

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* See, for example, Gary Mason, "The Environment was not a winning issue on this campaign trail" in the Globe and Mail Editorials, 15 October, 2008

† See "Q+A Climate Change" in BBC News Online, Special Reports, available at http://www.news.bbc.co.uk (accessed 20 January 2009)

> *is feasible in human affairs … the US political system will never permit a carbon tax. … Half the species one earth will go extinct in the coming century. There will be runaway climate change. These are not only predictions, they border on self-fulfilling prophecies. They sweep away the possibility of choice, though there is in fact plenty of latitude for choice. … And of course they are a direct invitation to inaction. Well, if it's hopeless, why try? Let's just sit around and wait for disaster. …" (Meadows 1999)*

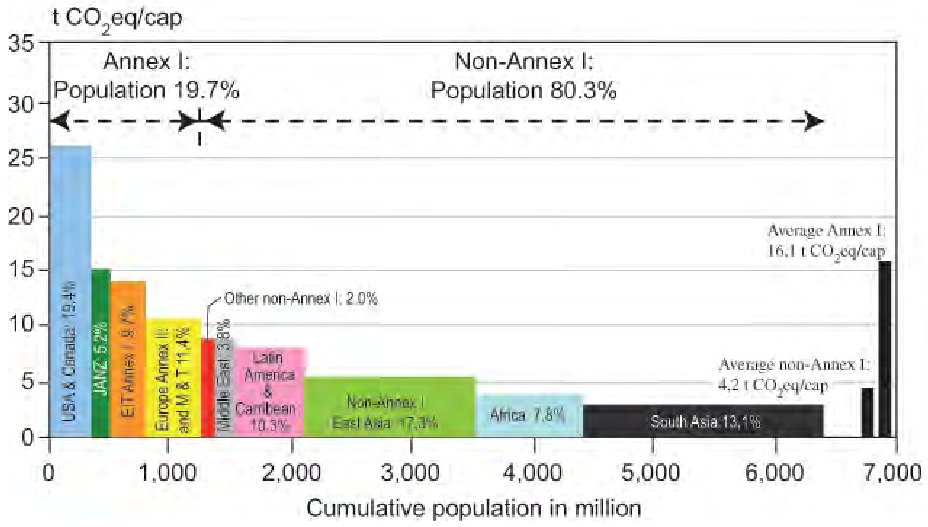
The scientific debate now concerns the extent of the damage, and whether it is irreversible. For people who design things that require combustion – architects included - the debate concerns how much change in "normal" practice is required, and how fast - that is "how to" begin mitigating the cumulative effects of combustion on the natural environment in the context of human economic activity. As discussed in Section 3.1, architects may also be concerned with not losing sight of other types of human needs. Meadows continues:

> *"… Which brings me to my favorite approach to the future: vision. … Visionary statements and actions come from a completely different place in the human psyche from predictions, forecasts, scenarios, or cynical, downer assertions of political impossibility. They come from commitment, responsibility, confidence, values, longing, love, treasured dreams, our innate sense of what is right and good. A vision articulates a future that someone deeply wants, and does it so clearly and compellingly that it summons up the energy, agreement, sympathy, political will, creativity, resources, or whatever to make that future happen." (Meadows 1999)*

In future years, many an architect will be engaged in moving toward solutions to the twin challenges of climate change and energy use - either through individual initiative, or as a result of practical exigencies that can be predicted now. One commentator suggests that building professionals ought to be concerned with climate change, because energy use in buildings is a significant contributor to the problem, and because the problem can reasonably be expected to have an impact on buildings in the future (Urge-Vorsatz 2007). Another team of researchers presents an imaginative vision of how the world could look, after action is begun:

> *"As we look back from 2056, if global emissions are indeed no larger than today's, what will have been accomplished? The world will have confronted energy production and energy efficiency at the consumer level in all economic sectors and in economies at all levels of development. Buildings and lights and refrigerators, cars*

Figure 3.1.6 a
Regional distribution of GHG emissions by population



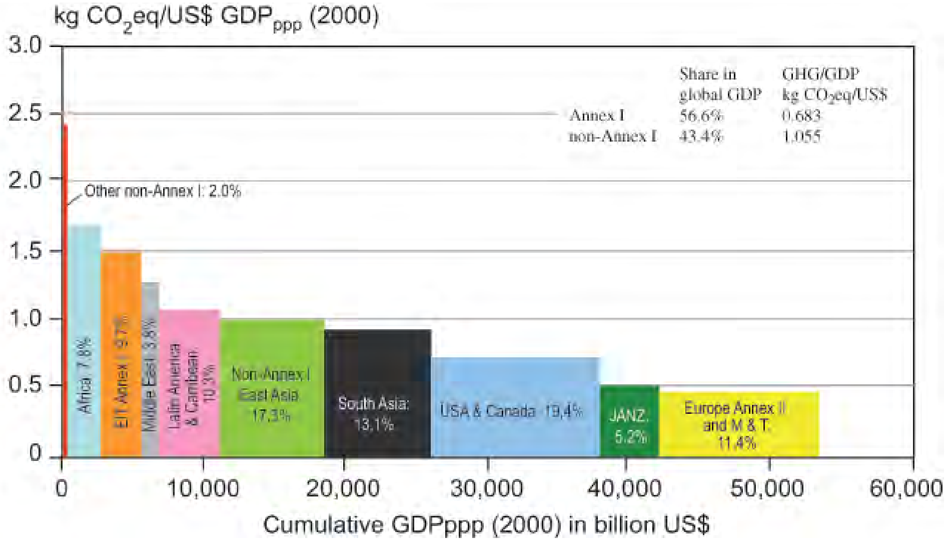


Figure 3.1.6 b
Regional distribution of GHG emissions by GDP

North America is a disproportionate emitter (IPCC SYR 2007, 37).

> *and trucks and planes will be transformed. Transformed, also, will be the way we use them. … Economic growth will have been maintained; the poor and the rich will both be richer. And our descendants will not be forced to exhaust so much treasure, innovation and energy to ward off rising sea level, hurricanes and drought. Critically, a planetary consciousness will have grown. Humanity will have learned to address its collective destiny – and to share the planet.” (Socolow and Pacala 2007)*

If we make sacrifices, will the “rest of the world” do likewise?

It has taken the work of hundreds of studies to account for all of the energy flows and greenhouse gas emissions, for all sectors of human activity, worldwide. Reconciling the findings now could constitute a project in itself; a deluge of information falls to one who begins to research in this area. But even after acknowledging the need for a “new normal”, the maelstrom of messages on the subject leaves a few questions in mind.

Many architects ask whether actions at the scale of a single building could be outweighed by inaction in land-use planning. One study has shown that, for the average U.S. office building, commuting by office workers accounts for two to three times as much energy as the building requires to operate (Levin 2007). Some may imagine that it would be more effective to improve fuel efficiency in our cars, to intensify land-use, and to reduce the total amount of car and truck transport – instead of making deep cuts in our architecture.

The assumption that deep cuts in architecture are necessary in order to realize drastic energy-use and emissions reductions will be disproved through the present study. The assumption that climate change mitigation might be achievable through the actions of just one sector, rather than the others, also is erroneous. It is clear from the scientific reports that there are other sectors that

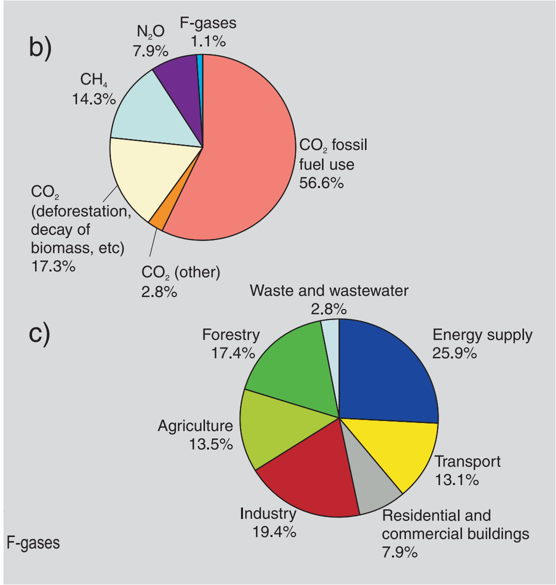


Figure 3.1.7
Global anthropogenic GHG emissions

Buildings are significant emitters, as is the production of the energy (at the source) (IPCC SYR SPM 2007, 5).

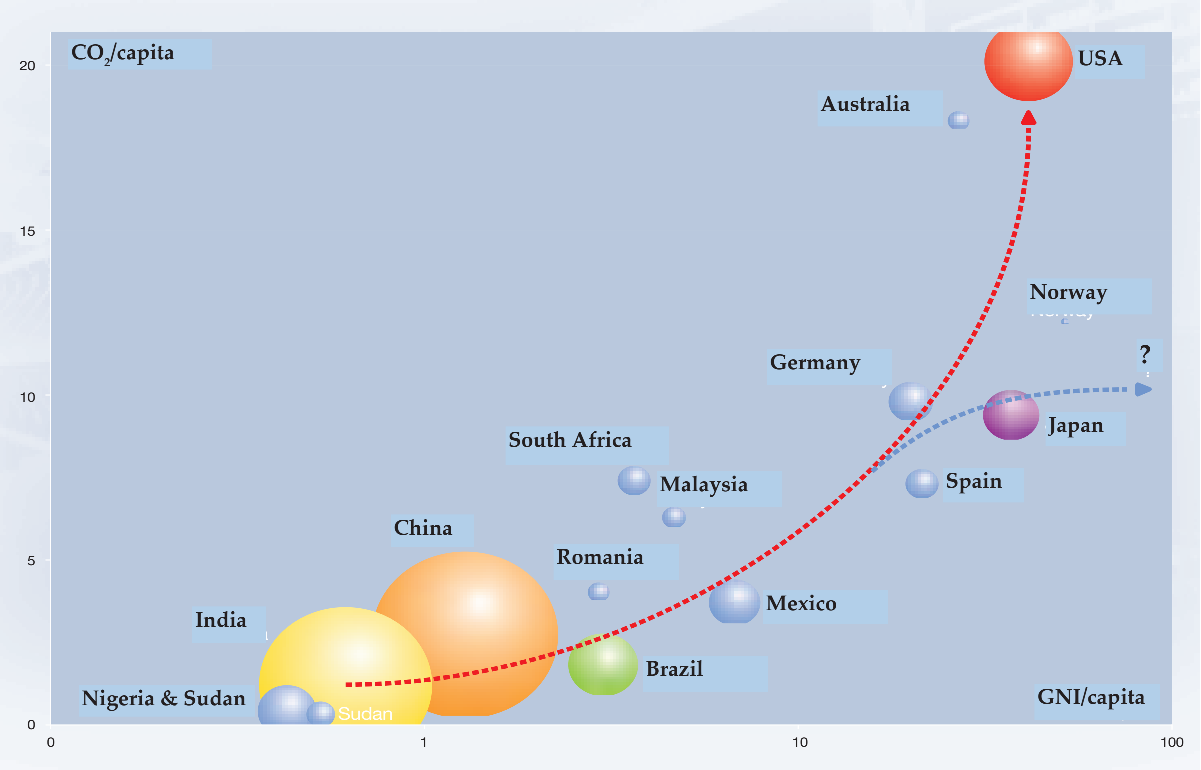


Figure 3.1.8
Recommended levels of emission depend on the position of the country in the figure

(from UNEP 2007, 55)

are a substantial contributors to the problem (see Figure 3.1.7). For instance, in one study, the CO_2 emissions-abatement potential in the U.S. building sector is estimated to be far greater than the potential for abatement in the U.S. transportation sector (Creyts et. al. 2007). In all of the studies examined here, all sectors are expected to contribute. The sectors expected to contribute the most are buildings, transportation, and energy production. Even within sectors, the reports are explicit in stating, *"No single technology can provide all of the mitigation potential in any sector"* (IPCC SYR SPM 2007, 14).

Another question is whether the effort to reduce emissions from the North American building sector would be negated by increasing emissions from future industrialization in Asia. The studies show that current emissions per-capita in North America far out-weigh per-capita emissions in Asia. Despite the difference in the size of the two populations, the total absolute emissions on the opposite sides of the Pacific Ocean are roughly balanced (see Figure 3.1.6). Questioning the trajectory for Asia, one report makes it very clear that the emissions intensity established in North America cannot be imitated worldwide, as illustrated in Figure 3.1.8 (UNEP 2007).

Orchestrating solutions in concert

One broad solution, suggested by Socolow and Pacala, would be to rebalance the emissions in the OECD states with that in the non-OECD states, in the following way. All OECD states would lower their emissions by 60% by 2050 (as the UK has committed to do) while the non-OECD states (where 80% of the world's population lives) would increase their emissions by a corresponding absolute amount. The result, at mid-century, would be that the average U.S. citizen would be emitting roughly twice what the average citizen in the rest of the world would emit – as opposed to fives times, which is the rate today. (2007)

Figure 3.1.9
Clusters of abatement potential

(Creyts et. al. 2007)

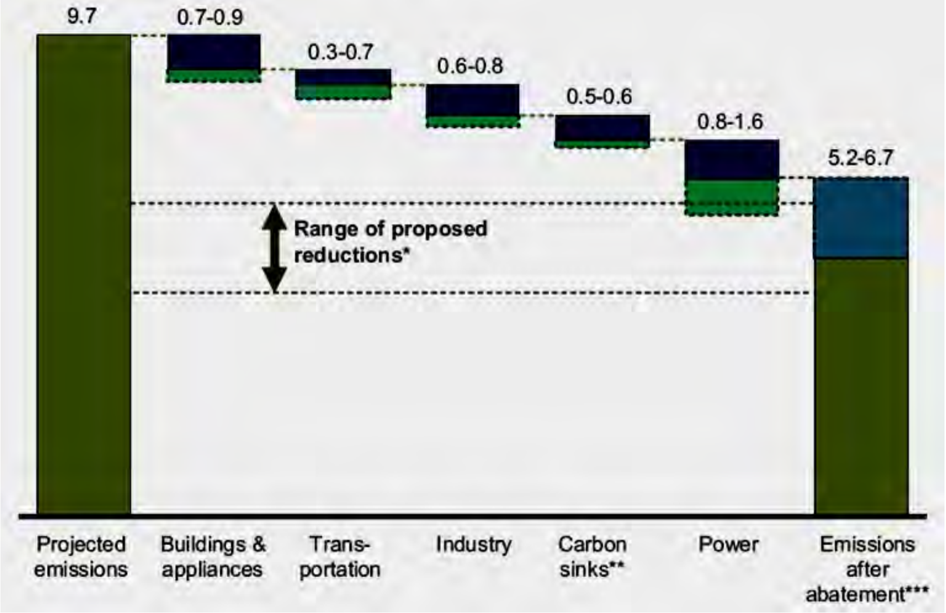
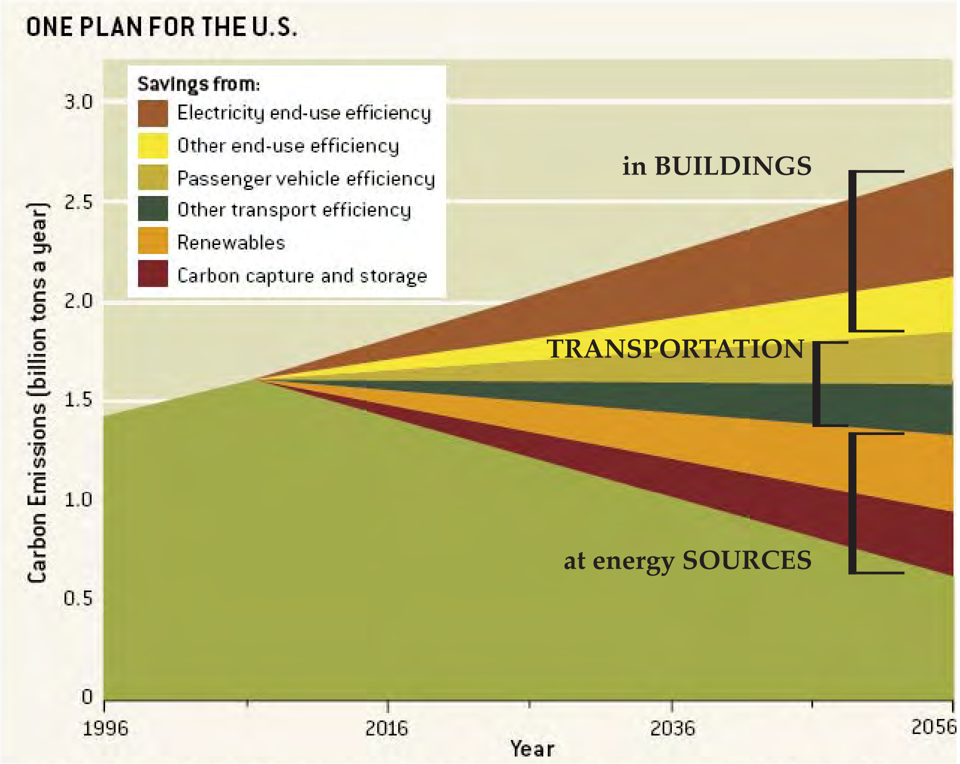


Figure 3.1.10
One plan for the U.S.

Mitigation is required in all sectors - and the building sector is always part of the equation (Socolow and Pacala 2007)



The mitigation scenarios, considered within the Fourth Assessment of the Intergovernmental Panel on Climate Change, are modeled at the global scale (2007). Other studies focus on North America exclusively (Socolow 2007, Creyts et. al 2007). At both scales, all of the studies show simultaneous contributions from several sectors – the three largest being the building sector, the transportation sector, and energy production at the source. The concept that simultaneous contributions are required from several sectors is illustrated in a report by McKinsey & Co. (Figure 3.1.9) and in the "wedges" diagram, proposed by Socolow and Pacala (Figure 3.1.10). This diagram has been proposed with a variety of different measures occupying one wedge or another – but the overall message is that all sectors must contribute - in order to hold global emissions to a level that, it is hoped, will not cause irreparable damage to natural systems.

The current study is concerned with energy savings "at the site" – bounded by the property line of an architect's project. But it is important to remember that every reduction within this boundary also leverages a second reduction, upstream at the energy-refining source. If the energy currently flowing into the building sector were reduced substantially, then the CO_2 emissions at the refinery (for every fossil fuel) would diminish substantially as well (see Figure 3.1.11).

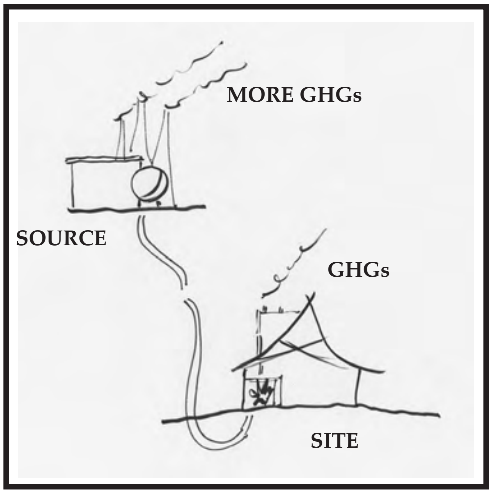


Figure 3.1.11
Leverage potential of reductions in use of energy at a building site

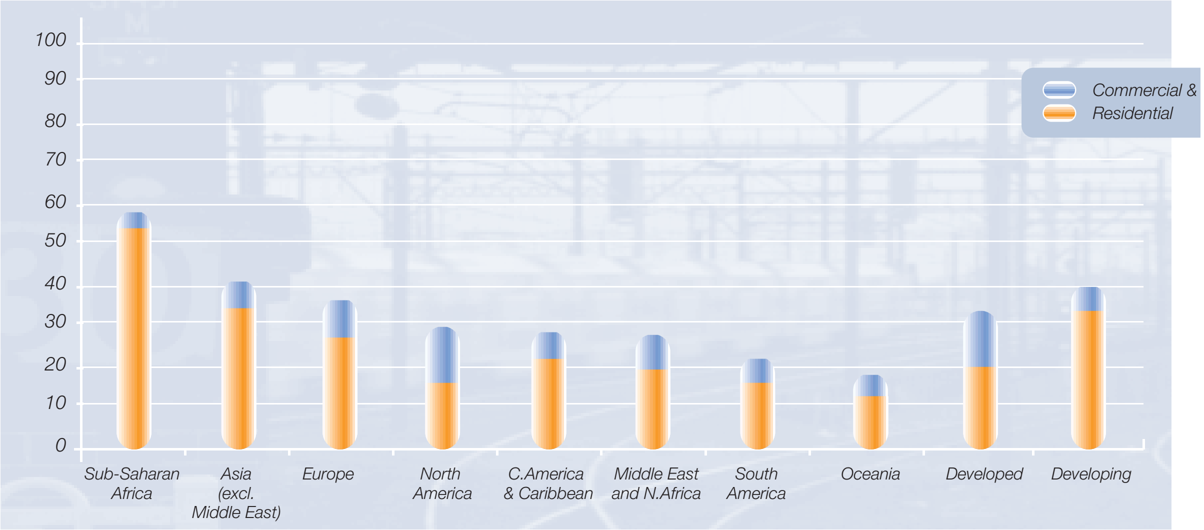


Figure 3.1.12
Share of energy use in different building sectors in the world, percentage of total energy use

(UNEP 2007, 16)

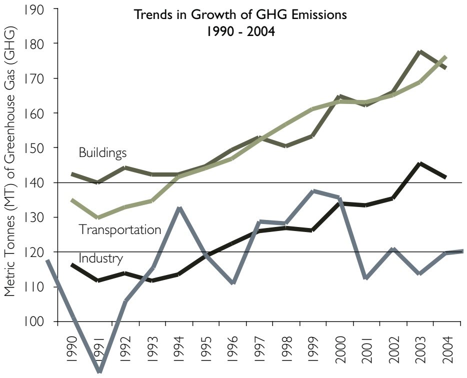
The role of North-American institutional buildings

Having determined that the building sector is a significant energy-user and GHG-emitter, the next question is how much potential it offers for increased efficiency. Relative to other sectors (such as transportation and agriculture), buildings currently are seen as "low-hanging fruit", in that:

> *"…buildings offer the largest share of cost-effective opportunities for GHG mitigation among the sectors examined in this report." (IPCC WG3, Levine 2007, 390)*

Recent studies of the potential cost of mitigating climate change in North America echo this opinion. In each study, the emissions-abatement potential in the building sector is compared to that in other sectors or "clusters". The building sector consistently is heralded as offering the most solutions that are most accessible and effective (Creyts et. al. 2007; CCSP 2007).

In North America, in contrast to other countries, non-residential buildings use a disproportionate amount of energy, compared to residential buildings (see Figure 3.1.12). Also, in both the U.S.and Canada, buildings and transportation share almost equal positions as the largest and fastest growing contributors to GHG emissions (see Figure 3.1.13). This is not surprising, given Canada's generally cold climate, and the very wide distances between its cities. Taken together, these observations show that the design of civic, non-residential buildings in North America deserves careful consideration, in the shift to a "new normal".



* "Real" means after taking into account price changes (captured in the GDP deflator - 1997 chained dollars).

Figure 3.1.13
Canadian GHG Emissions by Sector

(McAuley 2007)

Quantifying "how much buildings might contribute" was attempted, in relation to internationally agreed targets, during the years in which the Canadian government was honoring its commitment to meet the Kyoto Protocol (GOC 2000; Busby 2002). Federal government programs, during those years, had a better record of success in lowering energy use and emissions than any of the current voluntary "green building" programs (see Section 4.4). Recently, the massive project of upgrading existing buildings has become the focus for a new international program - the Clinton Climate Initiative (CCI 2006). And, to provoke architects to take responsibility for the loads their designs are imposing, one U.S. architect launched the program known as the 2030 Challenge – which has been endorsed by many of the professional associations in

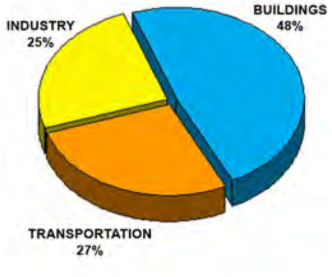
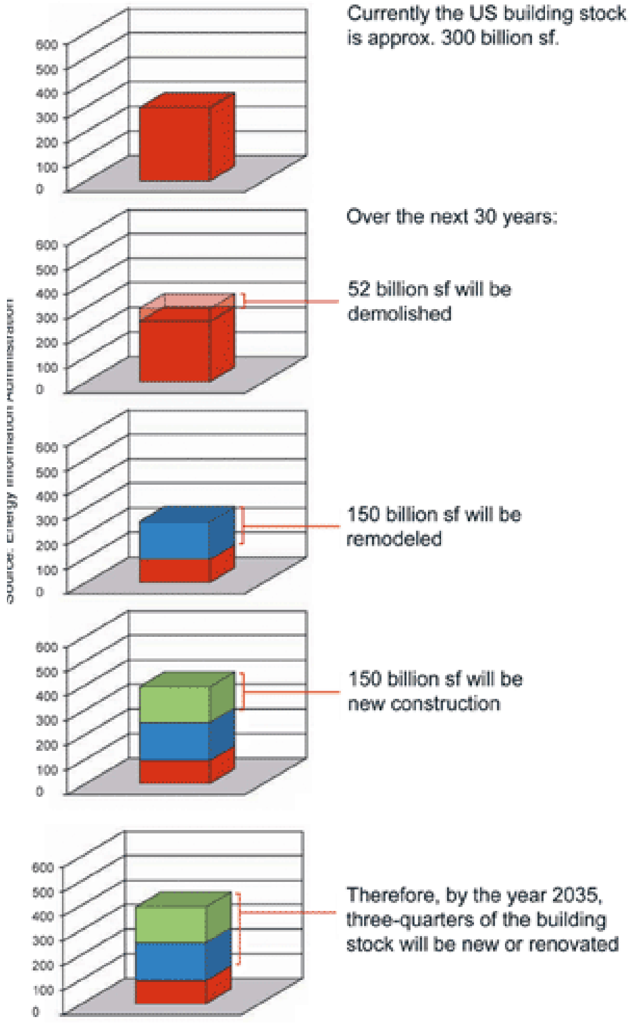


Figure 3.1.14
U.S. Energy consumption

(Mazria 2007)

Figure 3.1.15
Replacement of U.S. building stock prior to 2035

(Mazria 2007)



architecture and engineering in both the U.S. and Canada (Mazria 2007; USCM 2006).

A pie chart from the 2030 Challenge reference materials is designed to capture the attention of architects (see Figure 3.1.14). The argument that accompanies this chart is as follows. The transportation sector may, with increasing prices at the pump, reduce its overall emissions. The industrial sector in North America is shrinking, and also is capitalizing on every efficiency measure in can identify - to preserve profitability. Therefore, the building sector – which already is the largest consumer of energy in North America – is poised to become responsible for an even larger proportion of energy use and emissions. This suggests that, if the building sector is to reduce its emissions to a significant degree, then the design of a high-performance building can no longer be a rare, once-in-a-career achievement for an architect. Higher-performance design may no longer be the concern reserved for a select group of "niche" specialists; to make an impact on the overall effect of the North American building stock, it higher-performance design must become the "new normal", in everyday practice.

Another aspect of the 2030 prognosis is the estimate of how much new construction and renovation will take place in the next quarter-century (see Figure 3.1.15). There is an opportunity to make a significant reduction in the average performance of buildings, in the near term – but it suggests that such an effort must be sustained in everyday practice, in as many buildings as possible.

The institutional building types that are the subject of this study draw on a relatively small share of Ontario's total overall annual

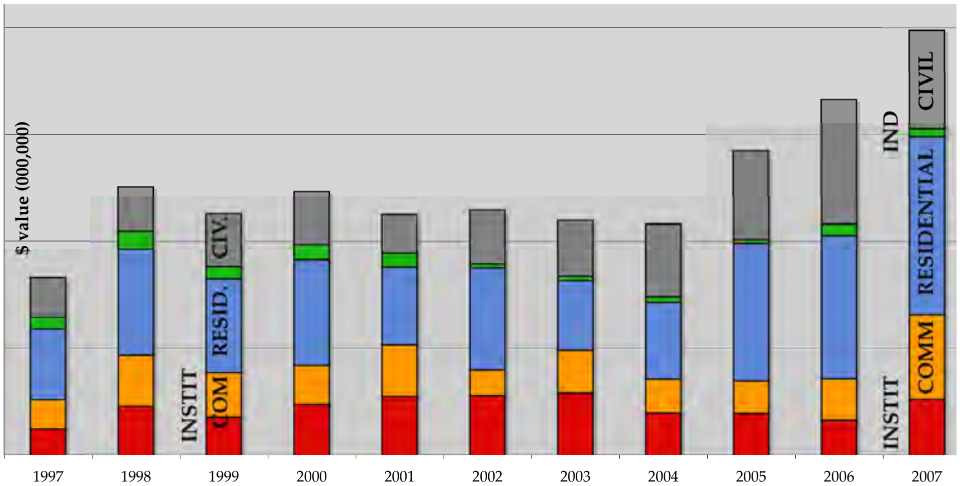


Figure 3.1.16
Value of construction starts in Ontario, by building use, 1997-2007

(after Kelleher 2008)

expenditure on construction. However, institutional and commerical construction together constitute is a growing share (see Figure 3.1.16). These buildings present a significant opportunity – expressing, as they do, the values and aspirations of the communities they serve. And, so-far, they have been overlooked in research (Kesick 2008).

The "new normal" in architecture

The idea that an architect can contribute a great deal to mitigate the climate change challenge, through the decisions made at the beginning of the design process, is mentioned several times in the background literature. In policy documents, editorials, and design manuals, the "wise choice" of building form, orientation and skin design is cited as an essential precursor to lowering energy-use and greenhouse gas emissions (see Section 3.5). However, a meaningful change in everyday practice currently is hampered by a limited uptake of existing knowledge, as is noted in a high-level policy reports for The Conference Board (Cretys et. al. 2007).*

A particularly regrettable appraisal of the design professions states:

> *"For Rosenfeld (1999), the most interesting result was not that an alert, motivated team could achieve a savings of 50% with conventional technology, but that it was very hard to find a team competent enough to achieve these results." (IPCC WG3, Levine 2007, 405)*

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* The Conference Board, located in New York, is self-described as a "not for profit, non-advocacy, research and educational institution … founded on the principal that fact-based analysis and debate will produce constructive changes in the U.S. economy and the health and prosperity of the free-enterprise system and American society."

In the same report, the reader is re-assured that there is *"a plethora of opportunities to achieve GHG emission reductions as significant as 70-80%"*, and that:

> *"substantial reductions in CO_2 emission from energy use in buildings can be achieved using existing mature technologies for energy efficiency that already exist widely and have been successfully used (high agreement, much evidence)"* (IPCC WG3 Levine 2007, 391, 406)

However, several gaps in knowledge are identified in the same report, including:

- "detailed end-use data is poorly collected or reported publicly",
- "there is a severe lack of robust, comprehensive, detailed and up-to-date bottom-up assessments of GHG reduction opportunities",
- "co-benefits are typically not included", and there is
- "a critical lack of understanding, characterization and taxonimization (sic: classification) of non-technological options (sic: "lifestyle choices") to reduce GHG emissions" (IPCC WG3 Levine 2007, 437).

If the trends, predicted in the literature cited so far, are anywhere near accurate, then many an architect's clientele will soon demand action on climate change. In such a world - while exploring the challenges and opportunities in the design of a single building - an architect will be called to account for the fundamental choices that "deal the cards" to the rest of the design team.

The results of recent scientific study suggest that the environmental impact of North American non-residential buildings must be lowered dramatically, in contrast to current practice. Therefore, profound adjustments in design approach may be in order. But the background literature is, by nature, a source of inspiration to try to design more carefully – not a source of specific advice to an designer about how to approach the work.

3.2 INTERLOCKING ATTRIBUTES: "LOW-LOAD + HIGH-SATISFACTION"

Even if reducing combustion dramatically becomes one of the primary goals of a project, human beings will still value meaningful buildings that look beautiful, function superbly, and fit well into their contexts. The following section shows a recent convergence of interests; energy-efficiency now is perceived as compatible with wider aspirations for quality in design. It assumes that architect William McDonough's criteria of *"ingenious design, locally relevant, culturally rich"* are particularly applicable to civic buildings, because these tend to be more permanent than others (2002). Also, it explains why operating energy is important consideration, at the scale of a single building.

A content review of the popular press shows a new convergence of interests in the environment and a host of other concerns. A content review of the architectural press shows that many in the profession support the idea that the "new normal" architecture ought to be both energy-efficient and "high-satisfaction". This suggests that the profession of architecture, while its voice is far from unanimous, may now be poised to mirror a pattern that already can be observed in wider society.

In the daily news, a coming-together of old adversaries now is plainly visible. As human activity has damaged natural systems, a ricochet effect now is hitting home. Issues such as climate change and energy scarcity have arrived on the front door of the average citizen, and the effects are being felt in many families. During the fall of 2007, global warming, or energy scarcity, or both were conspicuous in the pages of the mainstream press. On any given day, between 3% and 15% of headlines related to one of these two issues. Over the 3-month period, during which news content was reviewed, an average of 7% of headlines pertained to one or both of these issues.*

Various crises in society were beginning to be perceived as interlocking, and the response increasingly involved the dissolution of formerly held "compartments" of responsibility. During this period, environmental concerns became intertwined with other important matters – such as social equity, justice, defense, and the global economy. As a result, members of various sectors of human activity began to appreciate the need to address these societal challenges in concert (Hawken 2007, 12). The headlines reflect a discourse that took place in communities across North America; this survey shows that a new type of approach definitely was gaining ground.

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* For a detailed description of how the content review was conducted, see Appendix 1.

IN THE GENERAL PRESS

Pub1
"Distant drums":
far-away species are at risk

1	Threatened species Red List .. escalating 'global extinction crisis'	Guardian 12-Sep-07
2	Governments doing nothing as grizzly bears disappear	Globe 24-Sep-07
3	Salmon need help to survive climate change	Globe 4-Oct-07
4	Over and out from tagged walruses	BBC 11-Oct-07
5	Conservationists name 25 primates about to disappear	Guardian 25-Oct-07
6	Most of Amazon "lost" by 2030	Guardian 6-Dec-07

Pub2
"Approaching thunder":
human communities are at risk

1	Village of Widows renewal, cleanup of uranium mine ... hope for Dene	Globe 11-Sep-07
2	Malaria moves in behind the loggers (Peru)	Guardian 29-Oct-07
3	Disaster in Black Sea as tanker sinks	Guardian 12-Nov-07
4	In Alaska, whalers fear oil drilling may curtail way of life	NYTimes 3-Dec-07
5	Officials: major oil spill off South Korea	WashPost 7-Dec-07
6	Oil spill in North Sea off Norway	BBC 12-Dec-07

Pub 3
"Now playing, on a front lawn near you":
OUR community is at risk

1	CFB Gagetown - Agent Orange victims offered $20,000 payout	CBC 12-Sep-07
2	Urgent action urged to clean and protect Great Lakes	Globe 19-Sep-07
3	A heavy toll from disease fuels ... anger - Middleboro MA	NYTimes 8-Oct-07
4	Study finds carcinogens in water near Alberta oil sands projects	NYTimes 9-Nov-07
5	The road to enlightenment - 70% cuts must be at local level	Guardian 14-Nov-07

IN THE ARCHITECTURAL PRESS

Arc1
"Distant drums":
SOME components ought to be "green"

1	Some Glowing Issues, Heidi Overhill on light bulbs	Azure Jan-97
2	The Metropolis Observed: coal still heats schools	Metropolis Jan-97
3	NBC goes digital and NMS goes green	CdnArcht Aug-97
4	Tech-HiPerf windows in C2000 model office buildings (D Kerr)	CdnArcht Sep-97
5	Smog can be wiped out - Douglas Page on air scrubbers	ArchReview Dec-97

Arc2
"Approaching thunder":
green ideas may affect the architecture

1	Are awards superficial, should enviro … be given more weight?	CdnArcht Jun-97
2	Cdn Archt Awards of Excellence - Shades of Green	CdnArcht Dec-97
3	On the Up in New York - trends include sustainable design	Azure Sep-06
4	Super tall and Ultra Green - SOM's tower in Guangzhou	Metropolis Aug-06
5	The Straw House and Quilted Office	AD Nov-Dec-06
6	Government Buildings - open and shut	ArchRecord Mar-07

Arc3
"Now playing, in a design practice near you":
architects have a role to play

1	Energetics issue: Who's responsible?	ArchReview Jul-97
2	Building Kyoto (Busby)	CdnArcht Jul-02
3	Turning down the global thermostat	Metropolis Oct-03
4	Following carbon footprints leads architects … to their own doorsteps	ArchRecord Mar-07

Figure 3.2.1 (opposite) Environmental concerns in the headlines, Fall 2007

(for sources and more examples, see Appendix 1)

Within the profession, architects interested in "ecological design" have, at times, been viewed as members of a specialized niche, standing apart from their peers (Fitch 1999). For instance, during the "first oil crisis" of the 1970s, some designers made energy-efficiency the primary goal. The result often was a banal architecture and, in some cases, depression or physical illness in people who occupied these buildings (Vince 1987). As recently as 2004, many architects considered "going green" just another passing fashion. Even with the "sustainability niche", architectural critics are continuing to describe separate compartments, distinguished by aesthetic or conceptual emphasis (see Lukachko 2004; Guy and Farmer 2001).

However, of late, the discussion about "green design" has been geared to finding a more lasting balance between care for the environment and other concerns. Compartments are beginning to dissolve within the architectural design community, just as they are in wider society. Green design has quit the lunatic fringe, to which it once was relegated. Today, "sustainability" widely is perceived as an opportunity to improve upon design quality, in a more general sense (as will be shown later in this section). "Going green" even is touted – from a commercial real estate perspective – as an opportunity to realize increased profits. In this study, it is assumed that the "new normal" presents an opportunity for an architect to break free of the shackles of this kind of professional segregation, and to move forward with the practical task of realizing a truly low load building.

The "mainstreaming" of environmental concerns

Some time ago, natural systems and human systems were seen as exclusive realms with diverging interests. Many of the stories that were told, beginning in the 1960s – by the likes of Jacques Cousteau, Jane Goodall, David Suzuki, and their colleagues in science – brought focus to places in the world where the interests of human industry threatened a particular species or ecosystem. Today, reports of the threats to the survival of wild species, posed by human activity, are staple fare in the science pages of the popular press. The tales that once were heard as "distant drums" from the far horizons, now are playing out on front lawns around the Great Lakes Basin. Several examples of this type of story, from the fall of 2007, are listed in the left-hand column of Figure 3.2.1, sections Pub1 through Pub3.

Current stories in the first genre, listed in section Pub1, still are remote to the average North American citizen to be shrugged off as "someone else's problem". When such reports were the subject of the occasional news documentary, they could be received, in the "first world" as matters of mere curiosity, or subjects for specialists to study. Even now, as they are published almost everyday, these stories still may be heard, from within the industrialized world, as "distant drums" on the horizon. For instance, the headline decrying the fate of the gorilla in central Africa or the one about the future fate of the coral reefs around Australia may be valid and they may concern someone, but – since they do not affect the average North American reader directly – any practical reaction to them may be perceived as non-essential in the course of everyday life.*

The architectural press also began, some years ago, to include environmental concerns in its headlines. Several examples are listed in the right-hand column of Figure 3.2.1, sections Arc1 through Arc3. In the architectural realm, the "distant drumbeats" from a far horizon suggested that some components of a building ought to be specified with the natural environment in mind. They characterized "enviro-friendly" design as involving only such things as energy-efficient light bulbs, boiler types, or air scrubbers. Just as the stories of species at risk did not necessarily change everyday life in North America, the stories of energy-saving devices didn't necessarily change in "business as usual" on the principal design architect's drawing board. The response to this type of story could be delegated to an engineering sub-consultant, or a member of the team who selected certain finish materials. Examples of this type of story, dating back to 1997, are listed in Figure 3.2.1 section Arc1.

Closer to home, a second type of story tells of human communities, in the developed world, that are suffering the effects of local pollution. A few stories of this genre are listed in Figure 3.2.1 section Pub2. For instance, each November brings reports of oils spills to the fore, as distribution via supertanker increases, to prepare the northern hemisphere for winter. During November and December of 2007, oil spills occurred near large centres of population in the Black Sea, near South Korea, and on the Norwegian coast. These stories are the "approaching thunder" – conveying a concern about human-caused pollution, in the interest of preserving human settlements.

During the mid-1990s, an "approaching thunder" began to rumble through the architectural press as well – in the form of a discussion about how "going green" might affect the "look" or the concept of a new building. These stories – such as "The Straw House and the Quilted Office" - raise issues that are more difficult to ignore than the "distant drums" - because they advance closer to home. That is,

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* For an analysis of the cause of what has been described as a numbness, a denial, and a collective madness, as well as suggested further reading on this issue, see Gladwin 1997.

they pose questions that move outside the narrow confines of the engineering sub-consultant's judgment, and enter into the purview of an architect. A few stories – some of them revealing prejudices within the design community - are listed in Figure 3.2.1 section Arc2.

The stories that are the most difficult to ignore are those that are played out "on a front lawn near you", such as the carcinogens in the water near the Alberta oil sands, and Canadians suffering the effects of exposure to Agent Orange, near the Canadian Forces base in Gagetown (see Figure 3.2.1 section Pub3 for additional examples). An early example of this genre of story is *Silent Spring* - the chronicle of the effects of DDT spraying on neighbourhoods in central and eastern U.S. that is credited with starting the "environmental movement" in North America (Carson 1962). The "sea change" that slowly is taking place, as a reaction to stories of this type, is a renewed appreciation of the "intimate and reciprocal" relationship between the interests of local communities and the interests of natural systems (Hawken 2007, McKibbon 2007). *

At least two recent popular films address this question of the reciprocity between human activity and natural systems. The desire, in the "first world", to maintain a comfortable lifestyle, in the face of new constraints on energy use, is one theme in *An Inconvenient Truth*. Gore compares U.S.-style stewardship of fossil fuels to that of other industrialized societies, such as Japan and Western Europe, showing how equivalent satisfaction can be had, with much less environmental damage (2006). A sense of the "intimate and reciprocal" also is conveyed in the movie *Manufactured Landscapes* (Baichwal 2007), which follows a Canadian photographer as he captures images of very large-scale changes to the natural landscape made as a result of industrial activity in the U.S., China and India. The photographer says of the questions his work raises,

> *"We are drawn by desire – a chance of good living, yet we are consciously or unconsciously aware that the world is suffering for our success." (Burtynsky 2003)*

As in the mainstream press, the stories eventually begin to affect architects "where we live" – that is, in consulting practice. In 2007, a hope became increasingly popular - that "going green" might open the door to more "relevant and rich" design, in a general sense. A few examples of this type of story are listed in Figure 3.2.1 section Arc3.

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* The term "intimate and reciprocal relationship", referring to the one between humankind and natural systems, was coined by Wendell Berry in an essay entitled "Conservation is Good Work" in the collection Sex, Economy, Freedom and Community, 1992

While such a hope is not universally held, it has certain manifestations that are clear – including the meteoric rise in the presence of "green" as a theme in design publications, trade shows & conferences, and the fact that architects are turning out in far greater numbers than others in the design/construction fields to attain a credential (credible or otherwise) as a "leader in energy and environmental design".*

Shared interests: business and environmentalism

The idea to link interests that were, in the past, seen as separate, is expressed repeatedly in the background literature – particularly when in comes to "business" interests and concerns for natural ecologies. The Brundtland Report stated:

> *"Until recently, the planet was a large world in which human activities and their effects were neatly compartmentalized within nations, within sectors (energy, agriculture, trade), and within broad areas of concern (environmental, economic, social). These compartments have begun to dissolve. This applies in particular to the various global 'crises' that have seized public concern, particularly over the past decade. These are not separate crises: an environmental crisis, a development crisis, an energy crisis. They are all one." (WCED 1987)*

The idea that "everything is connected to everything else" also is a central message in the *Limits to Growth* series. "Everything, in this context, includes: resources, industrial output, population, pollution, life expectancy, consumer goods/person, food/person, services/person, the human ecological footprint, and a human welfare index. (Meadows et. al. 1972, 2004).

A merging of the interests of two old foes - ecology and commerce - is proclaimed, by many sources with past experience in either environmentalism or business. The intentional dissolution of boundaries can be seen in the titles of several recent books, such as: *The Chrysalis Economy, Natural Capitalism, The Ecology of Commerce, Deep Economy, and The Natural Step for Business*. (Elkington 2001; Hawken et. al. 1999; Hawken 1993; McKibben 2007; Nattrass 1999)

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* In the spring of 2008, of the nearly 50,000 LEED Accredited Professionals listed on the USGBC website for all countries, the 10,600 Architects were, by far, the largest group. The next largest group was comprised of 2,400 mechanical engineers, following by 1,500 general contractors, and less than 1,000 potential clients. Among Ontario's 3,900 Licensed and Intern Architects, a full 25% carried the LEED A.P. designation, as of 17 April, 2008. (http://www.cabgc.org and http://www.usgbc.org, both accessed April, 2008)

The confluence of global warming, global economic competition, and rising global population is described as both a challenge and an opportunity in *Hot, Flat and Crowded* (Friedman 2008). Because the concept of interlocking crises now is credible, Friedman builds on the idea of the "Triple Bottom Line". This concept is illustrated in Figure 3.2.2, in which solutions are sought to realize a "win-win-win" for "people, planet, and profit" (Elkington 1997). Also, the work of environmental organizations, worldwide, is described as a "movement" causing a cultural groundswell. Through it, one author learned that the "division between ecology and human rights was an artificial one" (Hawken, 2007).

In the fall of 2007, headlines in which business and ecology found common ground ran aplenty; several examples are listed in Figure 3.2.3 section Pub4. A number of business periodicals devoted entire features to the question of how business interests might coincide with environmental concerns. *

The architectural press in 2007 contained fewer examples of the convergence of business and environmental interests. However, the stories that were presented involved multinational organizations, such as Wal-Mart and LaFarge cement (see Figure 3.2.3 Arc4). At the same time, a sense of public accountability was budding among some holders of large portfolios of buildings. "Green design" increasingly was perceived, from the property developer's perspective, as an opportunity for market differentiation, and hence for increased profits (see RMI 1998; Yates 2001; Ross et. al. 2007).

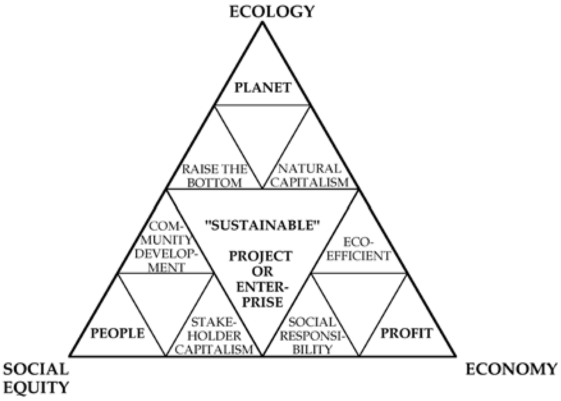

Figure 3.2.2
The Triple Bottom Line

(after Elkington 2001; Mc-Donough 2002)

During this period, business interests and environmental concerns intertwined in various new ways – some more profound than others. For instance, during 2007, there were numerous reports of big business calling upon governments to establish clear policies with respect to climate change. This has to do with either legislating, to "level the playing field", or establishing a new market for trading "carbon credits". The story of Canada's commitment to the Kyoto Accord – made manifest by one political party and then abandoned by its successor in government – is fully told in *Hot Air* (Simpson 2007).

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* See, for example: Devon Pendleton "The World's Greenest Billionaires" in Fortune, 18 April, 2007, a feature issue concerning the "Business of Green" in The New York Times Business Section, 7 November 2007, and Michael E. Porter and Forest L. Reinhardt "Climate Business – Business Climate" in the Harvard Business Review 85 (10) Forethought, October 2007, 21-44

IN THE GENERAL PRESS

Pub4
Business and Ecology find common ground

1	The World's Greenest Billionaires	Forbes	18-Apr-07
2	Banks urging US to adopt the trading of emissions	NYTimes	26-Sep-07
3	CEOs call for aggressive action on climate change	CBC	1-Oct-07
4	Firms need clear climate policies ("Four Hard Truths" Shell)	BBC	8-Oct-07
5	Climate change moves to the boardroom	Globe	15-Oct-07
6	Brown gets down to business with his captains of industry	Guardian	22-Oct-07
7	Business of Green: a special section	NYTimes	7-Nov-07
8	Climate dilemma - ... square economic growth with fossil fuel	BBC	19-Nov-07
9	CBI report urges business to tackle climate change	Guardian	26-Nov-07
10	Business call for plan on climate	BBC	20-Nov-07
11	Business leaders call for climate pact	Guardian	20-Nov-07
12	Ice scream - Ben and Jerry's founder turns attention to climate change	BBC	3-Dec-07
13	A new business perspective on climate change	Guardian	4-Dec-07
14	Conoco CEO tells Detroit of need for fuel-efficient cars	DwJnsNw	3-Oct-07

Pub5
Niche marketing: "eco-consumerism"

1	Green prophets reaping profits	OklndTrib	21-Apr-07
2	There's green in green	CinciPost	23-Apr-07
3	Eco-friendly bikes, surfboards, balls ... how do they perform?	WashPost	11-Sep-07
4	Reformed Libya eyes eco-tourist boom	BBC	12-Sep-07
5	Sustainability takes center stage - Frankfurt auto show	NYTimes	14-Sep-07
6	Can shopping save the planet?	Guardian	17-Sep-07
7	Fresh-faced eco-consumers	NYTimes	1-Nov-07
8	Can fabulous save the planet? The year of eco-decorating	NYTimes	19-Nov-07

IN THE ARCHITECTURAL PRESS

Arc4
The construction industry gets interested

1	Always green building, always, Wal-Mart announces	ArchRecord	Jan-07
2	AIA to green its HQ	ArchRecord	May-07
3	Wal-Mart is reassigning its environmental chief	NYTimes	19-Oct-07
4	Cement industry is at center of climate change debate	NYTimes	16-Oct-07
5	Power plants' CO2 levels revealed	BBC	14-Nov-07
6	America's leaky buildings and the climate challenge	NYTimes	14-Nov-07
7	IT industry urged to address growing carbon footprint	Guardian	3-Dec-07

Arc5
Niche marketing: "eco-design"

1	The Green Indoors - more green you'll keep in your wallet	Azure Jan	Feb-07
2	The top 500 design firms; technology and sustainability are	EngNewsRec	23-Apr-07
3	A LEED of faith (re saturation of market with "green")	CdnArcht	1-May-07
4	Siemens study confirms "greening" corporate America	BusWire	2-May-07
5	Real Estate brokerages say green is the new gold	RealtyTimes	15-Nov-07
6	Developments that go green with gusto are hit with buyers	Globe	4-Apr-08

A shallower type of intertwining is the current trend of "eco"-consumerism, including "eco"-tourism. From eco-friendly surfboards to the declaration that "there's green in green", the mainstream press reflected numerous attempts at niche-marketing to "green" consumers, in various areas of commerce (see Figure 3.2.3 Pub5). In architecture and interior design, "eco-design" seemed, just as frequently, to be promoted to a new character, known as an "eco-consumer" (see Figure 3.2.3 Arc5).

Figure 3.2.3 (opposite) Headlines showing an alignment of business interests and environmental concerns

(see also Appendix 1)

The "dissolving compartments" approach

Even in the polarized realm of American politics, encamped solitudes began to find common ground, during this period. Environmentalists, business (big and small), government (national and local), and the creative arts – all emerged from within their previously delineated territories, to consider fossil fuel use and climate change. After a long period at loggerheads, environmental concerns began to be connected to political benefits. In early 2007, in a Republican-governed U.S.A., a feature in The New York Times Magazine, entitled *The Greening of Geopolitics*, declared:

> *"We need a president who is tough enough to level with the American people about the profound economic, geopolitical and climate threats posed by our addiction to oil – and to offer a real plan to reduce our dependence on fossil fuels."(Friedman 2007, 42)*

A close association between the climate change crisis and various other types of crisis in international political affairs reverberated through the headlines in late 2007. The issues connected to environmental concerns were as diverse as terrorism, child obesity, food prices, and defense radar systems. The responses often were from coalitions that previously would be unimaginable – both left and right of the political spectrum, including partners with diverging agendas (see Figure 3.2.4, section Pub6).

Perhaps the most widely publicized event of 2007 that illustrates the current appreciation of the "interlocking" nature of the issues was the award of the Nobel Prize to former U.S. Vice President Al Gore and the IPCC. In an earlier time, the work of these laureates might have been expected to win a Nobel Prize for Science. Yet, in this era of "interlocking crises" the Nobel Prize was given for this scientific research, under the category of Peace (see Figure 3.2.4, Pub6).

IN THE GENERAL PRESS

Pub6
Interlocking crises: "green" and almost everything else

1	The Greening of Geopolitics	NYTimes 15-Apr-07
2	Can we fight terrorism by reducing CO2 emissions?	Guardian 11-Sep-07
3	Climate change "threatens equality" UK Foreign Secretary	BBC 27-Sep-07
4	Beneath booming cities, China's future is drying up	NYTimes 1-Oct-07
5	Old masters aid climate change study	Guardian 1-Oct-07
6	Gov. Spitzer picks activists to make state a bit greener	NYTimes 1-Oct-07
7	Gore and UN Panel share Peace Prize	Guardian 12-Oct-07
8	Two voices, one message on climate	NYTimes 12-Oct-07
9	Steep decline in oil produc'n brings risk of war, unrest, says new study	Guardian 22-Oct-07
10	Fight against coal plants draws diverse partners	NYTimes 22-Oct-07
11	"Fit towns" plan to tackle child obesity (proposals for 10 eco-cities)	Guardian 1-Nov-07
12	Climate-induced food crisis looms	Guardian 2-Nov-07
13	Challenges to both left and right on global warming	NYTimes 13-Nov-07
14	Warming takes out defense (NORAD) radars	NYTimes 7-Dec-07
15	UN warns on soaring food prices - crops for biofuel displacing food	BBC 17-Dec-07

IN THE ARCHITECTURAL PRESS

Arc6
Interlocking crises: "green" and "design quality"

1	Sustaining an argument (Lloyd Jones)	WorldArc Jun-99
2	Kyoto or Bust (Battle)	WorldArc Oct-01
3	Five Reasons to Adopt Environmental Design	HarvardD Spr-Sum-
4	OK, so it's "Green" but is it Gorgeous?	Perspecti Winter-06
5	Historic preservation meets planet preservation in Portland	Metropoli Jan-07
6	SABMag launches national SAB Awards	SA&B Jan-Feb-0
7	Making sense of the green agenda	ArchRevi Feb-08

This concept of "dissolving compartments" also has begun to reverberate within the architectural profession. The challenge of realizing a more satisfying public architecture and the idea of designing a building that imposes lower loads on natural systems are no longer seen as mutually exclusive. To the contrary, there is evidence that "green design" increasingly is seen, within the profession, as an opportunity for better design (Battle 2001; Lloyd-Jones 1999). This sentiment echoed in the headlines, both whimsically, as in "Can fabulous save the planet?" and more seriously as in "historic preservation meets planet preservation" (see also Figure 3.2.4, Arc6).

Figure 3.2.4 (opposite) Headlines suggesting a "dissolving compartments" approach

(see also Appendix 1)

Many architects are able to overcome the prejudices that linger from earlier decades. No longer must "environmental design" necessarily conform to a rough-hewn image. In a 2003 essay in the Harvard Design Review, the prospect of an architect "picking up the environmental gauntlet" was imagined as not only hopeful but also mandated by current culture. Architecture professor Susannah Hagan argued in favour of the dissolution of compartments within the profession, for intellectual, practical, technical, economic, and pedagogical reasons, in an ironic tone:

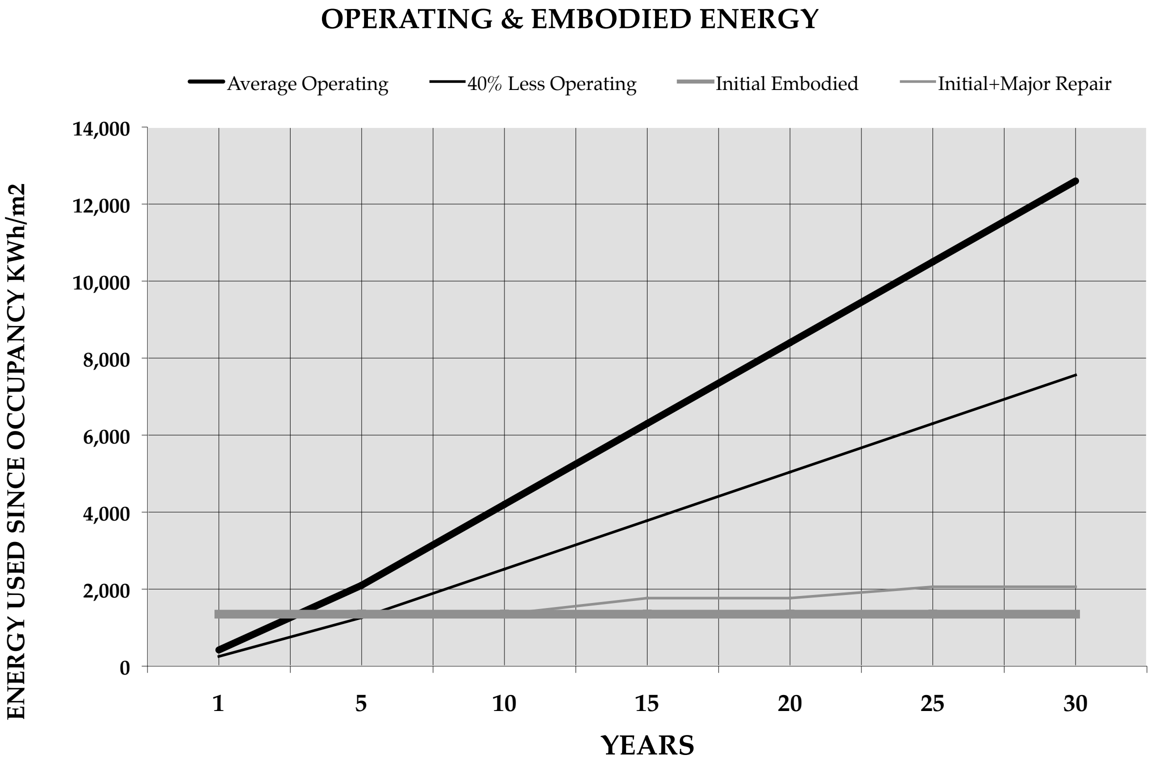
> *"A profound and wide-ranging reappraisal of material culture … is being developed within the disciplines of political science, geography, cultural theory, philosophy, economics, the fine arts, the life sciences, and – at last – architecture.*
>
> *Many within architecture, however, refuse engagement with this reappraisal. For them, environmentalism is embarrassing. It has no edge, no buzz, no style. It's populated by the self-righteous and the badly dressed. Its analysis is simplistic, its conviction naïve, its physics dubious, and its metaphysics absurd. It's a haven for the untalented, where ethics replace aesthetics and get away with it.*
>
> *… If these claims were ever true, they are no longer. …in a culture increasingly capable of merging nature and culture, why on earth are thoughtful talented people still addressing only one end of an enormous range of new possibilities?" (Hagan 2003)*

Support for the idea of interlocking attributes is less often evident in the headlines in the architectural press than it is in the general press. Compartments within architecture may not be dissolving as quickly as they are, in wider society. Yet, from well within the "energy-efficiency" camp, and in a more positive tone than Hagan, architect Jason McLennan argues that a "sustainable" building must also be beautiful

Figure 3.2.5
Cumulative energy use over time

The energy used to operate a 5,000 m^2 office building outscales the energy embodied in its construction by a factor of 3:1 at 10 years, and 6:1 at 20 years, using current average rates (--- line). Even in a much higher-performance building (--- line), operating energy still outscales embodied energy 4:1 at 20 years

(after Cole and Kernan 1996; Lloyd-Jones 1998).



– in order to endure for centuries, to be protected, and to inspire even deeper connected-ness between human society and the natural world. He states:

> *"The most environmentally friendly technology in the world is useless if it is not used in place of its more polluting counterparts. To be used, it must appeal on all levels." (McLennan 2004, 236)*

Between 1997 and 2007, the architectural discourse moved from stories akin to "Some Glowing Issues .. on light bulbs" (Figure 3.2.1 Arc1) to stories like "Five Reasons to adopt Environmental Design" (Figure 3.2.4 Arc6). These declarations of perceived opportunities - to realize locally relevant, culturally rich design, to realize increased profits, and to achieve increased public accountability - are manifestations of "Triple Bottom Line" thinking, from within the realm of architectural consulting practice.

In the "new normal" architecture, multiple challenges are intertwined, including: escalating energy prices, a trend toward greater accountability for emissions, an interest in appealing to the spirit of the age, as well as the age-old expectations of comfort, meaningfulness, and beauty. The headlines noted in the content review of the fall of 2007 suggest that design practice is poised to adopt a "dissolving compartments" approach, in which an architect may need to attain a better understanding of principles that have been recently perceived as belonging to the engineering disciplines.

Operating energy as the principal load

Given the challenges described so far, it will be difficult to argue, going forward, that a design really is "sustainable", unless it is a very modest fuel-consumer. The consumption of energy – to modify temperature, air quality, and light levels indoors - is the largest and easiest-to-measure demand that a building makes on the natural environment. The consumption of energy is very closely associated with pollution effects, including greenhouse gas emissions. Also, the limits within which energy use can be managed by a building operator are determined by design.

The reasons to decrease fossil fuel use outlined in Section 3.1, are re-iterated in *The Natural Step Story*, in a chapter devoted to "The Crucial Energy Problem" (Robert 2002). Accumulation of greenhouse gases, acidification, local air pollution, and accidents in the distribution systems (like the oil spills mentioned in the November headlines) are cited as reasons why consumers will, many expect, demand increased

Building Type & Location		**Size**	**E Intensity**	**Estimate or**	**GHG**	**Approx. GG Intensity**	
		sf	*kWhr/m2*	**Actual**	*tons/yr*	*tons/m2/yr*	
Courthouse	Youngstown, OH	52,200	225	A	589	0.121	
Office	Allentown, PA	280,000	219	E	2,875	0.111	
Higher Edu	Oberlin, OH	13,600	94	A	90	0.071	*
K-12 School	Harrisburg, PA	43,600	74	E	162	0.040	
Office/Plant	Hinesburg, VT	46,500	69	A	58	0.014	*
Office	Woods Hole, MA	19,200	50	A	79	0.044	*

Figure 3.2.6
Greenhouse gas intensity vs. energy intensity

*Very low energy-intensity buildings are also low in greenhouse gas emissions. (The energy intensities here are drawn from the US DOE High Performance Buildings Database. Conversion to greenhouse gas intensity was done, as if the buildings did NOT use energy from renewable sources, using EnergyStar Target Finder. An * denotes those that, in reality do generate renewable energy on-site.)*

energy efficiency, increased use of renewable energy sources, and the reduction of dependence on oil, coal, and gas.

"Embodied" energy sometimes is seen as the concern that "belongs to architects" (UIA 2007) - while operating energy (for heating, cooling and lighting) is "left to the engineers". But studies have illustrated the relationship between operating energy and embodied energy in non-residential buildings (Cole and Kernan 1996). For a typical office building in Toronto, operating energy (at today's average rate) outweighs embodied energy by a factor of approximately 6:1, after the first 20 years of occupancy (see Figure 3.2.5). Embodied energy is an important consideration, but it is more difficult to measure, and – given current averages - much smaller in magnitude than operating energy.

Measuring the larger load (operating energy) occurs in two phases. Verifying the actual consumption of a building – once it is occupied - is a simple matter of analyzing regular utility bills. * Predicting the energy consumption of a large civic building – during the design stage - was, until recently, a complex process, understood by a select few specialists. It still is complex, but is becoming more accessible to designers, with advancements in simulation software.

As already stated, the combustion of fossil fuels in buildings is a significant source of greenhouse gas emissions. The exact method of relating fossil fuel energy to CO_2 emissions is an emerging science, but it is certain that a very low-energy consumer will always be a low-CO_2 emitter. Proof of this is found in estimates of the emissions of a few of the case study buildings (Figure 3.2.6).

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* An example of the method for deriving energy intensity from a utility bill is found in Appendix 4.

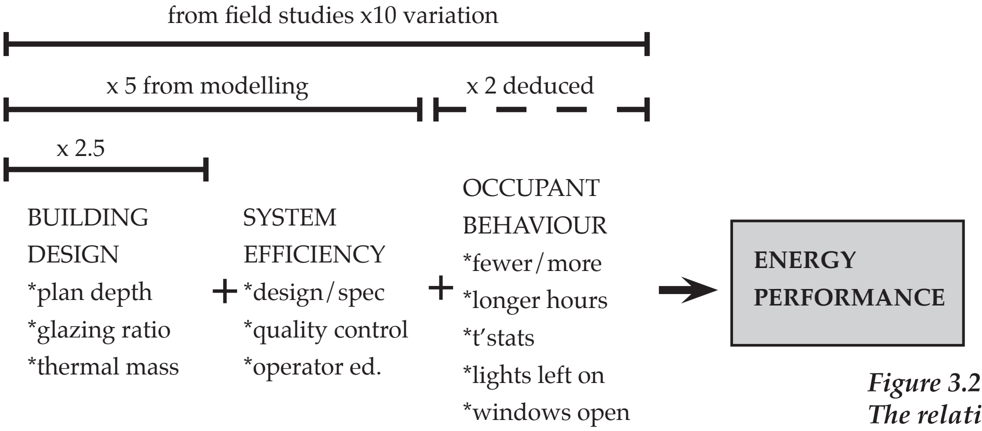


Figure 3.2.7
The relative contribution of building, system and occupant factors on energy use

(after McCubbin et. al. 1992)

Finally, operating energy can be reduced significantly, through architectural design. It is true that the conduct of the building operator, during occupancy, has a very large impact, and it is fairly common for a building to under-perform its predicted energy use. However, the most attentive operator can only achieve what the design will allow. Likewise, the efficiency of climate control systems has a very large role to play - although these systems can only achieve efficiency within the parameters that are dictated by the "cards the architect deals" with the schematic design (see Figure 3.2.7). This assumption is at the root of the study; it is tested and illustrated extensively in both the Analysis of Case Studies and Study of Design Parameters (Chapters 4 and 5). For all of these reasons, in this study, operating energy is the load side of the "low load + high satisfaction" equation.

Solving for low load and high satisfaction in a single design

The architectural press is full of "zero", at present (e.g. Gonchar 2006). Terms such as "net-zero energy cost" and "zero carbon" are all at issue in the quest for "the zero energy holy grail". One architectural commentator expressed the trouble that an architect likely would have with "zero" this way:

> *"Zilch. Nada. Zip. Nil. Architects don't usually demand this kind of breathlessly flattering description for their latest project …. but we want to get this conversation about 'achieving nothing' underway." (Fortmeyer 2007)*

Architect William McDonough is emphatic in his rejection of the quest for "zero". For many architects, the "hair-shirt" version of "environmentally-friendly" design is a thing of the past. Also, with respect to non-residential buildings in built-up areas in particular, there is a question about how much “autonomy” is really necessary – described as follows:

> *“Without reference to their wider context, it is somewhat more difficult to define specific ‘sustainability’ goals for individual buildings. The use of ‘sustainable’ targets such as zero fossil fuel use, zero greenhouse gas emissions, zero potable water use and zero sanitary waste entering municipal systems, implies that all future buildings should become more ‘autonomous’. It is unclear at this time what environmental strategies are most appropriately addressed at the building or community scale, or whether autonomy is an appropriate goal at either of them”. (Cole 1999, 234)*

McDonough points out that people quickly tire of being “less bad”. He suggests that the effort to design a building that is simply “efficient” is an “un-sustainable” practice. Instead, he acknowledges the presence, naturalness, and power of human desire (2002). This sentiment harkens back to the words of Buckminster Fuller, who declared:

> *“When I am working on a problem, I never think about beauty. I only think about how to solve the problem. But when I have finished, if the solution is not beautiful, I know it is wrong.” (Ferrara 2006, 51)*

In this study, it is assumed that an architecture that satisfies human desires (while imposing very low loads) has the potential to create positive feedback. A project that convinces people – by direct experience – of the quality and variety available at low loads may inspire more projects with similar ambitions. Only when a low-load architecture is understood as not just attainable, but also comfortable, reliable, and delightful – that is, very satisfying – will it become the “new normal”.

This snapshot of the public and architectural discourse, in late 2007, shows an evolving approach in sectors as diverse as commerce, industry, land development, defense, and science. The popularity of concepts such as the “Triple Bottom Line” illustrates that perceptions now are very different from what they were when Rachel Carson and Jacques Cousteau decried the impacts of industry on natural systems. Business interests and environmental concerns are trying out new ways to advance in concert - each in its own interest, to be sure – but with a new-found willingness to consider the potential benefits to both.

Also, environmental concerns now are perceived as connected to every realm of human enterprise – from international security to the family dinner table. Brundtland's declaration that "compartments have begun to dissolve", reinforced by current architectural discourse, suggests that an architect working with the "new normal" must prepare to address both low-load and high-satisfaction, in concert. This review also suggests that architecture, as an expression of the general temper of these times, is poised to address environmental concerns in a way that is fully intertwined with a host of other concerns.

Some critics insist upon demarcations between internal camps, which they label as "eco-technic", "eco-aesthetic", or "eco-cultural", or "eco-social" (Guy and Farmer 2001). Yet others enthuse about the prospect of a more de-compartmentalized approach (Croxton 1997). As an example of the sentiments expressed by many, Buchanan proposes:

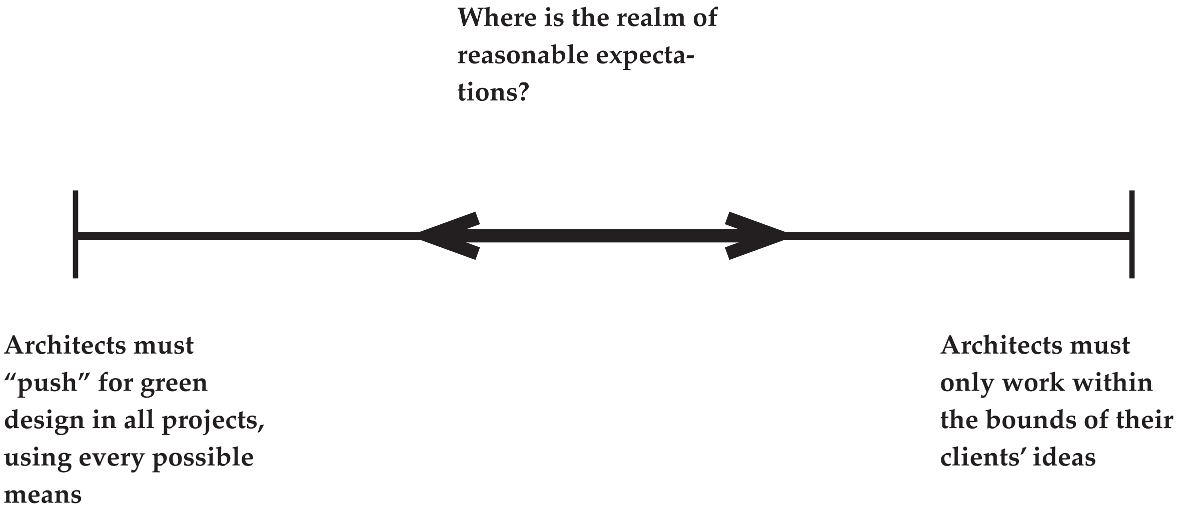
> *"Green design both influences the basic design parti of a building, especially the cross-section and the elaboration of the outer envelope, and transcends mere energy efficiency and the minimization of pollution. Instead it must attend to a whole range of matters from the technical and ecological, to the economic and social, including even the cultural and spiritual (2005)."*

Similar suggestions are made from the realm of engineering research:

> *"The impending energy shortage and increasingly acute environmental problems, which have arisen from our civilisation's hunger for energy, will radically change our buildings. The long-hidden question of energy efficiency will once again become a major theme in architecture. It is a matter of applying our technical knowledge and our long years of experience logically to create concepts for new and refurbished construction that will lead to low-energy buildings. ... There are already countless examples to show that these premises can produce good design and high-quality architecture. Concerning itself logically with the theme of energy will not mean a step back for architecture but should be an enrichment, provided it is tackled in a creative way. (Hausladen et. al. 2006, 29)*

This review has shown that the 21st-century round of energy-conscious design is very different from earlier versions. Given the science described in Section 3.1, and the change in public mindset described here, this round most probably will last much longer than the oil crisis of the 1970s. This time, environmentalists and business people are working together. And this time, "low-loads" are imagined for everyday civic buildings, which are expected to be no less "high-satisfaction" than their gas-guzzling counterparts, into the bargain.

Figure 3.3.1
When an Architect goes "green": choosing a reasonable role



3.3 ABOUT AN ARCHITECT'S MANY ROLES

Given the need for a "new normal" in North American civic buildings, what degree of change in the behaviour of architects would be reasonable? "Green" design is slowly working its way into everyday practice, amid exhortations that architects ought to advocate strongly for advancements in public policy that would make the built environment more "sustainable". On the other hand, some within the profession warn that architects who are new to "green" design ought to be careful to avoid raising unrealizable expectations. Meanwhile, many architects who have been trying to "green" their practices for some time confess to just how challenging the effort has been.

Moving toward a more "environmentally-conscious" design is the shared objective of all of the commentators here. The goal is not disputed, but a much-needed debate is beginning, about how to reach it. This literature identifies various ways in which an architect's roles may be affected, as concerns grow about for fitting buildings better, within natural systems.

In this section, four of the key roles that a consulting architect plays are considered, including: "strategic advisor" to the client, "imaginative" designer needing technical know-how, "facilitator or coordinator" of the design team, and "public advocate" for "sustainable design". This discourse begins to describe the gap between the conditions of practice, as they are now, and conditions that may be necessary, to realize buildings that truly are "lower-load", in the future.

The Architect as Strategic Advisor to the client

The statements at the left and right sides of Figure 3.3.1 express two extreme positions that an architect might take, toward their role with respect to "sustainable" design. On the right is an architect with an absolute unwillingness to assume responsibility for the environmental consequences of the advice that he or she gives. The architect waits passively for the client to identify "green" as a design goal, and to define what that means. On the left is an architect who assumes responsibility for the impact of his or her advice. It charges aggressively into territory that many feel is both well-suited to their own personal values, and in need of spokesmen. However, this degree of commitment is perhaps more than is reasonable, safe or even possible.

The statements presented in Figure 3.3.1 are made by consultants in North America every day. In the opinion of this researcher, they are both too extreme to be supported – either by the legal context in which architects work, or by the practicalities of advising with a real client. The statement on the left is problematic, because - from a client's point of view - neither stubborn adherence to a single opinion, nor enthusiasm that is unsupported by evidence, is an admirable quality in a professional advisor. Also, if an architect's passion for a proposed solution is not supported by "know-how", then there will be serious problems, when the building is occupied, if not prior. The statement on the right is problematic because it disavows all of the evidence about the importance of the "new normal", as presented in Sections 3.1 and 3.2. The assumption in the present study is that the approach to the "new normal" design that is most professionally responsible will emanate from a realm, somewhere between these two extremes.

At least one observer of the profession complains that some architects, when they espouse "green" design, display an "activist zeal" that is, in his opinion, unbecoming of a professional, and also very high-risk, saying:

> *"Green building necessitates a change in knowledge bases … there are two general risk issues that need to be addressed: information reliability and misguided advocacy. The two problems are clearly linked – bad information or information not closely examined is often intertwined with a strong desire for belief to substitute for judgment." (Vyas 2007, 9)*

Vyas takes aim at recent studies emanating from the U.S. - in particular, those that promise that a "green" design shall result in a positive return on investment, elevated worker productivity, and a reduction in illnesses such as asthma. He characterizes these studies as "seriously flawed or incompetent".

Vyas also is critical of what he sees as architects' tendency to want to "save the world" or, in the case of environmental sensitivity, "save" the planet - as if that were humanly possible. A regrettable tendency among architects to express themselves as if this were the aim is evident in some of the literature, quoted later in this section. However, his critique does not dispute the validity of the goal of realizing more "low-load" buildings. The concern is about more than just the rhetoric; it is with the way the challenge has been approached by architects, in some instances.

If advice, in this or any other area, is given to a client with no more than casual reference to emerging information, or without validation of the quality of that information, then there is a risk that a disappointing outcome will discredit the architects in the scenario, their clients, and the cause they so passionately espouse. For instance, a consulting architect may recommend that a client use a product or a "design guide", without examining the item for defects. The reasonableness of the less-informed party (the client and the public at large) in relying on the architect's expertise is well established in tort law (McLachlin and Wallace 1987). This expectation is as present in a "green" project, as it is in any other type of project. It may even be heightened in a scenario in which an architect claims to have specialized "green" expertise (McGarva 2007).

The providers of professional liability insurance in Ontario have identified a number of real risks that are arising as a result of the recent enthusiasm for "green" building. These risks have resulted in claims of negligence, made against practicing architects. They include:

- being found to have over-represented one's qualifications,
- being judged against an elevated standard of care,
- having raised an unattainable expectation about the comfort or productivity of building occupants,
- having predicted potential economic gains from energy savings incorrectly,
- having been over-optimistic about capital costs, and
- having to pay for a "guaranteed" outcome that is not realized, or realizable (Hackett 2006, 2).

As "strategic advisor" to the client, the architect has challenges in at least two ways. First there is the question of whether to "push" for "green" goals, with a client who has not yet expressed an interest in them. Second, there is the question of how to help a client, who expresses an interest in incorporating some "green" goals, to define what that is likely to mean on the particular project at hand. Architect Bill Reed, of Integrative Design Collaborative Inc., says this about the first question:

> *"It is often asked in various green design … seminars, "how can you convince a client or a boss to … take environmental issues seriously? The answer is you, on your own, can't convince anyone to do anything. People must be ready to question before they will listen to an answer. However, you can be proactive, to help create a shift in thinking. This requires an appropriate facilitation process, or patience, or both." (Reed 2004)*

Reed argues for a process of asking questions, in preference to "promulgating" a green agenda on an unsuspecting client. The distinction is profound – not only because of an architect's obligation to give objective advice, but also because there is no need for an architect to take over the role that properly belongs to the client. Architect JoAnn McCallum, whose practice has been dedicated to "green" design for a decade reports as follows:

> *"… our clients and potential clients need to become better informed about what it is they are really asking for. Many ask for "green design" or specific certification levels to be achieved, because it is the politically correct thing to do, with an expectation that it simply gets delivered without any input or effort from their side."* (Ross 2008)

Institutional clients, in particular, tend to rely on their architects to give strategic advice about both the short-term and long-term consequences of pursuing a particular path. Short-term consequences, related to "green" goals might included a change in the capital cost and or a change in the time frame or fee structure for the design process. Long-term consequences might include a change in the familiar maintenance routine, or adoption of such things as energy-monitoring protocols.

The onus, then, rests upon the individual architect, when counseling a client, to be impeccable with one's words, and to be very clear about expectations that are raised – both in terms of the design decisions, and in terms of roles and responsibilities. To mitigate the risks identified by Vyas and Hackett, it is essential to avoid disseminating "half-true truths". Also, in the manner of Reed, an effective strategy is to continue to seek for better information – particularly about the consequences of "green" design choices that reasonably can be foreseen.

The Imaginative Designer in need of technical "know-how"

Randolph Croxton, a consulting architect with long experience in green design, in the U.S. declares:

> *"... the greatest cultural barrier to the adoption of a fully integrated, high-performance design approach may be the tendency for architects to see issues of performance as technical or "engineering" issues, and as a drag on artistic freedom. The myth that you can be good artistically or good technically – but not both – lives on. There is no question that the sustainable/environmental approach is more demanding. The architect can no longer leave the 'uncool' technical and performance issues and code compliance to others." (1997)*

This sentiment echoes in the words of Charles Simon, an experienced practitioner from Ontario, speaking about the skills and attitudes required of an architect who would pursue "low-load + high-satisfaction" design:

> *"the greatest green-washing trap for all of us is the one we can so easily fall into unintentionally. … Mastering the art and technique of environmental design … is endlessly fascinating, deceptively complex, and periodically humbling. It calls for technical mastery combined with holistic thinking and design imagination" (2000).*

Despite the attitudes expressed by Reed, Croxton, and Simon, a profound gap - between awareness and "green" intentions on one hand, and real accomplishment on the other – has been measured, in at least two independent surveys of practicing architects. Many practitioners "talk the talk", espousing environmental concerns and advocating for "more sustainable" design - but a very small minority have "walked the walk" to realize a truly low-load building. Unfortunately, the use of green building rating systems seems to be contributing to this problem, substituting the application of an easy recipe for analysis and understanding. The curator of a "green design" exhibit at New York's Urban Design Center, observed:

> *"…too few architects, particularly in the United States, seem at all aware that the construction and operation of buildings is responsible for nearly half the energy consumed by developed countries. Moreover, they seem untroubled by an awareness that this is largely unnecessary …" (Buchanan 2005)*

In the U.K., this also is the case, as can be seen in the results of a survey conducted in 2005. From the 3,223-member roster of RIBA-certified practices, 829 respondents stated that they had a special interest, or were involved in, "sustainable design". Yet, when invited to respond to a more detailed questionnaire, regarding design drivers in green building, only 95 firms - approximately 3% of the membership - participated.

The U.K. architects were well aware of the impact made by buildings on atmospheric and resource depletion. And they were able to distinguish between energy-efficiency, as a primary "design driver" in a "green building", and the top ranking parameters of some of the existing green building rating systems. That is, they were "expert" enough to answer the detailed survey questions well. However, the majority of respondents said they expected to rely on technical and active strategies, rather than passive approaches, although most

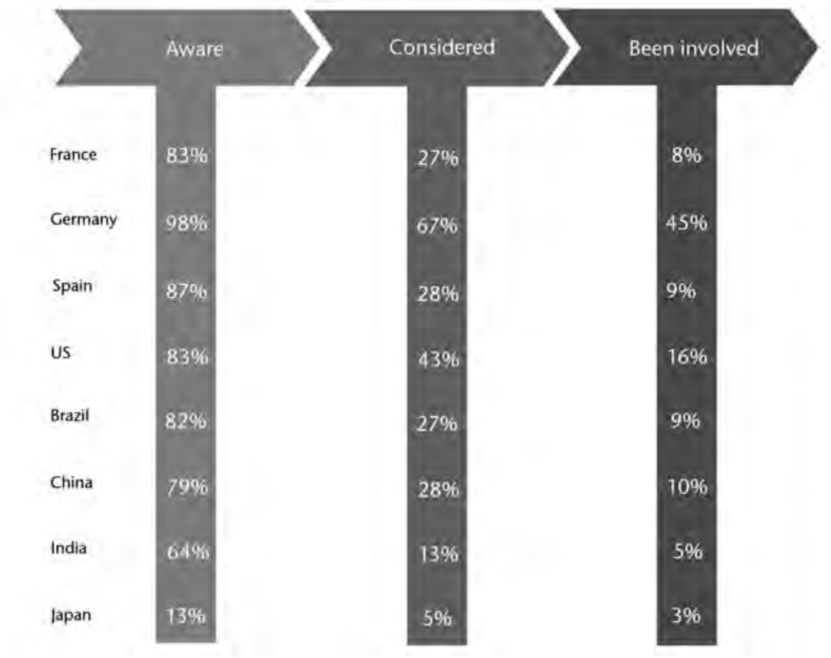


Figure 3.3.2
Experience with "green building" compared to awareness among building professionals

(WBCSD 2007, 20)

believed that passive design could contribute to energy-efficiency. In this sense, the answers revealed a degree of vagueness with respect to the power of the architecture to effect a lowering of environmental loads (Valkili 2007).

In another study, entitled *"Energy Efficiency in Buildings – Business realities and opportunities"*, the World Business Council on Sustainable Design examined the current situation in the six countries or regions that consume two-thirds of the world's energy (WBCSD 2007). In Brazil, China, Europe, India, Japan, and the U.S., more than fourteen hundred building professionals were surveyed – including architects, major contractors, professional landlords, and corporate tenants.

The common tendency in this mixed group was to under-estimate the impact of buildings on greenhouse gas emissions, and to over-estimate the cost of mitigating that impact. When asked about their level of involvement in green building, the survey responses revealed how few building professionals had direct experience with designing or running a "green" building, relative to the number that claim awareness of its general objectives. The results are illustrated in Figure 3.3.2. The findings in the six-region study were consistent with those in the U.K. study, with regard to how few have "walked" through the realization of a green building, as compared to how many are "talking" about it.

This raises the question of whether ability to design either a "green" or a "low-load" building is – or ought to be - considered one of the "core competencies" of an architect. All licensed design professionals in Canada - regardless of age, degree of education, or scope of practice - are held to the following standard of care:

> *"…to exercise the skill, care and diligence which may reasonably be expected of a person of ordinary competence, measured by the professional standard of the time."* *(McLachlin and Wallace 1987, 97)*

These duties are expressed similarly in the U.S. and the U.K. and are familiar to Intern Architects, as they enter the profession (AIA 2004). Yet, when describing the risks and the opportunities that face companies in the building industry as they enter the "energy efficiency market", the six-region survey concluded:

> *"The project's perception research showed that there is a widespread lack of know-how and a reluctance to innovate."* (WBCSD 2007, 9)

This survey quantified the degree to which lack of "personal know-how" is perceived – by the building professionals listed earlier - to be a barrier to adoption of "sustainable design" practices (see Figure 3.3.3). And it also quantified the degree of "conservatism" for which, the study says, "the building industry is renowned" (see Figure 3.3.4).

Figure 3.3.3
Percieved barriers to change in the building industry

(WBCSD 2008, 21)

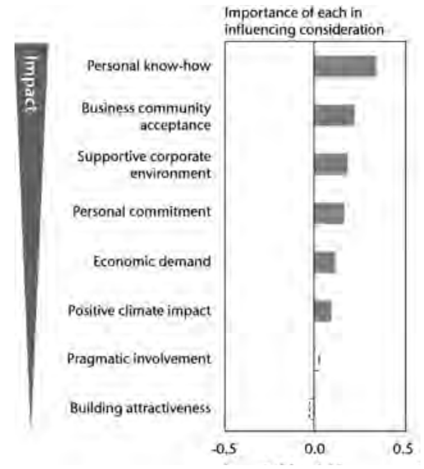


Figure 3.3.4
Conservatism as a barrier to change in the building industry

(WBCSD 2008, 39)

A lack of know-how about energy intensity was illustrated even among researchers and practitioners who are relatively experienced in sustainable design, at a meeting of the Canadian Design Research Network (CDRN) in July, 2007. When asked how many of the 26 participants could state the energy intensity of a design that was "on their drawing board" at the time, 8 of the 13 practitioners in attendance indicated they could. When asked how many could state the actual energy intensity of five of their completed projects, only 3 stated that they could. *

This pattern of "having talked" but not yet "having walked" is observable in the wider realm of Ontario architectural practice, as well. At the time of writing, 421 individuals, who described their primary area of practice as architecture, in Ontario, were listed as "LEED

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* Available at www.cdrn.ca/events/sustainability, accessed 10 Dec. 2008.

Accredited Professionals". Meanwhile, there were only 42 projects in Ontario that had received LEED Certification in Ontario.* Also, as will be shown in Section 3.4, experience realizing a LEED-certified building does not necessarily equate to experience with realizing a design that truly is low in environmental loads.

From the Valkili and WBCSD studies, the CDRN meeting, and the statistics about "LEED accredited" architectural designers in Ontario, it appears that "ordinary competence" includes a general awareness of green design intentions, but does not yet include proven experience with realizing a low-load building. This underscores the concern expressed earlier that the current groundswell of interest in "green" design – while justified by the science – nevertheless demands extra vigilance from architects, regarding the expertise that they claim.

Reasonable shifts: education & core competence in practice

Earlier in this chapter, it is argued that climate change and energy scarcity really are pressing issues. Here, it has become apparent that only a small proportion of the architectural profession has demonstrated "know-how" in designing with these issues in mind. Therefore, there is a need to make the information that is required to design in a "new normal" way available to architects, and quickly.

Increased education, for students and licensed practitioners of architecture alike, has been identified – from outside the profession - as an urgent need. Having identified lack of know-how and experience (among both architects and their clients) as one of the three most significant barriers to achieving lower levels of energy use, the WBCSD study identified the three most significant levers to effect change. Its report makes the following recommendation:

> *"Educate building professionals and users in order to encourage behaviours that will respond more readily to market opportunities and maximize the potential of existing technologies." (2007, 36).*

Rather than aiming to acquire the largest number of prizes in the competition to be seen as "green", an architect who truly wishes to realize designs that impose lower loads, might adopt a more studious approach. While the engineer, the developer and the building operator seek out solutions that each can manage on his own, the

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* There were approximately 370 projects "registered" with LEED; these were either starting design or pending review. It is not known how many of the 421 LEED A.P.s in Ontario were licensed architects, as compared to interns, or para-professionals listing their area of interest as "architecture" (from http://www.cagbc.org accessed 17 Oct 2008).

architect might inquire, “how much can the fundamental architecture contribute?” – which is the central question of the present study. Mark Shapiro, at BNIM Architects in Kansas makes the following comment about the competition between practitioners to be the “greenest”:

> *“I prefer not to use words like first or longest or best, when talking about design. … The idea is not to be the first one across the finish line. It’s to stay in the race and continue to get better as you go” (Schulman 2006).*

The scant supply of experience in practice also has been the subject of complaints about the North American Schools of Architecture, where:

> *“Fewer than half … have faculty with a deep understanding of the design principles necessary to transform architecture from its mindless and passive reliance on fossil fuels to an architecture intimately linked to the natural world in which we live. And, of the schools that do have faculty with experience designing low-energy buildings, many have only one faculty member with the necessary expertise.” (Mazria 2003a, 50)*

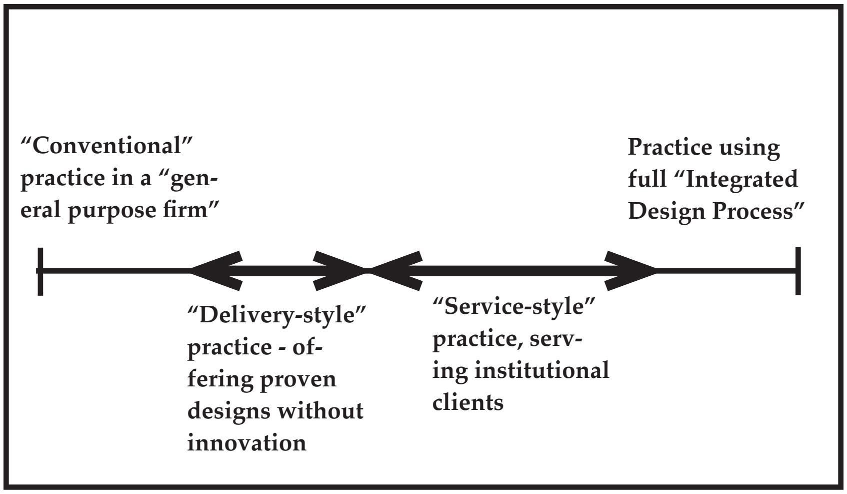
Mazria suggests that the training of young architects should include courses in computer simulation and living systems, to complement studios in which students and teachers investigate the necessary design principles, together. To ensure that a new standard be upheld widely, the accreditation of schools, and the requirements of licensure also would include requirements related to “core knowledge” of energy-reducing design principles. Outside the schools, Mazria speculates that if regulations were passed to reduce the energy-intensity of state and federal buildings, then practicing architects would learn how to accomplish this goal, within a year (Mazria 2003b, 104).

The Architect as Co-ordinator of the design team

It often is said that architects need more than new knowledge to accomplish a “green” design; they also need an enhanced design process. Many enthusiasts of “sustainable design” are quick to mention the benefits of the “Integrated Design Process”, or “IDP”. This approach is contrasted to a *“more conventional design process”* by a *“large majority of general-purpose design firms”* (Larsson 2004, 1)

Experienced consulting architects in Ontario, who are accustomed to working on mid- to large-scale institutional projects, may not feel

Figure 3.3.5
Architectural consulting practice as a spectrum, rather than two poles



that their practices are appropriately reflected in the term "general-purpose firm". They may find the word "conventional" both vague and, perhaps mildly offensive. Many of the features of the "IDP" sound like they already are present in a client-centred, "service-style" consulting firm, that has satisfied public clients.

The distinction between a practice that adopts IDP and a "conventional" practice is convenient to the promotion of IDP. However, it would be more accurate to acknowledge that architectural consulting practice runs a wide gamut, defined by such factors as clientele, type of "value-added" that is offered, the qualifications of personnel, and organizational approach. Figure 3.3.5 shows the position of two recognized types of practice, relative to those that Larsson mentions. *

In IDP, it is easy to recognize many of the activities that distinguish a "service-style" practice (which is often chosen by civic clients) from other styles of practice. For instance, on a large civic project:

- The architect always works with a large team of consultants, and is expected to co-ordinate the decisions of all disciplines, throughout all stages of the project.
- The architect and mechanical engineer consult one another, as the basic shape and layout of the building are established. (For instance, it is not realistic to establish the design of a hospital or a courthouse without making allowance for the central mechanical and electrical equipment, and the associated distribution systems.)

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* For a description of styles of consulting firms, see Maister 1986 a summary outline of which is included in Section 4.4.

- The institutional client often asks the architect, and sometimes other specialized disciplines, to assist with pre-design goal-setting. This may include the preparation of a program of space allocation. (This contrasts with "delivery-style" practices, who work for commercial developers that set their own - mainly financial - goals, usually without the benefit of a designer's advice.)
- Pre-design goal-setting often involves a wide range of "stakeholders", including building occupants and neighbours. (Again, this contrasts with firms who consult to speculative commercial or residential developers.)
- The client team includes experienced building operators, who have a say in the choice of climate control systems.
- Sometimes, the architect and mechanical engineer perform a post-occupancy evaluation (of a sort), particularly when they expect to work with the same client on a subsequent project. *

However, there are aspects of IDP that introduce a new flavour to the well-established practice described above. As one prominent Canadian proponent of IDP comments, *"There is no single element of integrated design that is revolutionary … IDP differs in intention and emphasis from conventional design."* (Zimmerman 2006, 7) The challenge that the IDP intends to address is to introduce better information earlier in the design process, and to avoid poor performance and high operating costs coming as a surprise to a client, on opening day (Larsson 2004). The IDP provides an alternative to the "prescriptive" approach offered by many of the design guides and green building rating programs. The consulting phases (schematic design, design development, and so on) don't change. *"What does change however is how the work gets done in each phase and how the team moves from one phase to the next."* (Zimmerman 2006, 6, 9) Proponents of the IDP argue that investment in a competent design team provides the best yield to the client or investor (IEA 2003). The IDP process is described as goal-driven, inclusive, holistic and *"just plain fun"*. (Zimmerman 2006, 6)

The key elements that distinguish IDP from earlier service-type institutional practice are:

- There are more "feedback loops", exchanging information between the architect and the other members of the design team, particularly early in the schematic stage.
- Performance goals are established by consensus of all members of the team, in consultation with the client. They are made explicit and tangible, early in the process, and are revisited at

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* author's experience in consulting practice in Ontario 1983-2005.

Figure 3.3.6
Framing better questions - the key challenge in "IDP"

(Zimmerman 2006)

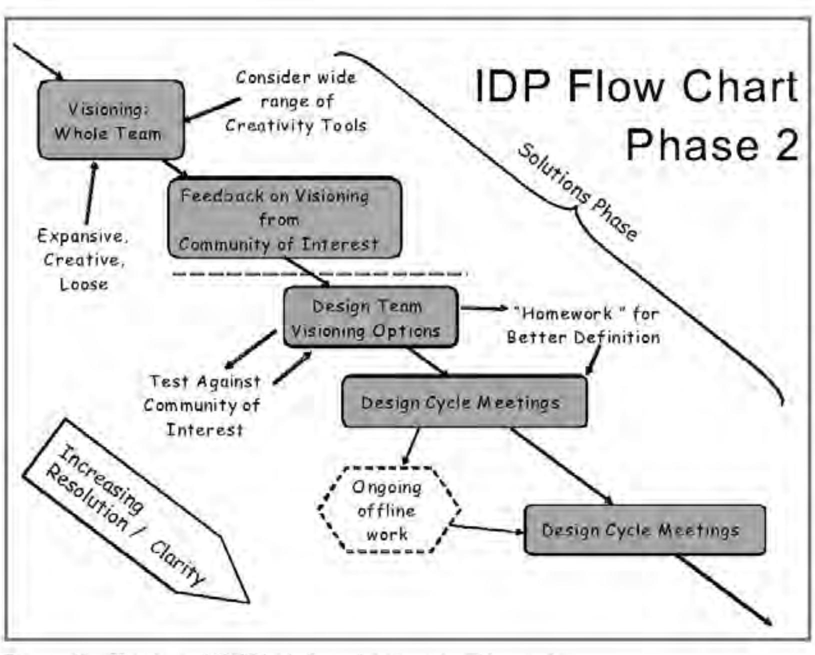

Figure 8 – Toronto IDP Workshop Approach – Phase 1

every stage, and they include specific targets for energy use.

- There is sustained involvement of a new specialist(s) in energy design and/or energy simulation.
- There is short-term involvement of other specialists who may be new to the team, such as daylighting, comfort, or biology.
- Post-occupancy evaluation is conducted in relation to the performance targets that were established at the outset.

The IDP most likely will play a part in the realization of a "new normal" in North American architecture. However, commentators have identified a few particular challenges to architects wishing to adopt the IDP approach. One has to do with "forsaking the ego for the eco" (Reed 2004). A designer of the egocentric variety may not wish to be seen to have practiced poorly in the past, or to be introduced as in need of fresh learning. * Also, there may be a perception that IDP portends a loss of "creative control", which Zimmerman counters thus:

> *"IDP sessions are generally challenging, creative, and personally rewarding. By setting "stretch goals" and finding novel ways to reach them, creativity is unleashed in ways that conventional design rarely allows for. I have seen battle-weary professionals become enthusiastic at what they can do in this context. People rediscover why they joined the profession in the first place."* (2006, 6)

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* Personal communication with Bob Berkebile of BNIM Architects, August, 2003.

In the "green" literature, this idea of enhanced collaboration takes centre stage (see Buchanan 2005). However, many architects believe themselves already adept at integrating. Also, architects are admired, from outside the profession for their skill in facilitating group problem-solving (Malin 2005). For example, one architect argues:

> *"Architects have the intellectual and educational framework and the team-building skills to conceive buildings in an integrated fashion with high intellectual equity, employing multidisciplinary teams. These 'architectural traits' are profoundly different from the reductive thinking that characterizes the scientific/engineering approach." (Croxton 1997)*

However, when it comes to "sustainable design", there is a persistent challenge that architects feel, that comes up often in conversation, but does not appear in the IDP literature. Architect JoAnn McCallum puts it this way:

> *"If the recent financial crisis has taught us anything, it must surely be that you cannot transfer risk. Nor can you download it, bury it, or hide it. The more fractured, less visible it becomes, the more exponentially dangerous. …There is tremendous inertia (and risk, both perceived and real) to exploring the potential savings associated with system integration. It is easier to understand building systems as separate and distinct silos and to size/specify them accordingly. As architects we must continually try to find the relationships between systems,* ***in order to know the right questions to ask.*** *Demanding that our clients and consultants think beyond their own specific area of knowledge is exceptionally challenging…" (Ross 2008)*

As well as co-ordinating the work of the design team, an architect must be able to integrate the technical with the more human concerns "within her (or his) own head". An outline of just one phase is illustrated in Figure 3.3.6. The key challenges are to frame effective questions, from the earliest stages, and to incorporate the answers into an effective whole design. This is the challenge that the information derived through the research in Chapters 4 and 5 may help to address. The Director of Architectural Practice at Arup Associates in London, who has been doing so for 40 years, says:

> *"In our studio …. it is proving possible to assimilate and consider a broad range of complex ideas, which reflect not only an aesthetic sensibility, but a real recognition of the imperatives that face us. … We need to reflect on whether our projects are fulfilling their potential for those that use and enjoy them, and for society and the*

> *environment generally. By thinking in this way, we can liberate the true creativity of designers to create non-formulaic approaches with skill and breadth of knowledge, humility and a committed sense of purpose as to how buildings can affect people and their environment, context and culture for the better." (Beaven 2008)* *

Public advocacy for "sustainable design"

As management guru Tom Peters says, "practice is what you mean to stand for" (1999, 14). So, despite the measurable lack of experience with realizing a "green building", many architects today believe that lowering the environmental loads of a building is an urgent goal to meet, and are prepared to say so in public.

Advocacy is part of professional culture; many architects, like those in other lines of work, view advocacy for some issues of importance to the public as one of their professional obligations. For instance, within the pages of professional journals, architects routinely encourage one another to speak up, in support of specific design values (such as putting a priority on pedestrian-friendly urban streetscapes), or to demonstrate the "value-added" by the way architects go about their work. A recent article typifies this kind of urging:

> *"There is growing evidence that architects are skillfully forging alliances in the realm of politics, policy and education. And there appears to be an increasing awareness of what architects can offer in the civic arena. … In a general sense, the skills architects practice virtually every day make them especially effective in public service: a capacity for synthetic vision, problem solving, and group facilitation." (Pressman 2000)*

In fact, the professional Codes of Ethics issued by architectural licensing bodies *"usually provide that members should adopt an active role in extending the effectiveness of the profession"* (McLachlin and Wallace 1987, 44). Advocacy in general – and benevolence toward the natural environment, in particular – is supported, in the Codes of Ethics of the American Institute of Architects (AIA) and the Union Internationale des Architectes (UIA). Advocacy on behalf of the improvement of natural habitats is held as an ethical standard, to which members are encouraged to aspire. One example of such a standard reads as follows:

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* See also Mike_Beaven.mp3 at http://www.aruponline.co.uk/podcasts/arup_podcast, accessed 30 March, 2009

> *"Members should continually seek to raise the standards of aesthetic excellence, architectural education, research, training, and practice. … Members should respect and help conserve their natural and cultural heritage while striving to improve the environment and the quality of life within it." (AIA 2004, 1)*

It is important to note that the AIA and UIA codes include such entries as "standards" not "rules of conduct"; that is, failing to uphold these standards does not constitute grounds for disciplinary action, or termination of a license to practice. These invocations simply indicate that there is, at present, a generalized institutional support for the idea that an individual architect ought to advocate, for public policies that lead to the reduction of loads imposed by buildings upon natural systems.

In Ontario, the ethical standards to which architects must adhere are not structured to convey generalized standards or aspirations, in the manner of the AIA and UIA codes. Currently, the applicable law defines only the varieties of "professional misconduct" that may be subject to disciplinary action. * However, the Ontario Association of Architects now publicly states that it

> *"…supports the integration of sustainable design and green building issues into the mainstream activities of the OAA and of its members."* **

On the strength of the evidence noted above, an architect's role in advocacy, for a range of issues, is assumed. It may be reasonable, then, that climate change - an issue for which there is extensive scientific evidence, that public opinion polls suggest is considered urgent by a majority of Canadians, and that has to do with the design of buildings - is an interest for which architects will advocate.

Since climate change is one of the highest-priority issues of the day, and the building sector is a major consumer of energy and emitter of greenhouse gases, then architects ought to be involved in this discourse , and asking challenging questions about the future. Asking – and eventually answering – these questions could help to re-direct public policy toward a more "sustainable" path.

In 2008, the Ontario Association of Architects established a new "Sustainable Built Environments" advisory committee, with a mandate to:

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* See the Regulation under The Architects Act, R.R.O. 1990 O.Reg. 27, s. 42 (## to ##)
** See http://www.oaa.on.ca, accessed 19 November, 2008

> *"…define, analyse, review and assess areas which the OAA can focus on (sic) in order to demonstrate leadership from the architectural profession on this emerging area of practice which is of paramount importance." (OAA SBEC 2008)*

This may sound promising. However, as mentioned earlier in this section, there are unfortunate lapses into tedious moralizing discourse, when architects pursue their role as public advocates for sustainable design. The following examples are from the pages of a feature issue on sustainability in *The Irish Architect*, and are characteristic of the some of the rhetoric elsewhere in the architectural press:

> *"At the dawn of the 21st century, we have the opportunity to be part of a new architectural movement, a movement that will be primarily motivated by the needs of the society of tomorrow, a movement that will emerge from the … cranks … the scientists … and the … 1990s … finding ways of synthesizing the various strands of the green movement of the late 20th century." (Joyce 2003)*

> *"And why do we need to change practice? Because it is widely recognized that too many buildings (and works of civil engineering) waste energy and water, are difficult to run efficiently, involved the use of materials that were won from inappropriate sources, involved far too much waste in their construction, were imposed on sites with too little consideration for their neighbours and, sadly, are not very pleasant places in which to live or work. What this idea means in practice is still a matter of some debate but, in principle, it means avoiding the pitfalls just listed." (Venables 2003)*

> *"…architects as leaders of the design team, often as the visionary, have a professional duty to provide this leadership, to market sustainable strategies and to make the client and the design team aware of these issues." (Brophy 2003)*

Such entreaties to "join a movement", and the casting of aspersions on all that was accomplished in the decades just-past, contain echoes of the manifestos of the early Modern era in architecture. This sort of rhetoric does not necessarily add to the credibility of either the speaker or the cause that is espoused. The last is perhaps the least prudent expression, for a professional with a duty of care to the public. As yet no "duty to market" is enshrined in the regulations, or codes of ethics, for architects in Canada.

Fortunately, there are alternative ideas, and more balanced way of expressing them. For instance, one antidote to the kind of urges expressed above may be found in *The Joy of Sales Resistance* (Berry 1992). Architect Richard Rogers uses much more moderate language, and captures both the sense of growing civic concern about issues such as climate change, and the complexity of the tasks that await designers, saying:

> *"It would be good to imagine that we don't have to experience a major crisis in order to take some action. As a civil society we have to be conscious of what is needed not just to maximize profit but to maximize value. If we can fuse social concerns, technical and structural innovation, and environmentally responsible design, I believe we can create architecture that properly reflects the requirements of the twenty-first century" (Gissen 2002, 173)*

As shown in Section 3.1, the awareness of environmental issues, and hence the expectations of the public are on the rise. This was illustrated by a comment from a lay juror during the assessment of projects for a recent design award in Ontario. After being asked to appraise a number of projects under a discrete category of "green" design, the juror asked, *"why isn't every building required to be green?"** In another venue, reflecting on a period of mid-career professional renewal, American architect Bob Berkebile gives a more personal example of this attitude:

> *"I asked what was the real impact of our designs on people? Do we promote their well-being? Do we contribute to the health of the neighborhood, and to the planet?" (Shulman 2006)*

"Contributing" is very different from "joining a movement" or assuming a "duty to market". In light of the models for climate change mitigation, suggested by the likes of Socolow and Pacala (in Section 3.1), "contributing" also is a more accurate description of what an architect really can accomplish.

However, architects are in a position to make a contribution that is not only symbolic, but also substantive. The editor of *The Architectural Review* argues:

> *"A profession should offer the possibility of using its arduously won knowledge to benefit society as well as individual clients. Professional people are not only called to their life by the ability to draw and count, cut kindly into bodies or make amazingly agile arguments. They are trained at great expense in traditions that are distilled from the work of their ancestors. All professional people have a wider*

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* juror's comment, 2005 Awards of Excellence at the Ontario Association of Architects.

> *responsibility than trousering their fees. …. There is so much to learn: so much to explore. Instead of messing about with blobs and similar formalistic stupidities, we should be inventing a fruitful and generous future based on decency and forethought for our successors." (Davey 2003)*

This overview has shown that all of an architect's many roles ought to be considered, with extra care, during the transition to "new normal" practice.

- As a strategic advisor to the client, on a project with "sustainable" goals, an architect would be well-advised to take extra care to be impeccable with one's words, to continue to demand better-quality information, and to analyze it.
- As an imaginative designer, one needs to acquire more technical know-how, and greater interest in using it. The literature clearly shows that the need for integration of concerns is widespread among architects in North America and the United Kingdom.
- As coordinator of the design team, the challenge is not just to conduct more frequent meetings, but to make the meetings more collaborative, and therefore more effective. Some architects, who have been trying to accomplish this for some time, express that one of the greatest challenges is to frame high-quality questions that will provoke the team to innovate well, and to contribute holistically. This may stem, in part, from a lack of information about the impacts of the primary architectural choices upon the work of the engineering specialists. Integrating the design inputs of the consulting team is one need; integrating thinking within the architect's own head is required to accomplish it.
- Finally, if one is really serious about being an advocate for an authentic "new normal", then one ought to speak publicly of "sustainable design" from relevant experience and real evidence, rather than from a position that is based only on hope, however well-intentioned that hope may be.

By analyzing high-performance case studies to find best practices, and by studying the power of design parameters, this study aims to provide information that will point the way toward a positive evolution in architects' practices, in all four of the roles considered here. In the absence of this kind of information, a degree of reliance currently is placed on some emerging tools that purport to gauge how much "sustainability" a design achieves. A critical appraisal of these tools is next.

3.4 HOW "SUCCESS" CURRENTLY IS MEASURED

Year after year, the complexity, sophistication, and number of "green building" yardsticks increases - each defining "green" differently. Today, issues of what to measure (and how to measure it) arise with increasing frequency. A user of one of these new instruments may measure the wrong things - or may measure the right things, but prioritize them poorly.

Remarks about the procedures involved in attaining a "label" - and about the challenges facing the organizations that promote each yardstick - are outside the scope of the present discussion. Instead, an assessment is made here - on behalf of any designer who hopes to realize the "interlocking attributes" of lowered environmental impact and elevated human experience. The question is, how much do these tools help in such an endeavour?

The following review shows what can be measured today, and what often is overlooked. It is not an argument in favour of one system in preference to another. A comparative analysis shows that each of these tools has certain flaws. If a level of professional skepticism is maintained, about building rating as an exploit, then architects and building owners may be better able to recognize the inherent limitations in any particular system.

Of the yardsticks surveyed, four are focused entirely on energy, six are so-called "whole building" measurement tools, and two are "green design" awards programs. These were chosen because they all have been used for some time, to measure the "green-ness" of non-residential buildings. Stakeholders in the institutional building sector - including designers, clients, builders and regulatory agencies – have used them on real projects. Most of these are everyday tools for everyday practice. They come from various countries, and arise from within various professional disciplines – so they represent a range of approaches to the challenge of appraising and comparing "green" buildings.

Questions about new tools, that arise in design consulting practice

When considering the adoption of any new tool within a business, an architect would weigh the answers to a number of questions, such as:

- what are we trying to do with this tool?
- what value does it help us offer our clients?
- does it help us work with our collaborators (i.e. engineers)?

- what learning curve is required to use this tool?
- how long is it likely to be in service? and
- do we already have a tool that will do this job?

Unfortunately, when considering today's green building yardsticks, an architect also must assess whether the thing functions properly. The best of intentions may have been present when these tools were conceived, but many of them have been launched into the world, under a "deploy then fix" mandate. This is evident by tracing the history of a single tool - such as LEED or SBTool - and counting the number of versions that have been released over the last ten years.

Architect's clients look at new tools in terms of the costs and benefits to their businesses, as well. For a public institution, "cost" may include political headache as well as hard currency. And "benefit" may range from goodwill or marketing advantage to actual high performance. When invited to consider using a green building measurement tool in an upcoming project, experienced clients in Greater Toronto Area (GTA) municipalities most often ask:

- Will this tool support – or fight - effective decision-making in this project? (Will it slow us down?), and
- Will using this tool incur added costs and/or bring in more revenue in this project?*

Sometimes clients also ask:

- Does this yardstick suggest design strategies (or products) that are applicable (or not applicable) in our project? Do we want more flexibility, or does the yardstick force us in one direction?
- Does this yardstick tip the balance between our growing concerns about the environment and the usual concerns that are essential in our business (e.g. functionality, durability, community message)? Does "green" compete with "our business", or can both be satisfied?**

Clients who have considered environmental issues for longer – the "deep greens" – will go even further, and ask:

- What creates "sustainability" - for us? (Is it measured by this yardstick? Is the measurement weighted appropriately?)

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* These questions were posed by an experienced, senior representative of the City of Toronto Economic Development, Culture & Tourism, in telephone conversation with the author, in July, 2005

** Author's personal experience in practice in Toronto, during 2003-2005.

If measuring the environmental impact is an important goal in a proposed project, architects and engineers may ask, "which yardstick should we apply to this circumstance?" Will it be …

- the one that's easiest to pick up?
- the one "that everybody's using"? (who is "everybody"?)
- the one that suits a stakeholder's agenda best?
- the one that is most defensible, in case of a claim of negligence? or
- the one that helps us to make a substantive difference in the impact of our work on the well-being of the public and the natural environment?

An evaluation of the tools in follows. First is a description of three types of yardstick: energy-use predictors, "whole-building" rating systems, and "green building" design awards programs. Next, several recurring problems with today's tools are identified. This section closes with a compilation of comments, from the literature, about the challenges inherent in the overall enterprise of measuring "green building" - plus a few predictions about what the future may hold. A summary of the authorship, origin and current usage of today's yardsticks is presented in Figure 3.4.1(overleaf).

Yardstick Type 1: Energy-use predictors.

Many North American consumers recognize the U.S. EPA's "Energy Star" rating, in association with refrigerators and other appliances. But it can apply to a whole building, too (US EPA 2007). Using the web-based Energy Star Target Finder, a designer can establish a target for any reasonably typical, non-residential project, such as an office building, school, courthouse, grocery store, or warehouse. The EnergyStar target rating shows two values: the target energy use (in kBTU/sf/year) and the corresponding CO_2 emissions (in Tons/year). The Target Finder is made for use in the first days of the schematic design stage. It helps set goals – but it offers no advice as to how to reach them.

A close relative of the US EPA's "EnergyStar" is Canada's "Screening Tool for New Building Design" (NRCan OEE 2008).* Also web-based, this yardstick yields an estimate of the annual energy use and CO_2 emissions of a schematic design.

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* This instrument was known as the "CBIP Screening Tool" when the Commercial Buildings Incentive Program (CBIP) was underway. Although the program it was meant to serve was terminated (with the change in party leadership of the Federal Government, in 2006), the Screening Tool has remained available, online. It was re-named during 2008.

	“yardstick”	*source name*	*origin*		*source type*	*number of projects to June 2007*
Type 1, Energy only	**EnergyStar Target Finder**	U.S. Environ’l Protection Agency (EPA), and U.S. Dept. of Energy (DOE)	2004 (1992)	U.S.	Federal Govt. agencies	not tracked
	Screening Tool for New Building Design (CBIP Scr. Tool)	Nat’l Resources Cda (NRCan), Commerical Bldgs Incentive Program	1996	Cda	Federal Govt. agency dedicated to supply-side mgmt of energy sources	approx. 1,000 received grants
	eQuest & DOE2	1-James J. Hirsch & Associates for U.S. Dept. of Energy	1 pre-1990 2 2000	1 U.S. 2 Aus /U.K.	privately owned software businesses	not tracked; thousands of users in North America
	Athena Environmental Impact Estimator ver. 3.0.3	Athena Institute	pre-1997	Cda	not-for-profit corp, funded by donations from industry assoc’ns (construc product manufacturers)	not tracked
Type 2, “Whole Building”	**LEED Ca ver. 1.0 (sim. to U.S. 2.1)**	**Canada Green Building Council (franchise of USGBC)**	2004 (1999)	U.S.	not-for-profit corp, with committee governance structure	66 in Cda, 600 in U.S. (July 2007); 113 Cda, 1,240 U.S. (Oct. 2008) *NC only
	BREEAM (Offices 2006 Design+Procure. Pre-Assessment Estimator)	**Building Research Establishment (BRE)**	1988	U.K.	publicly traded corp, owned by charitable trust, employs ~650 archts, eng’rs, sci’sts	100,000 in U.K. - includes all units of many multiple-residential developments
	SBTool 2007 (formerly GBTool)	**International Institute for the Sustainable Built Environment (iiSBE)**	1996	Cda+	non-profit org. with international Board of Directors; managing Secretariat located in Ottawa, ON, Cda	from Canada: ## fully measured projects plus ## posters; from all countries: ##
	CASBEE (NC 2004)	**Japan Sustainable Building Consortium (JSBC)**	pre-2004	Japan	Japan Ministry of Land, Infrastructure, Transport & academics; current chair is Prof. at Keio U; U of Tokyo and Hokkaido IT	?
	Green Globes (v.1 Post-Construction)	**The Green Building Initiative (GBI)**	1996	Cda & U.S.	non-profit org, governed by a Board of Directors	?
	BOMA (Canada) BESt (formerly “Go Green”)	**Building Owners & Managers Association (BOMA) Canada**	2005	Cda	industry association for realtors and commercial/multi-res property owners	more than 325 across Canada
Type 3, “Design”	**American Institute of Architects “Top Ten Green” Award**	**AIA Committee on the Environment**	1997	U.S.	committee of member arch’ts in 49 chapters; volunteer jury is different each year; consists of practicing arch’ts, eng’rs, arch’l critics	approx. 85
	Holcim Awards	**Holcim Foundation for sustainable construction**	2004	HQ, Switz.	fdtn. established by multinat’l corp that produces cement & concrete products; jury in each region primary reputed academics	15 awards - 3 in each of 5 world regions - plus 31 “acknowledged & encouraged”

Very simple inputs are required to use these estimators. For the Energy Star Target Finder the only requirements are: building size, type, number of occupants, and zip code. The NRCan Screening Tool requires a bit more technical detail, such as: the thermal resistance of the enclosure, local fuel rates, the efficiency of equipment, and lighting power density. To many architects, these details would seem to belong in the normal purview of the mechanical engineer - and would seem not to be among the architect's concerns. This is unfortunate, because the Screening Tool – while not as finely tuned as a detailed energy model - is accurate enough to help an architect quickly assess the energy conservation potential that is inherent in a schematic design concept.

Figure 3.4.1 (opposite) Authorship, origin, and usage of "green building yardsticks", as of June, 2007

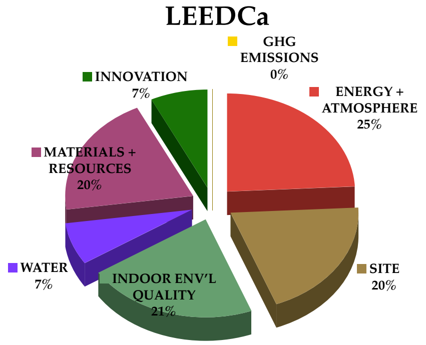
(starting at the top: US EPA 2007, NRCan OEE 2007, JJH 2007, Athena SMI 2007, CaGBC 2004, BRE 2007, Larsson 2007a, JSBC 2007, GBI 2007, BOMA BESt 2008, AIA COTE 2006, Holcim 2008)

The NRCan Screening Tool predicts how a design will perform, relative to a reference building that meets the minimum requirements of Canada's Model National Energy Code (MNECB). The EnergyStar Target Finder relates the contemplated building to a database of existing buildings of similar size and occupancy, at the same U.S. Zip Code. Both the Energy Star Target Finder and the Screening Tool gauge a design in comparison to "average practice", and both of these tools express greenhouse gas emissions and energy performance, "front and centre", in absolute numerical terms. But neither offers a clear way of testing the potential impact of design parameters such as overall form, orientation of the building, or orientation of glazing.

More sophisticated predictions of the behaviour of a design, through the year, are attainable using software programs such as DOE2, and its Canadian cousin, EE4. Both require an experienced, specialized technical operator, and extended time to generate an estimate of energy use and greenhouse gas emissions. The required inputs demand that the design is advanced well past the schematic stage. Also, the estimation of several design options is very time consuming. For these reasons, it is difficult to imagine a design architect using either DOE2 or EE4.

However, there are other programs that are more user-friendly for architects – such as eQuest, Ecotect, and EnergyPlus. For reasons that are explained in detail in Chapter 3, the Quick Energy Simulation Tool, "eQuest" is used in this study (JJH 2007). It requires more numerous technical inputs than the Target Finder or Screening Tool, but it provides defaults that represent common practice in North American construction today. It accepts the input of building shape and orientation, as well as glazing orientation. Multiple iterations of eQuest models are easy and swift to perform. Absolute energy use is presented as the result of each run. This tool was designed for architects, and it is well-suited to use during the schematic design phase by a design generalist.

Figure 3.4.2
***LEEDCa v1.0** offers up to 29% of its total points under "Energy Use & Atmosphere", although reductions in GHG Emissions are NOT given credit (CaGBC 2004)*



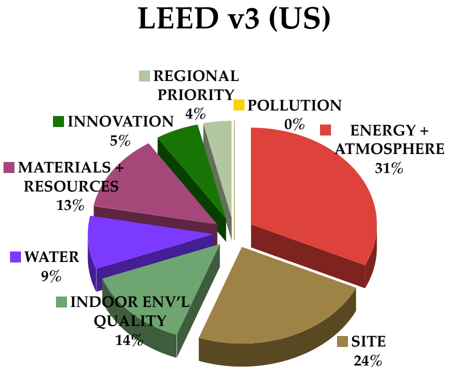


Figure 3.4.3
LEED v3,

... released in the US offers up to 31% of its total points for "Energy + Atmosphere" (USGBC 2008)

The Athena Environmental Impact Estimator (Athena SMI 2007) can be used to measure the impact of a building, over its entire life cycle. The Estimator contains a database of the embodied energy of materials and assemblies typically used in North American construction. Using input from one of the energy use estimators (such as eQuest), Athena also can calculate the pollution emissions over the total life cycle of a building. It is a useful complement to the other energy-use predictors.

Yardstick Type 2: So-called "whole building" checklists

Using energy and emitting pollutants are significant ways that buildings impose loads upon natural ecosystems – but they are not the only ways. Questions of the overall "fit" of buildings into the natural world are the subject of yardsticks that purport to tally "whole building" performance in a numerical "score". In North American architectural practice, The Leadership in Energy and Environmental Design (LEED) checklist currently is the most recognizable example of this type.

A comparison of LEED to its closest relatives - particularly the Building Research Establishment Environmental Assessment Method (BREEAM) and Green Globes - raises questions about how to appraise whether a "whole building" design is "green". Each of the systems reviewed here puts a different level of priority on energy and pollution, within the "whole-building" performance pie. The weight of energy use (red wedge) and greenhouse gas emissions (yellow wedge) - as compared to other important environmental impacts, such as water and resource use - is shown in Figures 3.4.2 through 3.4.9. (Since the environmental loads are grouped differently in each system, this comparison is somewhat crude, but it begins to put the intentions of the various systems into perspective.)

The primary benefit of the LEED checklist - for designers and others in the construction industry - is that it is very easy to use. In fact it can be applied within minutes of a first reading. A preliminary measurement can be made in the early phase of schematic design, and can be done with very little "green building" expertise. The LEED reference guide is instructive to architects entering "green" practice, wishing to be introduced to a wide gamut of environmental concerns. Also, through its extensive marketing of LEED tools, the United States Green Building Council (USGBC) has captured the interest of product manufacturers and builders, bringing "green" concerns into the mainstream of commercial and institutional construction in North America. Their nascent interest is making new alternatives available to designers - particularly with respect to items that can be specified, such as interior finish materials and fixtures.

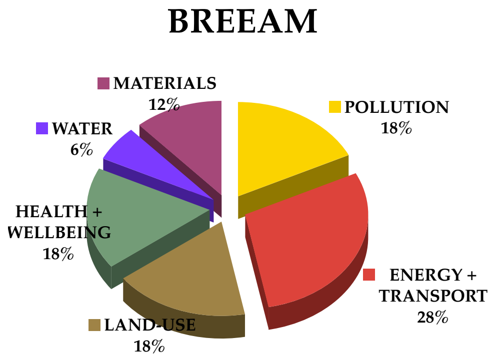
The allocation of points in the current Canadian version (LEED-Ca ver. 1.0) is shown in Figure 3.4.2 (CaGBC 2004). At the time of writing, in the US, "LEED v3" was in the final stages of review; the allocation of points in the draft US version is shown in Figure 3.4.3 (USGBC 2008).* Note that percentage of points for Energy and GHG Emissions has increased, but only slightly.

With respect to energy-use and GHG emissions, important caveats about what is measured, using LEED, are as follows:

- Of the six "whole building" yardsticks examined here, LEED allocates the fewest points to energy-use and pollution - by a substantial margin.

- The LEED checklist is applied uniformly in all climates. Whether the project is in Regina or

Figure 3.4.4
***BREEAM** offers up to 46% of its total points under "Energy + Transport" and "Pollution", giving credit for reductions in GHG emissions in addition to credit earned for reductions in fossil-fuel use (BRE 2007)*



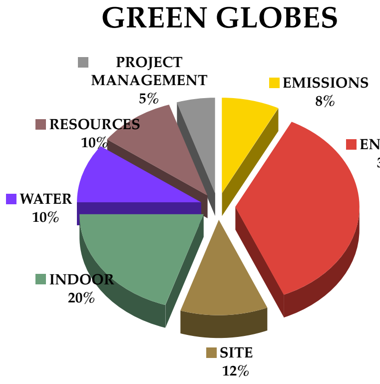


Figure 3.4.5
Green Globes

... offers up to 43% of its total points under "Energy" and "Emissions" (GBI 2007)

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* The Canadian checklist analyzed here, LEEDCa 1.0 corresponds most closely to the U.S. LEED ver. 2.1, although it contains two important variations - an added credit for "durability" and a different reference standard for energy use. As of October, 2009, the CaGBC had not announced to what extent its next upgrade would follow the US LEED v3 model.

Miami, the score is tallied as if the issues were of equal weight in both places - although the amount and type of energy used various considerably, from one location to another.

- The reference standards in LEED are an aggregate of building regulations, and enviro-friendly bylaws, drawn from diverse jurisdictions, all around North America. The hypothetical "near-market" building, which a LEED-certified building is said to be better-than, is a "fuzzy" baseline - slightly-better-than-average practice in a place that does not exist.*

- The "energy use" figures required to obtain a LEED rating are predictions only – none of its many versions awards real performance, during occupancy. (Gifford 2008)**

- Finally, points are earned in LEED (US) for saving energy costs, rather than saving energy consumption. *** This may favour, for instance, an all-electric design (call it A) in a region where electricity rates are high (more cost savings means more LEED points). That is, a design in the same region, using a blend of energy sources (call it B) would save less cost, and therefore earn less credit in LEED, even if the total energy consumption of A and B was the same. The added layer of calculation obscures the comparison of buildings, and does not necessarily contribute to lower-load design.

Energy Use
Water Use
Construction Waste
Recycling
Hazardous Materials

Figure 3.4.6
BOMA Canada's BESt

... program requires performance, with respect to 5 categories (BOMA 2008)

The Building Research Establishment Environmental Assessment Method (BREEAM) - which originates in the U.K. - is the parent of LEED. BREEAM is said to be the most widely used and longest established environmental assessment tool for buildings in the world (BRE 2007). The allocation of points to the main categories of environmental load in BREEAM Offices 2006 Design + Procurement Pre-Assessment Estimator is shown in Figure 3.4.4.

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* For instance, the LEEDCa NC 1.0 invokes the Centre for Resource Solutions' Green-E Product Certification as a benchmark for Green Power, and the State of California's South Coast Air Quality Management District's Rule 1168 (SCAQMD Oct 2003), as a benchmark for low-VOC adhesives and sealants. Neither of these is applicable law in any Canadian jurisdiction.

** In 2008, the USGBC released a study (NBI 2008) of the energy actually used in LEED-certified buildings, after occupancy. Gifford criticized the methodology, the study findings, and the way LEED awards points for energy use (2008). A formal rebuttal to Gifford's article was posted on a blog hosted by Building Green (Malin 2008), and this was followed by a missive from the USGBC to all Chapter Leaders (USGBC 2008), to reinforce the defense against Gifford's critique. This discussion - which echoes sentiments expressed elsewhere - is ongoing at the time of writing.(Schendler 2005, Horst and Todd 2008).

*** In LEEDCa, savings in energy consumption may earn credit, if using the MNECB as the reference standard.

The LEED and BREEAM lists are similar in scope, way of measuring, and associated processes. The BREEAM checklist - unlike the LEED list - can be applied to a building at any stage in its life cycle (pre-design and operations phases included). In a BREEAM-scored building, a design team has considerable latitude in the choice of issues to be addressed - just as it has, using LEED. But, in BREEAM, there is a higher priority put on energy efficiency and pollution effects than in LEED. A designer must pay serious attention to the energy question, in order to earn even a minimum BREEAM rating.

In BREEAM, credit is given with direct reference to the needs of specific ecosystems. For instance, in the “Land-Use” category, the ecological impact of a proposed design is calculated based on the area of habitat and number of species displaced, using BREEAM’s “ecological value calculator”. And, in the “Pollution”category, the global warming potential (GWP) of refrigerants and insulation materials, as well as absolute rates of NO_x emissions must be proved, with evidence, in order to earn points.

Green Globes (formerly known as GreenLeaf) is another North American offspring of BREEAM. The allocation of points to the main categories in Green Globes is shown in Figure 3.4.5. Using Green Globes, more weight is put on energy performance than in LEED, but less than in BREEAM. Green Globes is more prescriptive about the means by which energy efficiency is accomplished than any of the other systems. For instance, using Green Globes, a building, if it is situated with its long flanks facing north and south can earn extra points, apart from any energy-efficiency credit it earns (GBI 2007).

The Building Managers’ and Owners’ Association of Canada’s (BOMA Canada) BESt labelling system (formerly known as “Go Green”) takes a different approach to measuring “whole buildings” – focussing on existing operations in large commercial buildings. The BOMA BESt rating systems is the only one so far identified that requires periodic re-certification, as an essential practice. Every three years, a building operator is required to re-apply for re-inspection – or lose the right to advertise compliance with the program (BOMA 2008). Hundreds of buildings, constructed in earlier decades, in the financial cores of cities across Canada, are achieving a BESt label. This is an important addition to the suite of available labelling systems - addressing key “non-design”, or operations issues. The criteria used in BOMA BESt are listed in Figure 3.4.6.

One complaint that designers often make - about the “whole building” green yardsticks in general – is that they don’t typically recognize architectural quality. In the words of one architect, “I want to be able to deduct points for bad design and sprawl!”* Using the LEED, BREEAM, Green Globes, or Go Green yardsticks, qualitative aspects are rewarded - but in an extremely limited way. The only qualities measured are those that can be gauged against a simple numerical scale (such as indoor temperature range, distance from a workstation to a window, quantity of daylight, noise levels, and turnover rate of fresh air.) While these are important metrics, they represent only a fraction of the full spectrum of qualities that design can offer.

In two additional yardsticks, attempts are made to include an appraisal of qualitative aspects of design - within the numeric “score” that they present. Both SBTool and CASBEE begin by measuring many of the same things as the other “whole building” yardsticks – but both go much further. In addition, these tools try to evaluate a building in terms of both environmental load and satisfactoriness to a range of human wants and needs. Both emanate from academia; SBTool is the standard employed to compare buildings (post-occupancy) in the International Green Building Challenge.

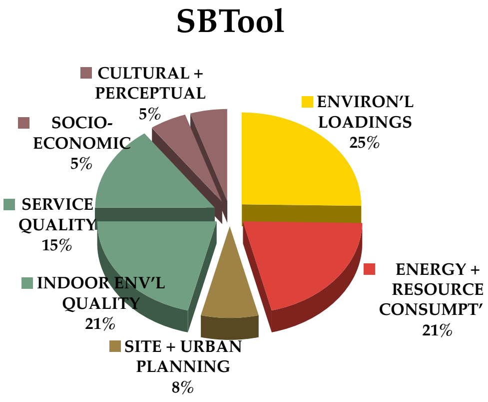

Figure 3.4.7
SBTool

... offers up to 46% of its total points funder “Energy+Resource Consumption” and “Environmental Loadings” (the latter includes GHG Emissions) (Larsson 2007)

SBTool may be described as a flexible framework, rather than a fixed yardstick, because it allows individual users to customize the number of parameters to be measured, and the proportioning of points, to suit a particular climate and locale. The allocation of points to the main categories in SBTool (customized for Ottawa, Canada) are shown in Figure 3.4.7.** The developers of SBTool state,

> *“Even in regions where other systems, such as BREEAM or LEED, are predominant, SBTool can play a very useful role in helping large organizations to set performance requirements for their building portfolios. In this role, the*

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* audience member at a presentation at the Ontario Association of Architects (OAA) Conference in June, 2003.

** In both SBTool and CASBEE, for each of these “soft” issues, a descriptive phrase that most closely matches the qualities of the design may be chosen from a range expressed on the yardstick. A score – low, medium, or high – then results.

> *wider scope of SBTool and its ease of adapting to local conditions - even down to a municipality or university campus - makes it a more relevant and finely graduated instrument than other commercial systems." (Larrson 2007b)*

In SBTool, the score is presented as a number. Unlike other systems, this number rates a wide gamut of qualities, under categories such as "Cultural & Perceptual" and "Socio-Economic".

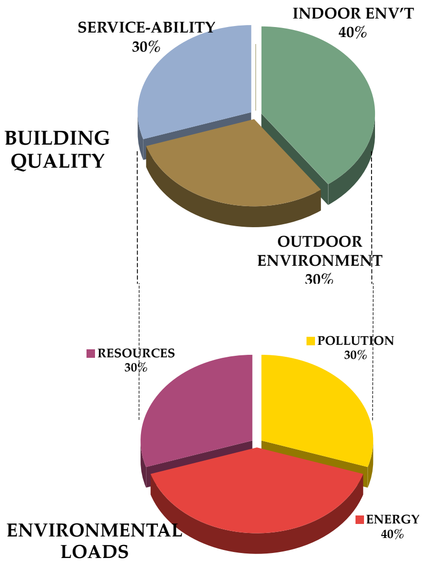
Using SBTool, a few of the technical limitations identified above, with respect to the LEEDCa checklist are avoided. For instance, the baseline standards are selected for each region, or for a particular portfolio of buildings. Yet, by allowing not only climate-specific but client-specific weightings, SBTool raises a question as to how far customization can go, before the system fails to uphold a "standard".

A research-based yardstick from Japan, the Comprehensive Assessment System of Building Environmental Efficiency (CASBEE) distinguishes itself by presenting its score in a way that is radically different from all of the other yardsticks (see Figs. 3.4.8 and 3.4.9). In CASBEE, the quality achieved (Q) is registered as one axis of a graph, while the environmental load (L) is the other axis. CASBEE includes the category, "Outdoor environment", in which ratings are given for issues such as biosphere preservation, townscape, and local character. And, under "Service quality", ratings are given for qualities such as functionality, durability, and adaptability.

At present, SBTool and CASBEE have the following disadvantages, in comparison to the LEED-BREEAM family:

- both are more challenging to learn (they are intended for research, not consulting practice),
- in North America, there is some organizational support for SBTool, but none for CASBEE, and
- their international focus may lower their perceived value to some North American municipalities.

Figure 3.4.8
Allocation of points in CASBEE (JSBC 2007)



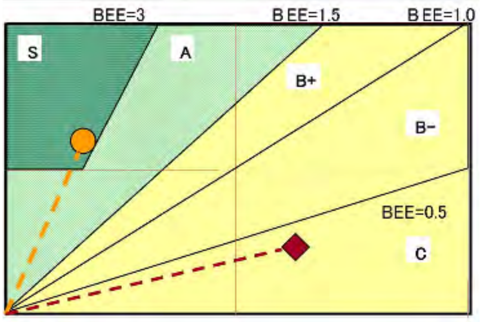


Figure 3.4.9
Sample CASBEE score,
"Building Quality and Performance" (vertical axis) is charted vs. "Environmental Loadings" (horizontal axis). The high-load, low quality building (red diamond) is an "ordinary" design; the higher quality, lower loading design (orange circle) is considered more "sustainable".(JSBC 2007)

The Type 2, “whole-building” rating tools are at mid-spectrum - with Type 1, “energy-use predictors” on one side, and Type 3, “green design awards programs” on the other. The energy-use predictors typically do not gauge architectural quality, but the green design awards programs, in some cases, gauge energy use.

Yardstick Type 3: “Green design” Awards programs
The annual AIA Top Ten Green list and the triennial Holcim Awards for Sustainable Construction currently are the most widely recognized yardsticks of this type, in North America. And - among the awards and exhibitions that have celebrated “green” buildings for their overall design excellence, to date - these two are the most transparent about the criteria used to select the projects that they recognize. Both acknowledge that measured energy performance is a very important aspect of “green” design.

While the focus on infrastructure in the Holcim awards fills an important gap, it is not the subject of this study. And, the worldwide nature of Holcim means that relatively few of its awards are made in cold climates.

With respect to this research, the AIA Top Ten Green program is the more relevant of the two. First, it has been established for longer than Holcim (11 years, as compared to 3). Second, its criteria include energy metrics.

The criteria in AIA Top Ten Green (listed in Figure 3.4.10) have been applied with reasonable consistency, since 1997. Energy use data (predicted or actual) is required, in addition to design commentary. And, judging by the growing number of applicants each year, this awards program is reasonably well accepted among consulting practitioners of architecture and engineering in the U.S. and Canada. The Holcim program requires only the submission of qualitative descriptions, not metrics in the application package (see Figure 3.4.11).

In the spirit of the “interlocking attributes”, the competition brief for the AIA Top Ten, the Committee on the Environment (COTE) states:

Sustainable Design Intent & Innovation
Regional/Community Design & Connectivity
Land-Use & Site Ecology
Bioclimatic Design
Light & Air
Water Cycle
Energy Flows & Energy Future
Materials & Construction
Long Life, Loose Fit
Collective Wisdom & Feedback Loops

Figure 3.4.10
Criteria used in judging the AIA Top Ten Green Award

... of which the weighting is not disclosed

(AIA COTE 2006)

> *"COTE recognizes that great design includes environmental, technical, and aesthetic excellence. Stewardship, performance, and inspiration are inseparable."* *(AIA COTE 2007)*

The AIA Top Ten Green submission requirements demand both metrics and qualitative description, but the COTE does not disclose how any of the criteria are weighted. Qualitative descriptions required of AIA Top Ten contenders include:

- how the architectural expression demonstrates the sustainable design intent,
- how the design promotes regional and community identity,
- how the development of the site responds to its ecological context,
- what the most important issues to address for the specific climate (leading to passive design strategies),
- why the project is likely to continue thriving far into the future, and
- how collaboration with the community contributed to the success of the design.

Winners of the AIA Top Ten Award are deemed, by a jury of professionals, as significant designs that are both "low-load" and "high-satisfaction". All of the AIA Top Ten Green projects have been measured by one of the other yardsticks (such as Energy Star, LEED or GBTool). Because most projects recognized by the AIA Top Ten Green program are fully documented, their energy performance is revealed - showing the full range of what design can do. The roster of AIA Top Ten Green Award winners was helpful in selecting the case studies to be analyzed in Chapter 4.

Problems with today's yardsticks

No measurement tool is available today - to the North American designer of "green" non-residential buildings - that provides a well-balanced appraisal of both the environmental impact and the general satisfactoriness of an architectural design. Most tools favour one side of the equation or the other; some are focussed narrowly on

Quantum change and transferability

Ethical standards and social equity

Ecological quality and energy conservation

Economic performance and compatibility

Contextual and aesthetic impact

Figure 3.4.11

Criteria used in judging the Holcim Awards

... are weighted at the discretion of the jury of the day

(Holcim 2008)

Figure 3.4.12
Problems with today's yardsticks

		E-Star Target Finder	NRCan Screening Tool (frmr. CBIP)	DOE2 and EE4	eQuest	Athena	LEED Ca-NC 1.0	BREEAM - Office	SBTool	CASBEE	Green Globes	Go Green	AIA TopTen Green	Holcim Awards
		1 - Energy					Type 2 - "whole building"						3 - Design	
What does the yardstick help a designer do?														
1	"score" reports greenhouse gas emissions	yes	yes	yes	no?	yes	no	yes	yes	yes?	no	no	no	no
2	"score" always reports absolute energy intensity	yes	yes	yes	yes	no	no	no	yes	*	yes	yes	no	no
3	high score always means energy intensity is well below average	yes	yes	n/a	n/a	no	no	yes	*	*	no	*	no	*
4	"score" rates architectural//civic qualities	no	no	no	no	no	no	no	yes	yes	no	no	yes	yes
5	yardstick helps choose arch'l form &/or orientation	no	no	yes	yes	no	no	no	no	no	yes	no	no	no
6	way of "scoring" varies with climate	yes	yes	yes?	yes	?	no	no	yes	*	no	yes	yes	yes
When / by whom is the yardstick used?														
7	used in phase(s) of building life	des	des	des	des	des	des or reno	des const ops	des const ops	des const ops	des	reno & ops	des	des
8	used in phase(s) of design	SD	SD	SD, DD	SD, DD	DD	SD, DD, CA	SD, DD, PO	PO	*	SD	n/a	PO	PO
9	degree to which users may weight the issues	none	none	*	ltd.	no	very ltd.	very ltd.	very wide	no	lim	*	yes	yes
10	approx. # hours of study before first (cursory) use	1	5	*	1	5	2	2	*	*	1	5	n/a	1
11	# of tools (incl. this 1) that take a similar measurement	2	2	2	3	1	3	3	1	1	3	1	2	2

Legend

SD	schematic design	des	design phase
DD	design development	reno	renovation project
CA	contract administration	const	construction phase
PO	post-occupancy	ops	operations (occupancy) phase
*	insufficient information is available to answer the question		

measuring energy use, while others try to gauge “human satisfaction”, using a variety of methods.

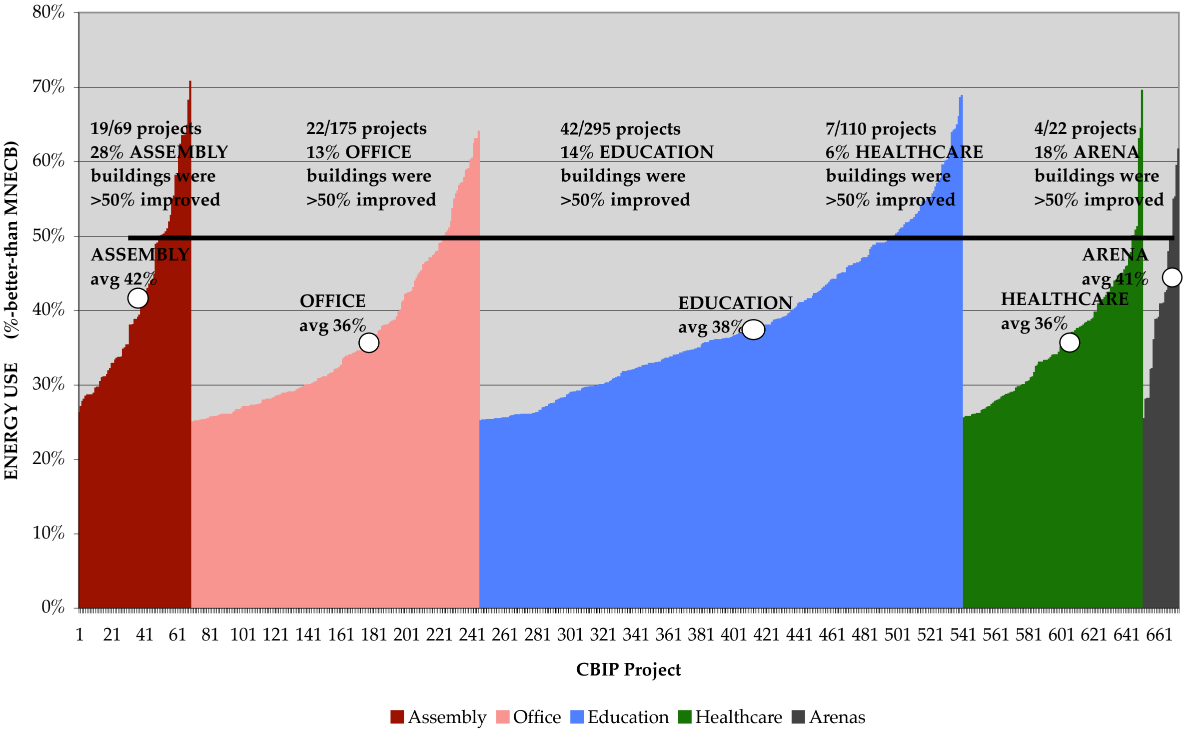
Also, these instruments suffer from a common confusion: the means of attaining a goal sometimes is mistaken for the goal itself. For example, a designer (or a developer) may list “reach a high rating” among the other goals of a future project. Yet, if the true goal is to “reduce environmental damage”, then the act of “reaching a high rating” is just one of several navigational aides. The problem seems to be most severe when the “whole building” yardsticks – the LEED checklist and others - are adopted.

A critique of the measurement tools (summarized in Figure 3.4.12) shows what each yardstick helps (or fails to help) a designer do, and provides basic information about the contexts in which each may be used. The overall inconsistency suggests that reliance on the today’s yardsticks for research purposes would be unnecessarily limiting - and that methods outside today’s yardsticks must be employed in order to understand the fundamental principles of “low-load” design.

Comparing the systems in this way reveals several specific problems with measuring “green-ness”, as an exploit - and with the yardsticks as presently constituted. Six problems are outlined below. Each problem can be seen in more than one yardsticks - all of which are competing for traction in the construction industry. The number and range of these problems suggests that consulting architects and their clients would be well advised to continue to draw on a wider frame of reference – about environmental impacts – than that contained within the language of any one yardstick, always maintaining a healthy professional skepticism, and a focus on known fundamentals.

Figure 3.4.13
Predicted energy performance of relevant buildings that were awarded CBIP grants

(NRCan 2007)



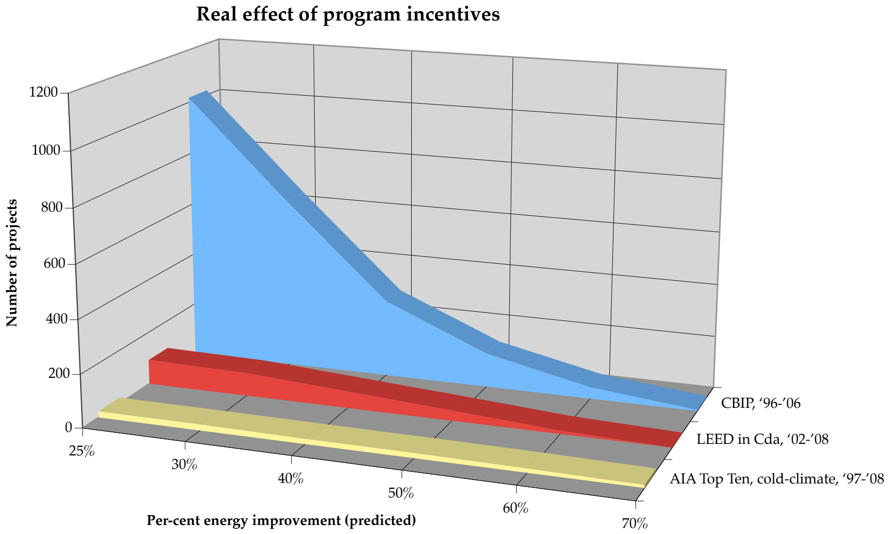


Figure 3.4.14
Predictd energy performance of CBIP, LEED in Canada, and AIA Top Ten Green buildings

(NRCan 2007, CaGBC 2008, AIA COTE 2009)

Problem #1:
Buildings that are not very energy-efficient are celebrated as "green"

In North America today, it is possible – in fact fairly probable – that a "green" rating on a building does ***not*** indicate that the building is energy-efficient. The following shows the track record of the most relevant programs for which the most complete data is available - CBIP, LEED in Canada, and the AIA Top Ten Green Award. The number of buildings so far involved in these programs, and the energy-efficiency promised, is summarized in Figure 3.4.14.

The roster of 1,018 projects that were granted money under the Commercial Buildings Incentive Program (CBIP) shows a wide range of expectations - from 25% to 81% less energy use than a Model National Energy Code (MNECB) "reference building". In Figure 3.4.13, the predicted performance of the building types more relevant to this study is shown. The overall average was 36% better than MNECB. Roughly one-third (372 projects) were predicted to perform at modest improvement (25-30% better than MNECB); one-third (354 projects) were predicted to perform between 30-40% better than MNECB; and one-third (292 projects) were predicted to better the MNECB by more than 40%. *

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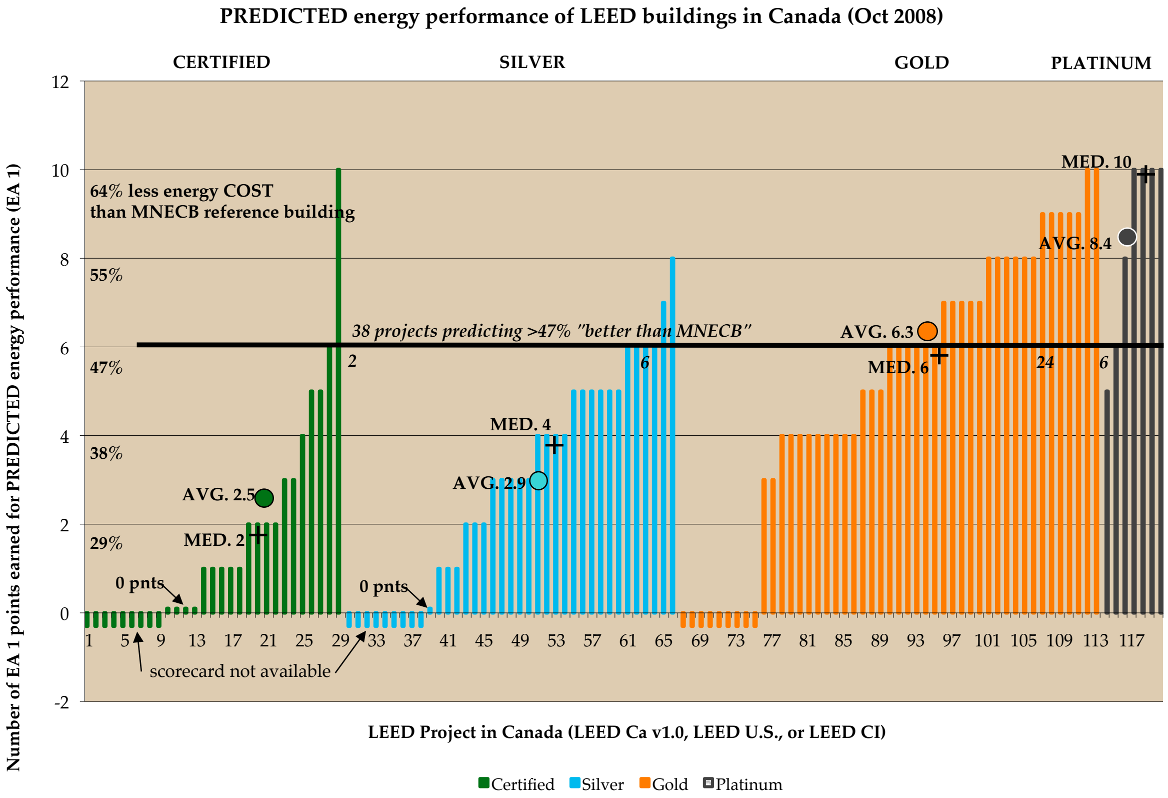
* The author was permitted, in 2007, by a representative of NRCan, to view an unpublished roster of all CBIP projects - showing the predicted energy use of non-residential buildings that received Federal Government grants, in locations across Canada. Under the CBIP program, industrial and retail buildings, multi-unit residential developments, and grocery stores also were able to obtain Federal grants.

Figure 3.4.15
Predicted energy performance of LEED buildings in Canada

(CaGBC 2008)



An analysis of the roster of Canadian projects certified by LEED also shows a wide range of expectations. By October 2008, there were 120 projects in Canada that had been certified by LEED, for which 93 scorecards were available - including all climates, and all building types (CaGBC 2008).

Of these, 38 projects (41%) predicted 47% or greater reduction in energy cost, as shown in Figure 3.4.15. However, this data illustrates the lack of correlation between LEED level and energy-efficiency. For instance, three of the projects that predicted the greatest energy-efficiency (those with the most points under EA-1) are rated Silver or Certified, while 15 projects predicting less energy-efficiency are rated Gold or Platinum. Paradoxically, a project that has the lowest overall LEED rating (the AUMA Headquarters in Edmonton) is predicted to be one of the top seven energy-performers rated by LEED, in all of Canada. Also, there are five projects certified by the "Leadership in Energy and Environmental Design" program, which promise no improvement in energy use whatsoever - one of them rated LEED Silver. * As already noted, the actual energy-use may not be as suggested by the LEED scorecard, and the prediction of performance is of 25% to 64% less energy ***cost*** than a reference standard (which varies, depending on which LEED checklist was used for approval).

A look at part of the roster of AIA Top Ten Green projects shows less range, better performance overall, but far fewer projects than have been recognized by CBIP or LEED. As shown in Figure 3.4.16, the cold-climate, civic assembly, administration, and education buildings celebrated among the annual "Top Ten Green" bettered their Canadian "status quo" benchmarks by a substantial margin - between 60% and 70% reduction in absolute energy use, in each category.

This analysis raises a few questions. First, are the benchmarks in these programs set appropriately? Second, are the benchmarks clear? (Should energy use be the standard, rather than energy cost?) Third, are there enough buildings participating in these programs to make a substantive difference in the energy use and GHG emissions of the North American building sector? And, if not, what will it take to create the incentive to ensure that there are?

Concerns also are being raised that - even if a "green" label on a building signifies that the design is intended to be energy-efficient (which is questionable, based on the data above) - the predicted performance is unlikely to be matched, during occupancy. Since LEED

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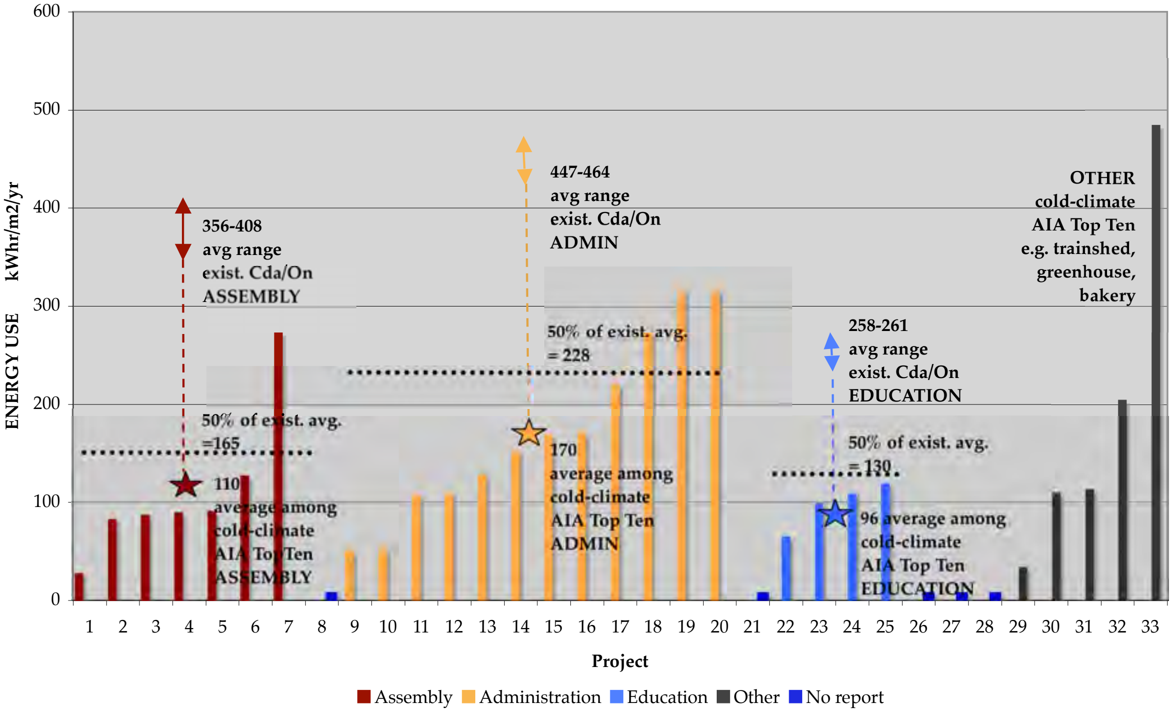
* In the U.S., surprisingly little data is readily available for quick analysis of how many projects put priority on "scoring energy points".

Figure 3.4.16
Predicted energy performance of cold-climate, non-residential AIA Top Ten Green Buildings *(AIA COTE 1998 - 2008)*



is so conspicuous, it presently is bearing the brunt of this criticism. According to the marketing materials about LEED, the "average energy savings of green buildings is 30%" (USGBC 2007). After a study was commissioned by the USGBC to prove this claim (NBI 2008), a hot debate ensued (for which see Kamenetz 2007; Malin 2008) - in which it has been suggested that:

> *"Rated buildings should mount award plaques with removable screws, because each year the building's energy bills would have to be reviewed" (Gifford 2008).*

In fact very little data is available regarding the actual energy use of so-called "green" buildings in the U.S. This is proved by comparing the size of the roster of LEED-certified buildings (by September 2008, more than 1,700 projects, which may or may not be energy-efficient) with the size of the roster of "High-performance" buildings (fewer than 100 projects). To be included in the latter, a project must submit actual end-use data for third-party review, by an agency of the Federal government (US DOE 2009). Even the modest amount of data collected during the research in these pages suggests that it is quite rare for a real building to use less energy than was predicted during the design stage. Real life (including the variability in quality control during construction, changing weather and nuances in the pattern of human use in a building) is more complex than many of the models created in a computer - usually by a factor of at least 20%.

In this background survey, several buildings that are celebrated as "green" – but perpetuate "status-quo" levels of energy-intensity" – are mentioned. These "green-but-not-energy-efficient" buildings are considered not worthy of detailed study, for this very reason. Instead, the case studies that will be examined in detail are all operating at very low levels of energy intensity. Plus, they all satisfy human needs – of various sorts – admirably. Among the case-study buildings, some are not LEED certified, and one of those has not been measured with any of the popular green building yardsticks. Yet, it will be argued, these buildings represent the best of what "green design" can achieve. *

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* The status in October 2008 was: Jean Canfield was pending LEED review; Holyrood, Gilman Ordway at Woods Hole Research Center, the AJLC at Oberlin College, and the Alice Turner Library were never intended to be measured by LEED; The School of Architecture at Cambridge is not considered a "green" building though, it may be argued that it is more "sustainable" than many

Problem #2:
Absolute energy intensity is undetectable, behind the obscurity of a "per cent-better-than" measurement

Two ways of presenting a measurement - of how much energy a building consumes - commonly are recognized as valid. One is "absolute energy intensity", which may be expressed in:

- MJ/m^2/year (used in Europe and Canada to record all energy used in a building),
- kBTU/sf/year (used in the US to record either gas usage or all energy used), or
- ekWhr/m2/yr (used here to record all energy used in a building, from all sources).

The other way of presenting a performance metric is "relative intensity", using a phrase that begins with "%-better-than", implies a hypothetical reference building, and ends with a reference to a standard (usually to ASHRAE 90.1 or, in Canada, to the Model National Energy Code for Buildings, the MNECB). Absolute figures are presented when using EnergyStar, the Screening Tool, eQuest, BREEAM and SBTool; relative terms are presented when using LEED, and elsewhere in the literature.

The study of how to measure energy use is evolving into a professional discipline in its own right. And the most credible way to present a measurement is the subject of ongoing debate, among specialists within this new discipline. In a 2005 study, commissioned by the U.S. Department of Energy, it was concluded that:

> *"The building industry uses many approaches to assess the energy performance of buildings, with very little standardization. This disparity makes it difficult to understand the real energy performance of buildings and to transfer knowledge from one activity to another." (Deru 2005)*

The Deru study goes on to describe metrics for measuring the effectiveness of the energy-measurement metrics. This could become an ever-descending vortex of deliberation – one that a busy consulting architect would hope to avoid. But it is useful to be familiar with the general landscape of the debate - because both ways of presenting energy data have pros and cons. Deru suggests that the quest for standardization is likely to continue for some time - as very specialized engineering researchers continue to enhance the "art" of the energy measurement.

Proponents of relative ("%-better-than") measurement indicate that it is superior because it takes all of the specific conditions of a design into account, including locality, and predicted intensity of use. While this may be true, the downside of relative measurement is its obfuscation.

Using the "per cent-better-than" standard, a comparison of a design-in-progress is made to a reference building – which is a mercurial "shadow", shifting each time there is even a slight shift in the terms of the design challenge. In practice, it has been difficult to chase this shadow. The design of the reference building is, itself, a product of the discretion and imagination of the energy-modeller, and rests upon detailed, specialist knowledge of the standard, as well as the inner workings of the energy modeling software. * It also is easy to forget, during all of this obscurity, that the code or standard represents a minimum acceptable level of performance.

Unfortunately, this attribute may be used to compound Problem #1. That is, a building that aspires to a "green" rating may be presented as "significantly better-than" something (not the standard, but a reference building concocted in relation to the standard). This strategy may be used to conceal lacklustre energy performance behind language that looks accurate, but contains undisclosed assumptions.

And the reference standards shift as well. For instance, within the study period (2006-2008), four versions of LEED-NC were in use in the U.S. and Canada, each one referencing a different version of the energy standard. ** If the requirements for the "baseline" building are slowly ramped up within the reference standard, then a design conforming to an early version of LEED design is not truly comparable to a design conforming to a more recent version. It is cumbersome to repeatedly double-check; it would be much clearer to simply refer to an absolute energy consumption figure.

The architectural historian James Marston Fitch tells the story of an early schism between proponents of "absolute" versus "relative" measurement (1999). In 1975, ASHRAE first introduced its Standard 90, for energy efficient design in buildings. At the time, the AIA found the standards "too prescriptive" and too limiting on design; it did not join ASHRAE in recommending adoption of the new standard - or its relative terms of measurement. Instead, the AIA endorsed what was then known as a Building Energy Performance Standard (BEPS), which was based on "targets of BTUs per square foot per year that varied by

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* The author's personal experience was echoed by architect Bruce Kuwabara, of KPMB Architects, during a presentation at the Toronto Green Building Festival in October, 2007.
** LEEDCa v1.0 references MNECB or ASHRAE 90.1 1999; LEED v2.1 also references ASHRAE 90.1 1999; LEED v2.2 references ASHRAE 90.1 2004; and LEED v3 references ASHRAE/IESNA 90.1 2007.

building type and climate zone". Fitch acknowledges that ASHRAE 90.1 has since become "more flexible and less prescriptive". The AIA has held fast to the use of an absolute measure of energy intensity. And now, it is the form used to communicate targets to architects, within the 2030 Challenge.

Critics of the "absolute" approach say that it is over-simplified, and therefore, prone to inaccuracy. They complain that it is unfair to compare a building in, for instance, Nunavut, to one in New Orleans – because the demands of the two climates are so different. Or, that it is unfair to compare a hospital (which is used around the clock and is heavily equipped) to a church (which is used briefly but intensely by large assemblies of people). Both of these are fair criticisms. But they may be taken as guidance in selecting relevant comparators, when using absolute measurements – not as arguments for abandoning the format altogether. Also, a kilowatt hour used, or a volume of CO_2 emitted, is a direct measure of the impact of a design on a natural system.

The primary benefit of an absolute measure is its resounding clarity. Using one simple number brings focus to a goal that everyone on a design team can share. And an absolute measure allows comparison of the performance of buildings that are reasonably similar in size, use, and location.

In this study, "absolute" measurements are preferred. A simple graphic frame of reference, the "Intensometer" (introduced in detail in Section 2.5) is used to record the annual energy use of all of the buildings analyzed here. All case studies are selected from a "cold climate". Average ranges for building types (offices, schools, etc.), the actual energy use of the case study buildings and the predicted usage from the study of design parameters are all placed along a common yardstick.

Problem #3: The greenhouse gas emissions of a building rarely are reported

As reviewed in Sections 3.1 and 3.2, public awareness of climate change is on the rise. Meanwhile, the various rating systems are promoted as a valid indicators of "green-ness". Implicit in a "green building rating" is the expectation that buildings that wear a label must emit fewer greenhouse gases than their "non-green" counterparts.

Very few of the green building rating systems present enough facts to support such an expectation. The Type 3 (design awards) clearly do not. (However, the AIA Top Ten easily could supplement the report it already makes of actual annual energy use, by adding related CO_2 emissions figures.) Some of the type 2 (“whole building”) yardsticks present emissions figures – but those that do so are not the tools most often used today in North America. *Only the Type 1 yardsticks (EnergyStar, and its counterparts) produce an estimate of the expected CO_2 emissions of a given design.

Any building that is an average, or high, energy-consumer is an average, or high, greenhouse gas-emitter. Thus, compounding Problem #1, a “green”-labelled building that is not energy-efficient also is not contributing to the mitigation of climate change, any more than its un-labelled neighbours.

Of even greater concern than poor reporting, is the fact that some of the Type 2 systems do not even *require* an estimate of CO_2 emissions as part of the assessment of a building. Using the LEED checklist, there are no “points” to be gained for lowering greenhouse gas emissions.

The Canadian reference guide for LEED describes the intent behind the Energy & Atmosphere Credits this way: *“to reduce the environmental impacts associated with excessive energy use.”* Climate change impacts are listed among a host of other building-related environmental impacts (including NO_x and SO_x emissions, acknowledged causes of smog and acid rain, disruption of habitat from coal and uranium extraction, toxic sludge from cooling power plants, and particulate emissions that aggravate lung disease in humans). Climate change is also mentioned under Materials & Resources (credit MR4.1), where recycling is identified as a goal, “by-passing greenhouse-gas-intensive industrial and manufacturing processes”. (CaGBC 2004)

Nowhere in the LEED score is there a place for emissions reduction to be rewarded. If such a calculation happens to be associated with LEED documentation, it lies buried deep in the detailed energy models required to support the energy credits, which are, in LEED, elective. It is possible – indeed probable – that designers, using the LEED checklist, may be distracted by dozens of other suggestions (from bike racks to bamboo flooring) and lose sight of two of the most significant reasons to pursue “green building” – namely the reduction of fossil-fuel reliance and the mitigation of climate change. Worse, the same

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* Among the Type 2 (“whole building”) yardsticks, the only one that lists “Tons of CO_2 / square meter / year“ - front and centre - on the summary “score sheet” is SBTool. But this yardstick primarily is geared to post-occupancy research - and not well positioned to enter everyday practice in North America.

designers may imagine that somehow, in "scoring" all of the various points, they are mitigating climate change, even though emissions are not explicitly measured. More than one building owner interviewed during the Analysis of Case Studies rejected the LEED tools, on their project, for this reason.

In this study, the greenhouse gas emissions of a building will be calculated, once the absolute annual energy use is known. Challenges specific to the geographic area in which the study is focussed are discussed in Chapter 6.

Figure 3.4.17
***Winners of the author's "LEED Eyesore of the Year Award, 2007"**.*

Because issues like local relevance, urban design, visual interest, are not evaluated in LEED, these buildings may be celebrated as crowning achievements of design.

a (top): Omron Dualtec plant and offices, located in an industrial park in Oakville, LEED Silver, 2006.

b (bottom): Pavillion Lassonde, in Montreal, LEED Gold, 2005.

(images from cagbc.org)

Problem #4:
A numeric "score" is a poor indicator of overall design quality

Some of the "whole building" yardsticks (e.g. LEED and BREEAM) gauge the satisfactoriness of a design, relative to human needs, in a restricted sense - limiting their scope to such quantifiable attributes as the typical distance from a workstation to a window and the per cent of fresh air supplied to a workspace. In other yardsticks, and appraisal of a wider range of architectural qualities is made. These qualities include: responsiveness to context, contribution to community, adaptive re-use of historic buildings, and functionality. Three of the tools – SBTool, CASBEE, and the AIA Top Ten Green – include an assessment of such architectural qualities - but the attempts raise some thorny issues.

Design in response to local context is recognized under "sense of place" in the AIA Top Ten (criterion 2), under "compatibility of urban design with local cultural values" in SBTool (category G1.2) and under "building placement and orientation responsive to the surrounding environment" in CASBEE (Q3.2).

The qualities available through the adaptive re-use of an historic building are recognized under "adaptive re-use potential" in the AIA Top Ten (criterion 9), under "maintenance of heritage value of existing facility" in SBTool (G1.3), and under "consideration for memories of previous uses of the land and the continuation of local culture" in CASBEE (Q3.3.1). Re-use of existing building fabric is measured in LEED in quantity of material only - not for any social value.

The suitability of a design for its intended use is a measure of success in CASBEE and SBTool – but not in the AIA Top Ten. In CASBEE, under the banner of "Quality of Service", the following attributes may be credited: "usability" (including barrier-free planning), "amenity" (including décor), and "reliability" (earthquake resistance, service life, and durability). Likewise, in SBTool, under "Service Quality", credit may be earned for spatial and volumetric efficiency, capability for partial operation of systems, and adaptability of structure, envelope, and mechanical systems. And, under "Socio-Economic Aspects", credit may be earned for such things as barrier-free access, and visual privacy.

Despite its reputation as a "whole building" measurement system, the LEED tool may grant a very high score to a building with few or no redeeming architectural qualities. For instance, many of the LEEDCa Gold buildings are not very responsive to neighbouring buildings, nor conducive to the creation of pedestrian streetscapes. A few "architectural eyesores", celebrated by LEED are presented in Figure 3.4.17a and b. Also, LEED does not grant "points" to a significant design achievement, which is rich in meaning and visually appealing. An eyesore is celebrated at the same level as a design that contributes meaning and richness to its community. The author's picks for the better, in this sense, from LEED Ca in 2007, are presented in Figure 3.4.18a and b.

The SBTool and CASBEE attempt to gauge design quality with a number; the AIA Top Ten Green relies on descriptive text. The number scores in SBTool and CASBEE appear to be objective, because they are numbers. But they are derived in a highly subjective manner, and some of the categories present further difficulties.

For example, in SBTool, points may be earned for the "social utility of the primary building function". The potential scores under this point are defined in broad, qualitative terms, from "work against regional social values or stability" to "very positive impact". A credible methodology must be in evidence in order to earn the point: the opinion of an expert panel, that includes a sociologist and an economist is required and one of four scores may be given: -1, 0, 3 or 5.

Figure 3.4.18

Winners of the author's "LEEDCa + Architectural Merit Award, 2007".

Desirable attributes that LEED does not recognize are more obvious here than in the projects at left. Transparency, daylight, and care in composing materials are evident.

a (top): Crowfoot Library, Calgary, AL, LEED Certified, 2005.

b (bottom): Semiahmoo Library & RCMP Station, BC, LEED Silver, 2004.

(images from cagbc.org)

Figure 3.4.19
Cold climate projects rated by the North-American green building yardsticks (as of October 2007)

	Number of Projects (approximate)			
	Total	**Cold Climate**	**Cold & Non-Resid**	
CBIP Program (Cda)	1,029	929	509	1
LEED (US)	992	399	331	2
LEED (Cda)	56	35	26	3
GB/SBTool (Cda)	29	18	17	
Go Green (Cda)	344	262	262	
AIA Top Ten Green (US)	85	33	28	
Holcim Awards (world)	15	2	1	

1* excludes arenas, MURBs, hotels, industrial, healthcare & retail
2* analysis updated 29 August, 2007; includes branch banks
3* excl. arenas, MURBs, hotels, industrial (winery), healthcare & retail; incl. office

Project,	**Location**	**LEED Level**	**LEED pnts.**	**GBTool**	**Energy kWh/m2/yr**	**Award for Quality**
in the U.S.:						
The Solaire, 20 River Terrace	NYC, NY	**Gold**	41/69	2.0	**383**	AIA TopTenGreen 2004
CBF Merril Env'l Learning	Annapolis, MD	**Platinum**	33/69	2.7	**132**	AIA TopTenGreen 2001
DEP Cambria	Ebensburg,PA	**Gold**	45/69	?	**126**	AIA TopTenGreen 2000
in Canada:						
TOHU	Montreal, QC	**Gold**	40/70	*	**442**	-
North Cariboo Community	Quesnel, BC	**Gold**		*	**123**	-
White Rock Operations	White Rock, BC	**Gold**	44/69	*	**84**	AIA TopTenGreen 2004
Jackson Triggs Winery	Niagara, ON	**-**	-	?	**?**	OAA Excellence 2002
Nicola Valley Inst. of Tech.	Merritt, BC	**-**	-	?	**159**	Gov. Gen. Cda. Medal 2004

Figure 3.4.20
Comparison of the scores of projects rated by more than one yardstick

In devising criteria that could be enumerated by experts in non-architectural disciplines, the authors of SBTool move well beyond the task of appraising a designer's success. Instead of sticking to the test, "given the decision to make a building for x, y, z, how well did the designer do?", a question is posed more like "how valuable was the decision to make this building in the first place?" Curiously, the opinion of an architect is not noted as essential. The developers of the SBTool may have been trying to get at a quality something like "meaningfulness" in design, but by avoiding the considered opinion of an architect, an opportunity was lost.

These attempts - to capture such attributes as contextualism, contribution to the public realm, adaptive re-use of historic buildings, and functionality in a "green building rating system" - are full of omissions and fraught with complications. However, this brief review shows that, around the world, developers of "whole-building" yardsticks are trying to present an appraisal of both energy-efficiency and design satisfactoriness in one report. The fact that such efforts are being made shows that there is support for the bias in this study - to work toward a low-load, high-satisfaction architecture. An extended analysis of the issues would be a very interesting area of further study, as the development of a fair and comprehensive gauge of success remains challenging.*

To address the issue of how to measure quality, in this study, numerical rating of "human satisfaction" goals will be avoided. However, a rigorous appraisal will be made of the case study buildings. This will involve first-hand experience of each building, interviews with project participants, and a written response to a series of yes/no questions, that gauge accomplishment against a consistent set of expectations.

Problem #5:
Climate-specific, and location-specific challenges are not often acknowledged

The use of LEED, to date, in most American states and Canadian provinces may give the false impression that "the measures on the checklist are equally important in all climates". In fact, fewer than half of the buildings recognized in North America by any of today's yardsticks

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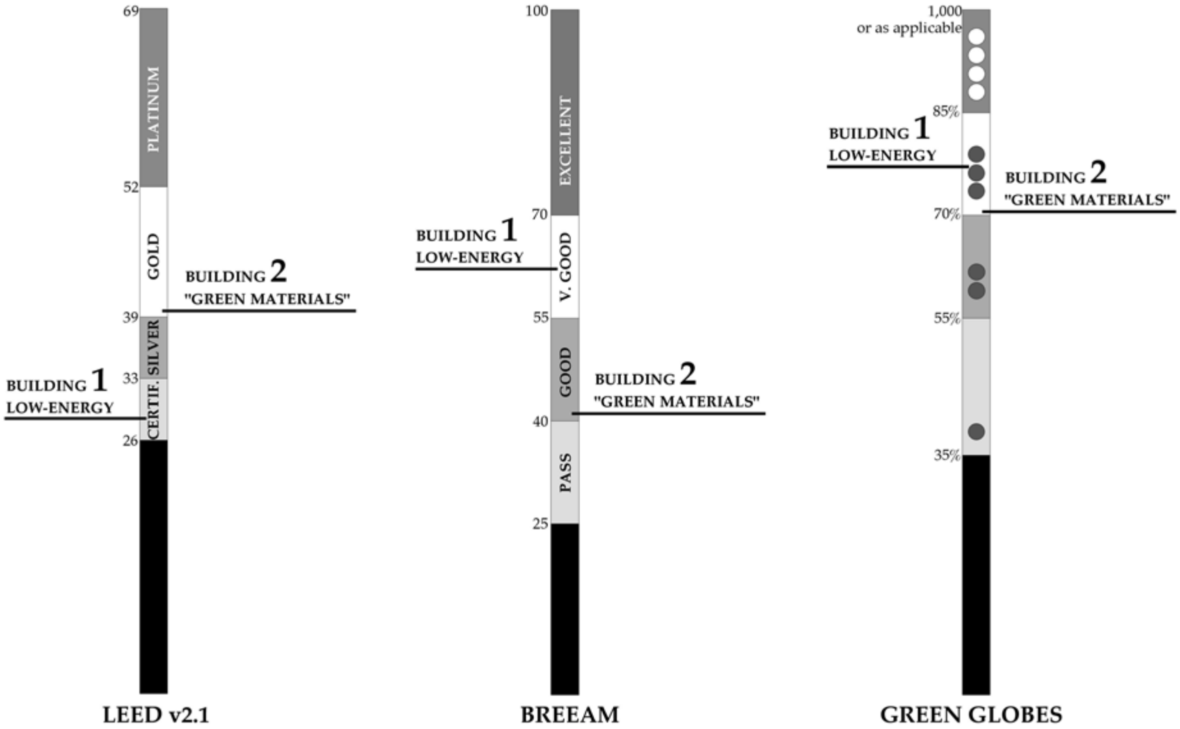
* In 2007, the Royal Architectural Institute of Canada made its first yearly "Award of Excellence – Green Building". Until then, there had been no architectural award in Canada that recognized high achievement in both "design" and energy efficiency. In 2007, the RAIC used only the general categories of LEED as its criteria for judging success - a disappointing practice, in light of the more comprehensive attempts being made in other countries, using other instruments.

Figure 3.4.21
Three yardsticks report
very different results for the
same two buildings

(see Appendix 2 for detail)



are in climates that pose challenges comparable to the study area – and only 30-40% of those are non-residential (see Figure 3.4.19). Instinctively, many people might guess that an environmentally-conscious design for an office building in Baker Lake, Nunavut, might be different from one in Phoenix, Arizona. For instance, water conservation is a far more important aspect of environmental stewardship in Phoenix than it is in Baker Lake. And locally manufactured materials are a near-impossibility in the far Canadian north, but readily available in the American southwest. Yet, using the LEED checklist, design choices regarding both of these issues are scored equally - as if Phoenix and Baker Lake were similar places.

The energy-only yardsticks are clear about the impact of climate. The design awards and whole building yardsticks are mixed on this point. Because so many projects celebrated by LEED and Green Globes are in climates that are not cold, there is a real need to look critically at the strategies employed by the designers. Not all measures are equally effective in all climates. To address the gap regarding specific climate challenges this study is confined to North American cold climates. All aspects of this study are meant to be applicable in an area lying near the Great Lakes - St. Lawrence River Basin.

Problem #6:
Various yardsticks may give contradictory readings about the same building

One might assume that a good score on one yardstick equals a good score on another. To the contrary, the handful of buildings in North America that have been measured by more than one of the “whole building” yardsticks highlights some of the issues. The projects listed in Figure 3.4.20 show that:

- a building with low energy intensity, and a very satisfying design may have represented its country at the iGBC - and NOT bear a LEED certification,
- there is no automatic correlation between LEED score and GBTool score (as would be expected, since they measure different things),
- there is no easy correlation of LEED score and energy intensity – even within one stratum of LEED (Gold), there can be a five-fold range of energy-intensity – from a high of 442 kWh/m^2/yr to a low of 84kWh/m^2/yr,
- similarly, AIA Top Ten Green buildings may have high, average, or low energy-intensities that cannot be explained by differences in function or locale,

- in contrast, GBTool scores are affected by energy intensity,
- yet, low energy intensity is not a prerequisite to selection of a building to represent its country at the iGBC (there are projects that are taken forward for their achievements in other “sustainability” areas).*

To further determine whether the whole building yardsticks differ significantly in their assessment of the “green-ness” of buildings, a small experiment was conducted, as part of this study. Two LEEDCa-certified buildings were selected, and measured with LEED, BREEAM, and Green Globes. At the outset, it was hoped that the scores would not differ very widely, since these three yardsticks are the most closely related among all of the instruments surveyed. However, it was suspected that there would be some difference, since each of these tools assigns a different weighting to energy and emissions (within the overall pie).

The two buildings selected for the test are located in the same city (Edmonton) and both are of modest size (9,600 sf and 26,157 sf). However it was clear from the LEED scoresheet (CaGBC 2008) that Building 1 excelled in energy-efficiency, while Building 2 did not.**

The results of this test are shown in Figure 3.4.20. The assessment using LEED is the inverse of the assessment by the other two systems. And the gap in performance is much wider according to BREEAM than it is according to Green Globes. Clearly, LEED, BREEAM and Green Globes present quite different stories about the comparative success of Buildings 1 and 2. Perhaps this would be the case with other buildings as well.

False impressions left by today’s yardsticks:

The rapid rise in visibility of LEED, throughout the construction industry, may raise the false impression that “everybody’s using it”. Although the buzz around USGBC and CaGBC has increased exponentially since 2003, the number of LEED projects is still very small in relation to the overall activity in the Canadian construction industry. ***

The impression also may be growing that “if it’s sustainable, it must be recognized by one of these yardsticks”. Evidence of this

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* All of these measurements were made by teams familiar with the yardstick in question, and have been verified by third parties.

** For a summary of the detailed analysis of this pair of cases, see Appendix 2.

*** As of 2 Oct. 2009, the total floor area of all LEED-certified projects in Canada was 20,693,000 sf.(CaGBC 2008, 2009). This would equate to roughly eight office towers, at the size of First Canadian Place in Toronto, which is 2,700,000 sf.

lies in architects' use of "LEED" and "sustainable" as if they were interchangeable.* But this, too, is false. It is important to remember that green building yardsticks are relative new-comers in the realm of building appraisal, and these still are very early days, in their evolution. Many buildings and townscapes that may legitimately deserve the description "energy-efficient" - or even "sustainable" - have, for millennia in the history of architecture, escaped measurement, labeling and promotion as "green".

True intentions when measuring success

During the same year that saw a rapid acceleration in the activities of the USGBC, the AIA COTE - an organization with 49 chapters and 7,200 members - identified several limitations in the LEED tool.** Qualities not addressed in LEED but cited by the AIA as very important to architects, and the public, include: regional/community design, bioclimatic design, "long life, loose fit", feedback loops (community involvement in the design process), "buildings that will last because they are loved by their communities", and planning for the energy future. (AIA COTE 2006)

The AIA has been consistent in avoiding endorsement of one green building rating system over another. This should serve as a cautionary note to an architect who might be tempted to "promote" LEED, or any other system. Recognizing that the continued evolution in these tools is essential, the AIA has identified sixteen parameters that would characterize and effective yardstick, as follows (emphasis by Ross):

> *"The AIA encourages … the inclusion of the following features in "green building" rating systems (sic) … That it …*
>
> - *is developed and renewed on a regular basis ...,*
> - *require ... documentation to demonstrate compliance ...,*
> - *require compliance to be validated by an independent third party,*
> - *require the development of sustainable sites ...,*
> - *require specific goals in the efficient use of water resources ...,*
> - **require specific goals for significant reductions in energy use …,**
> - *promote the use of renewable energy sources ...,*
> - *require reduced use of non-renewable natural resources ...,*
> - *require specific goals for improved indoor environmental quality,*
> - *promote the development and application of innovative designs ... that tend to improve environmental performance,*

---

* Author's personal experience in three settings between August and October, 2008.

** http://www.aia.org/cote_about accessed 29 October, 2008

- *recognize the life cycle value of a community or project ...,*
- *utilize life cycle assessment data as the basis for design and construction decision-making,*
- **acknowledge national, regional, and bio-climatic differences,**
- *reduce (and eventually eliminate) on-site and off-site toxic elements ...,*
- **require specific measurable reductions in CO_2 production …,** *and*
- **require documentation of actual building energy and operational performance.”** *(AIA SRC 2005)*

In various studies for diverse North American government agencies who wished to adopt the “best” green building rating system, LEED compared favourably to the others - including BREEAM, Green Globes, SBTool, and CASBEE. In a study for the U.S. DOE (Fowler 2006, AIA SDiG 2008), the desirable criteria for a green building rating system, were that it be:

- applicable to large and complex buildings,
- stable (no wild swings in evolving way of measuring),
- inclusive of quantifiable achievements that can be verified by a third party, and
- in current use, with practitioner awareness.

In an earlier Canadian study (Cole 2001), thirteen desirable criteria were mentioned. Stakeholders selected a short-list of the highest in priorities for a green building rating system, that it be:

- simple and practical,
- inexpensive,
- able to offer comparisons and benchmarking,
- able to be customized while retaining universality,
- supported by a viable organization, and
- having potential to be adopted, as a North-America-wide system.

Yet - no matter which tool is used - there is a fundamental problem, inherent in all “green building rating systems” that has been described this way:

> *“The assumption is that by continually improving the environmental performance of individual buildings, the collective reduction in resource use and ecological loadings by the building industry will be sufficient to fully address the environmental agenda.”* (Cole 1999)

This is to say, the presence of a green building rating, as awarded today, raises two fallacies within the construction industry, and in wider society. First, it may appear as though something is being done - when, in fact, the measurement devices are inadequate to read whether or not true results are being realized. And second, it is difficult to tell how the collective results that are being realized compare to the overall need for mitigation of environmental damage.

Added to the fundamental problem identified above, there is another complicating issue, to do with the voluntary nature of these "standards". Gifford likens the data collection strategy that was to analyze energy use in LEED buildings to "making generalization about drivers' blood alcohol levels from the results of people who volunteer for roadside Breathalyzer tests" (2008). In a more sober way, Cole goes on to say:

> *"Voluntary assessment protocols must serve two conflicting requirements - they must function as an objective and sufficiently demanding metric to have credibility within the environmental community, while simultaneously being attractive to building owners who wish to have something positive to show for ANY effort that they have placed on environmental performance. Satisfying these twin requirements invariably compromises both the number of criteria that are assessed and where the bench-marks are set before performance points are earned. ...*
>
> *Given the ... dependency on market acceptance, it is uncertain whether this mechanism will be sufficient to create the necessary improvements in environmental performance of buildings needed to meet broader national environmental or sustainability targets." (Cole 1999)*

Proof that Cole's analysis was prescient has just been published, in the following statement, that introduces the upcoming release of LEED v3:

> *"While the urgency of pending environmental crises that face the coming generations weighs heavily on all of us, there is recognition that LEED cannot completely forsake market uptake for environmental priorities. ... Continuing to strike the optimal balance between market uptake and technical advancement is one of the driving forces behind the LEED 2009 work." (USGBC 2008a)*

Regarding the future of “green” design, and of the rating systems used to measure it, architect Jason McLennan predicts:

> *“By 2015 the sustainable design movement will be mainstream, but will still have a lot of room to grow. ... Near the end of the decade stricter standards such as California’s Title 24 Energy standards will become commonplace in all states. ... The USGBC will have to find ways to reinvent itself and resist bureaucratic complacency to continue with its success. Competitors to LEED will emerge by the end of the decade. ...Twenty years from now what was the gold level of performance in LEED will be the standard level of performance for all buildings in the United States and Canada. ... Most buildings will use forty to fifty percent less energy than their counterparts today. The best buildings will use eighty to ninety percent less energy than their counterparts today and use fifty percent less water.” (2004)*

Today’s yardsticks have been shown to be “works in progress”. Most of them are burdened with significant complications - either in their fundamental intent, or in the way they take their readings. The way they prioritize the issues - particularly energy use and greenhouse gas emissions - remains highly questionable. None of today’s rating systems provides the guidance or the balance being sought in this study. These are the reasons that some practitioners characterize these tools as burdensome, rather than helpful - distracting rather than advancing the effort to realize a lower-load and higher-satisfaction architecture. Moving closer to that task, there are a few elements of the background yet to acknowledge.

3.5 THE IMPORTANCE OF SHAPE, ORIENTATION AND SKIN

None of the “whole building green rating systems” adequately demonstrate the consequences – with respect to energy use, and, hence to climate change - of an architect’s fundamental design decisions. The tools provide few aides, with respect to the first choices that architects make, that “deal the cards” to the rest of the design team, namely: the overall form of the building, the orientation relative to the sun, and the design of the enclosure.

After applying the various yardsticks to a few familiar buildings, architects are left with questions like:

- How much can choices of form, orientation, and enclosure design influence the energy-efficiency of “mid-sized” and “big” buildings? (e.g. are skinny floor plates, oriented east-west, an absolute “must”? If so, how “skinny”? What is the latitude?)
- What is the interplay between form, orientation and enclosure design? (Can the effect of a choice in one area fully over-ride the effect of a choice in another? Where are the cross-over thresholds?)
- Do choices of form and orientation have similar consequences at different scales?
- What is the relative magnitude of energy flowing to various functions (i.e. heating, cooling, lighting, fresh air)? Where exactly is the waste?
- What guidelines – about massing, orientation, and enclosure design - pertain specifically to cold climates, in contrast to milder climates? (e.g. Toronto vs. California).

The literature is full of statements that these things matter. A few samples are reflected in Figure 3.5.1.

*"The **form of a building**, however, is crucial to its environmental performance, as are its **orientation** and materials" (Hagan 2003)*

Figure 3.5.1

The role of building form & orientation in achieving the "new normal"

(emphasis by B. Ross)

*"At the early design stage, **key decisions – usually made by the architect** – can greatly influence the subsequent opportunities to reduce building energy use. These include **building form, orientation, self-shading, height-to-floor area** and decisions affecting the opportunities for and effectiveness of passive ventilation and cooling." (IPCC WG3 Levine 2007, 395)*

*"Solar **orientation of the building's form** reduces heat gain and augments daylighting" (Boecker 2008)*

*"**Building orientation** is a crucial element to harvesting site energy. Rules of thumb for **passive solar orientation and optimal building sections** are well developed and can be found in references." (USGBC 2003, 138)*

*"The key to understanding building performance as a whole is to understand the maximize integration among the various building systems. Begin by carefully and systematically reducing the overall building loads. ... A good practice is to **work on the orientation and massing of architectural elements first,** the building skin second, and finally the glass itself. ... Make maximum use of **building orientation,** shading, exterior landscaping, and other passive solar opportunities to reduce overall heating and cooling loads, while admitting beneficial daylight." (Mendler and Odell 2000, 9)*

*"Reducing the cooling load **depends on the building shape and orientation** … and a whole host of other decisions that are made early in the design stage by the architect and are highly sensitive to climate" (IPCC WG3 Levine 2007, 397)*

*"The government White Paper suggests that buildings could deliver 1% (24 MT) of the required GHG reductions. This target is pitifully low; we can do much better! . … Readily available architectural and engineering design strategies have been developed that are applicable to buildings in every part of the country: improved thermal envelope performance; rational envelope design improvements **(orientation, massing, shading);** natural ventilation, combined with operable windows and stack effect cooling; passive solar heating; thermal mass energy storage …." (Busby 2002)*

“Minimize heating and cooling loads and maximize daylighting potential through ***orientation, building configuration, an efficient building envelope*** *and careful consideration of the amount, type and location of fenestration.” (Larsson 2004)*

“…minimizing energy use requires optimizing the system as a whole by ***systematically addressing building form, orientation, envelope,*** *glazing area, and a host of interaction and control issues …” (IPCC WG3 Levine 2007, 418)*

“The ***orientation of the building*** *has a considerable influence on its behaviour in summer. ... Room climate can be considerable improved at little extra cost if the characteristics of a facade arising from its orientation are taken into account in the strategies for providing solar screening and adequate ventilation. (Hausladen et. al. 2006, 40)*

“The amount of solar radiation entering the building increases directly in proportion to ***the proportion of window area.*** *In practice, however, in administration buildings over 30% of the solar gains from the ... window area cannot be exploited. Windows lead to increased heat losses in times of low solar radiation, which ... affects total energy balance. In summer high solar energy input may result in overheating. (Hausladen et. al. 2006, 34)*

“We realized ... that it is only by exerting early influence on the architectonic design that noteworthy impact on the future energy consumption and user comfort of the planned building can occur ... we prefer to get involved in new projects at the competition stage or when the first sketches are being drawn, in other words, ***at a point where the architectonic approaches are still receptive*** *to outside suggestions.” (Thierfelder 2003, jacket)*

Relating the site to issues of ***orientation and massing*** *will begin to impact the way that programmatic requirements may be accommodated in the building. ... The consideration of local site conditions may help to determine the placement of daylit versus non daylit or service spaces. The* ***cross sectional characteristics and building height*** *may also need to be modified to feed into lower energy, natural solutions. ... Issues such as these are not to be found on any “checklist”, but greatly impact the overall environmental performance and energy requirements of the building. (Boake 2008)*

to be proved

Figure 3.6.1
Estimate of capital cost premiums for various LEED levels

(BNIM 2002; Kats et. al. 2003; US GSA 2004; McAuley 2007; Matthiessen and Morris 2004, 2007)

Study author and scope	**Capital Cost Premium for LEED / other**					**Baseline defined as**
	Certified	Silver	Gold	Platinum	"Living"	
BNIM 2002						
est. energy use (kWhr/m2/yr):	***259***	***207***	***138***	***87***	***n/a***	***329***
estimates re 6 options for a	**1%**	**13%**	**15%**	**21%**	**29%**	**"market"**
new 90,000 sf, owner-occupied						
office bldg. in California						
Kats et. al. 2003						
est. energy use (kWhr/m2/yr):	***?***	***?***	***?***	***?***	***?***	**varies**
33 estimates re new offices (25) &	**0.66%**	**1.40%**	**1.82%**	**6.50%**		**with each**
schools (8), of undisclosed size		**to**				**project**
in 12 states CA-NY		**2.49%**				
US GSA 2004						
Energy Performance, EA1:	***1-3 pnts.***	***3-5 pnts.***	***5 pnts.***			***1 pnt.***
estimates re 2 options for a	**-0.40%**	**-0.03%**	**1.40%**	**-**	**-**	**GSA**
new 262,000 sf courthouse	**to**	**to**	**to**			**standard**
prototype in Washington, DC	**1.00%**	**4.40%**	**8.10%**			**(>market)**
US GSA 2004						
Energy Performance, EA1:	***3-5 pnts.***	***5-8 pnts.***	***7-8 pnts.***			***1 pnt.***
estimates re 2 options for a	**1.40%**	**3.10%**	**7.80%**	**-**	**-**	**GSA**
reno to a 306,600 sf office bldg.	**to**	**to**	**to**			**standard**
prototype in Washington, DC	**2.10%**	**4.20%**	**8.20%**			**(>market)**
McAuley 2007						
Energy Performance, EA1:	***?***	***?***	***?***	**-**	**-**	***?***
9 real projects of undisclosed	**1.00%**	**3.00%**	**4.00%**	**-**	**-**	**varies**
size, in "ICI" sector, '04-'07	**to**	**to**	**to**			**with each**
estimated by Altus-Helyar	**18.00%**	**14%**	**5.00%**			**project?**
McAuley 2007						
est. energy use (kWhr/m2/yr):	-	***145***	***149***	**-**	-	***220-260***
estimates re 3 new (imaginary)	-	**8.00%**	**7.60%**	**-**	-	**varies in**
132,-170,000 sf office bldgs.			**to**			**ea. pair of**
in Nova Scotia & Ontario			**11.50%**			**cases**
Matthiessen & Morris 2004	**Capital Cost for LEED projects**					
Energy Performance, EA1:	***?***	***?***	**-**	**-**	**-**	*non-LEED:*
actual bids for 138	**$190/sf**	**$205/sf**	**-**	**-**	**-**	**$175/sf**
new library, lab & edu bldgs.	**to**	**to**				**to**
undisclosed size & US loc'ns	**$370/sf**	**$280/sf**	*"academic buildings" (52 projects)*			**$425/sf**
Matthiessen & Morris 2007						
Energy Performance, EA1:	***?***	***?***	***?***	**-**	**-**	*non-LEED:*
actual bids for 221	**$250/sf**	**$310/sf**	**$260/sf**	**-**	**-**	**$240/sf**
new civic buildings (5 types)	**to**	**to**	**to**			**to**
undisclosed size & US loc'ns	**$500/sf**	**$520/sf**	**$300/sf**	*acad. bldgs (60)*		**$590/sf**

3.6 OPINIONS ABOUT THE COST OF "GREEN" BUILDING

What can an architect reasonably advise a client, at the project definition stage, about the potential cost implications of "going green"? The following section provides an overview of the responses to this question, offered by recent studies. There is an impression - somewhat vague, but gaining traction in the construction industry - that it is possible to formulate a rule about the cost of a "green" building. If there were such a rule - broadly applicable, reliable, and easy to apply to most situations – then that could guide goal-setting at the beginning of a project. Here, a comparison of the approaches and conclusions used in these studies asks whether the search for an "easy rule" of this kind is reasonable.

The studies were selected because they are the work of teams with notable track records, and because their conclusions are widely quoted in the literature of "green" building. All of them were launched on the assumption that it usually costs more to realize a "green" design than it does to realize a "default" or "market standard" design. In all but one, the LEED rating system was used as the measure of the "greenness" of the design. Fortunately, most of the studies also refer to the level of energy-efficiency that is expected to be attained by the design - so this is cited, here, as well.

The following overview begins with a focus on "capital" cost premiums, independently of any other consideration. Next there is a comparison of the claims made about "payback" or the "value" of investing in "green" premiums.

What the studies say about capital cost

Each of the cost studies cited here is concerned with new institutional or office buildings, in North America. In some of the reports, the size of the buildings that were studied is not disclosed; however, qualitative descriptions suggest that the range is from approximately 40,000 sf to 300,000 sf. In some of the studies, a team of estimators predicts the cost of specific cases; in other studies, data about several buildings is collected, post-bid, from various sources, and compared. The findings of five of the studies, with respect to capital cost premiums, are summarized in Figure 3.6.1.

The first study, by a design team with extensive experience in commercial building, and fluency with "green technology", was conducted for the Packard Foundation - a philanthropic organization, with an interest in the environment. The consulting team, led by BNIM

Architects of Kansas, developed six alternative designs for Packard's future office headquarters, on an urban site in Los Altos, California (BNIM 2002). In each option, the form of the building was modified, as was the orientation of the major facades, the thermal resistance of the enclosure, the lighting design, and the climate control systems. The designs were associated with either a "market default" level of quality, or a LEED level, or a level beyond LEED, called "Living Building". With each increment in LEED level, there was a steady increment in the number of points, under the "Energy and Atmosphere" category of LEED. The estimated energy intensity of the designs ranged from 329 kWhr/m^2/yr for the "market default" office building (close to the U.S. national average), to 87 kWhr/m^2/yr, for the LEED Platinum option.

The consulting team concluded that the capital cost premium for "greening" the Packard headquarters building would vary in direct proportion to the LEED level of the design (see Figure 3.6.1). The authors make it clear that the results pertain to the specific options developed for the Los Altos site, in 2002; they make no representation that the "green premiums" discovered in their study might be applicable to a different project in a different circumstance. However, the consulting team does suggest that the "decision making framework" developed for Packard sets an example of an overall approach to the assessment of costs and benefits that might be used by other teams on future projects. The estimated benefits in operating costs and "costs to society" are discussed below, under "paybacks".

In a second study, a group of former public servants, with experience in energy monitoring, provided advice to the California Sustainable Building Task Force. The group collected cost data for 33 buildings that had applied for LEED certification (Kats et. al. 2003). For each of these designs, the original client-architect team provided the research group with a comparison of the cost of the "green" version to the cost of a "non-green" version. The case studies were drawn from twelve states, and were completed between 1995 and 2004. This was a period of significant change in the construction marketplace, and the general economy, across North America. The report implicates that the data includes both post-bid (actual cost) and pre-bid estimates, depending on the date of completion of the project; however, it does not make explicit which figures are which. No comment is made with respect to market forces that would influence the construction costs in different localities at different times.

The 33 cases that Kats examined include 25 office buildings and 8 schools. Although the study was directed to California legislators, there is considerable representation of cold climate cases: 12 of the office buildings and 5 of the schools are in Pennsylvania, New York, Ohio, Illinois, and Wisconsin (2003, 112). The consulting team again concluded that the capital cost premium for a LEED design increased, in direct proportion to its LEED level, although the size of the premium was much lower than that estimated in the Packard study (see Figure 3.6.1).

The Kats report includes a lengthy argument that increased energy performance is a key element of "green design". However, it invokes the findings of other studies of LEED-certified buildings that show an average 30% reduction in energy use, versus various baselines. The report does not present the Energy and Atmosphere point scores, under LEED, nor any form of energy data, for any of the 33 case study buildings whose costs are compared. On the basis of cost data collected from diverse corners of the US, it argues that the average cost premium for a LEED building in California is approximately $4/sf, and makes the following declaration:

> *"Although this report was written with specific regard to California state buildings, data is national in scope and conclusions are broadly applicable to other types of buildings and for other public and private sector entities." (2003, v)*

The Kats study commonly is cited as the "definitive" opinion about the cost premium of "green" design. Despite the vagueness in its methodology, the resounding simplicity of its findings has helped to establish an expectation that there is a "universal rule" about the capital cost premium for a "green" – or, more particularly, for a "LEED" – design.

A third study was prepared by a team led by Stephen Winter and Associates, an architecture/engineering research firm, self-described as specialists in building science, energy-efficiency, and cost-estimating. The U.S. General Services Administration (US GSA) commissioned this study, to help with future capital cost planning, for its entire portfolio buildings (a portfolio that currently includes 8,300 Federal facilities, nation-wide, that house over 1,000,000 employees). At the time, the GSA wished to set a reasonable range of expectations for attaining LEED certification (at the Silver level, or higher) in all of its projects. Estimates were made of the cost of design options for two large prototypical projects, as proxies for future government-funded projects of similar size and complexity. One was a new 262,000 sf Federal courthouse, and the other was a full renovation of a 306,600 sf Federal office building (US GSA 2004).

The consulting team for the GSA study developed six LEED rating scenarios for each of the prototypical buildings. That is, for each LEED level that they studied (Certified, Silver and Gold), a “low-cost” and a “higher-cost” set of LEED points was written into an outline specification, and then the implied costs were estimated (18). The team noted that the existing standards for a GSA building already included LEED-worthy attributes that would be more costly than an average, “market” building, such as: energy-efficiency targets that are more demanding than the code minimum, mandatory commissioning, and dedicated ventilation systems (5). Because the approach to LEED is “bracketed” for cost, and because the “baseline” for comparison is higher than in other studies, the cost premiums that the Winter team estimated are quite different than those estimated in the previous two studies (see Figure 3.6.1).

The authors of the GSA study express a strong caution that their results may not be applicable to other building types, smaller buildings, or non-GSA projects. In addition to the federal standards and the specific approaches taken to LEED in this particular study, the demands of the functional program and assumptions about the specific sites and contexts are among several important “qualifiers”. These, the authors warn, would make it unreasonable to translate their results to dissimilar scenarios (4).

A fourth study was conducted as a research thesis, within the Masters in Architecture program at the University of Waterloo (McAuley 2007). The study begins by reporting the cost premiums for nine “LEED” projects, shown in Figure 3.6.1. The premiums were estimated by the Altus Group of Toronto, in its consulting role to real clients (42). Next, McAuley designed and developed an outline specification for three typical speculative office buildings, based upon real buildings. With help from the Altus Group, he made an estimate of the cost of a LEED version and a non-LEED version of each case (McAuley 2007). Like the BNIM and GSA studies, McAuley’s test cases incorporated measures that gained a significant number of “Energy and Atmosphere” points on the LEED checklist. Unlike the earlier studies, the gradation, from one case to the next, was not in even increments (6 EA points were designed into the LEED Certified case; and the two LEED Gold cases sought 6 EA points and 9 EA points, respectively).

The second entry in Figure 3.6.1, with respect to the McAuley study, shows estimates of the premium to “green” each of three office cases. In his results, the relation between capital cost premium and LEED level is not as neatly linear as it is in the first three studies. This study casts some doubt on the presumptions that “green always costs more”, or that “higher levels of LEED always cost more”.

A fifth study was conducted by the US branch of a major international cost-estimating firm, Davis Langdon, as a general reference to be read by its clientele and the public at large (Matthiessen and Morris 2004, 2007). In the first version of this study, the analysts searched the company’s database of non-residential projects, and selected 138 reasonably comparable projects (2004). Drawing from several US states, the actual construction cost of “academic classroom buildings”, laboratories, wet laboratories, libraries and branch libraries was “normalized” to a common time. Three years later, the analysts updated the study, selecting an additional 221 projects and repeating their steps. In the update, the categories of occupancy were the same as in the first, with the addition of community centres and ambulatory care centres as well (2007).

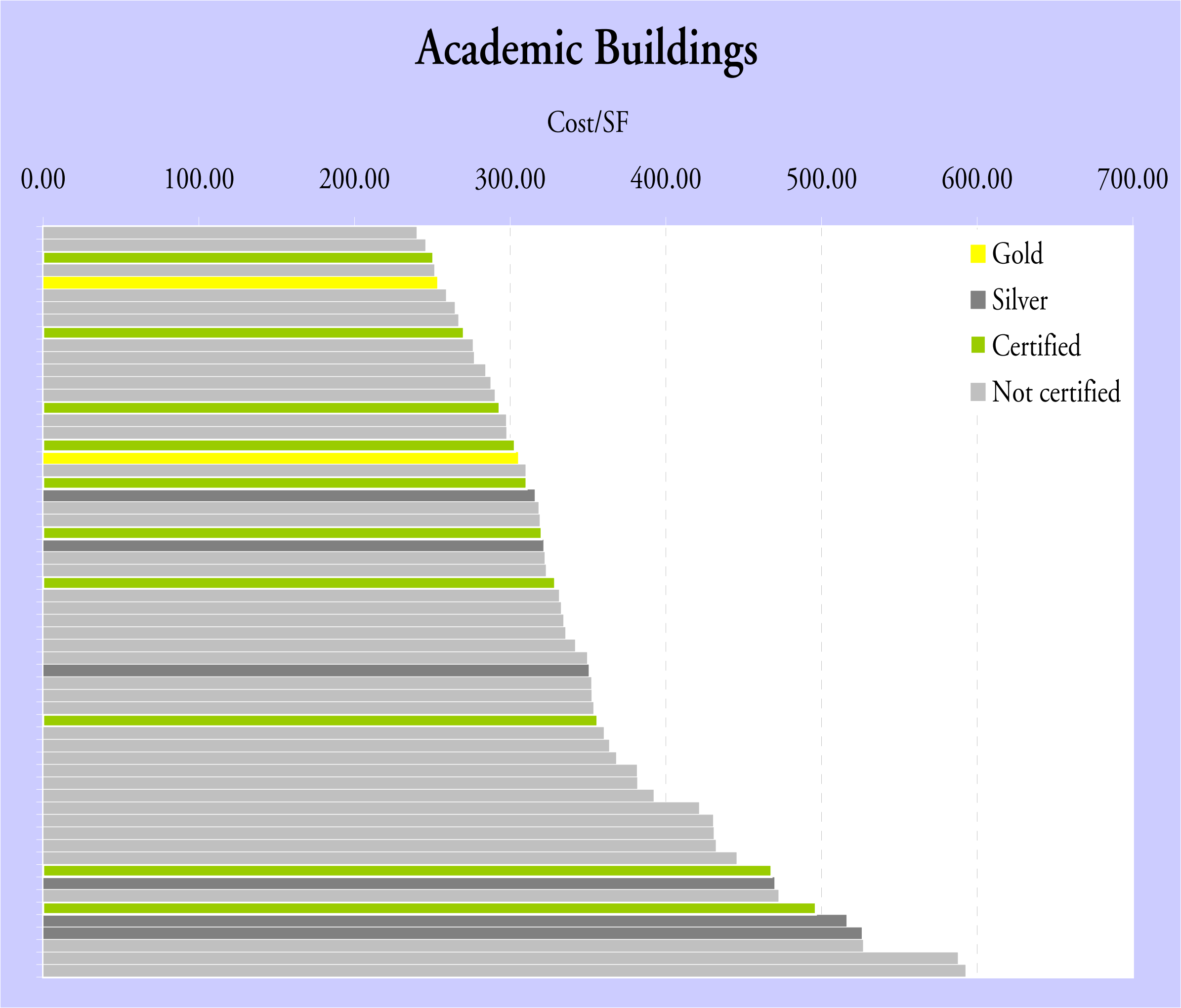
Matthiessen and Morris’ conclusions are starkly opposed to the conclusions made in the Packard, Kats, and GSA studies. The Davis Langdon data shows a very large variation in costs of buildings of the same occupancy category, and no statistically significant difference in the cost of LEED-seeking and non-LEED buildings (2004, 23; 2007, 10). In their sample set, LEED, and non-LEED projects appear in roughly equal numbers at every price point, across a threefold range. The data for academic buildings is shown in Figure 3.6.2. These conclusions are highly credible because of the size of the data set and the fact that Davis Langdon used actual cost data. In both reports of their research, Matthiessen and Morris use strong language to caution readers against budgeting buildings “on averages”.

A sixth study (not reflected on Figure 3.6.1) was conducted by a team led by a building science professor at the University of Toronto, in consultation to the City of Toronto. Its purpose was to evaluate the impact on the public purse, of enacting a “green building standard” for all new construction in the region (Kesick 2008). For a generic 220,000 sf office building, Kesick and his team developed eight options, using two distinct climate control systems, and four levels of whole-building energy-intensity for each.

Since LEED was not used as the measurement of “green”, the findings of this study, with respect to capital cost premiums, are not easily comparable to the other studies. However, Kesick concluded, as did the earlier studies, that the cost premium to a building developer, would vary in direct relation to the level of energy-efficiency of the design. For instance, this study represents that the cost premium to

Figure 3.6.2
Capital cost of a LEED academic building vs. non-LEED comparators

(from Matthiessen and Morris 2007)



take a “market” quality office building, with an energy-intensity of 225-260 kWhr/m^2/yr through a series of stages to an energy-intensity of 188-196 kWhr/m^2/yr range from $0.62/sf to $5.45/sf.

Capital cost premiums – compared to what?
The comparison presented in Figure 3.6.1 highlights how illogical it is to try to formulate a “one-size-fits-all” rule about the “typical” capital cost premium for a “green” building. The six landmark studies show a wide gamut of results, because they are concerned with a variety of designs for buildings to suit various purposes, on sites that pose unique challenges. Also, they are subject to the factors at work in various bidding environments. Even with the delimitations of “North American non-residential building”, the conclusions of these studies range from “a green building costs up to 20% more than a non-green building” to “green building may cost much less than a non-green building”.

Trying to compare projects solely on the basis of LEED level, or a simple measure of energy-efficiency, as if the designs were comparable is ineffective. The gamut of results from these studies is also due to variability in the architectural quality of the subject buildings, and the fact that the baseline – against which the cost premium is compared – is different in each study. For instance, in the GSA and Davis-Langdon studies, there is an assumed baseline architectural quality that is higher than the market default. The cost premium for “greening” appears lower than it does in the Packard study, where the baseline is the market default. Also, in the Packard study, the architectural qualities are enhanced as the LEED level increases; there is more natural light, more interesting facades, and an atrium which, one imagines, would bring an added amenity into the interior of the building.

The first version of the Davis Langdon study identified several factors that influence the feasibility and cost of seeking LEED, including: bidding context and culture, local design standards, demographics, values of the project, climate, timing, size of the building and LEED point synergies (2004, 13).

Matthiessen and Morris provide detailed commentary on each of these factors. For instance, the impact of climate is illustrated, by estimates of the cost of a known design in five different US climates (Denver, Houston, Boston, and two different regions of California). The cost premium for the same project varied from 1.0% to 3.7% for a Silver rating, from 2.7% to 6.3% for a Gold rating, and from 7.6% to 10.3% for a Platinum rating, with anomalies arising from local conditions at each LEED level.

This again shows how unreasonable it is to try to apply a "rule" about "green" cost premiums, derived in one location, to a different location with distinct climate and construction marketplace. One project may be bid during a "boom" in local construction activity, when costs are high; a similar project, in another location, may be bid when construction activity is at a low ebb, and costs are relatively low. More cost studies, with credible methodologies and large data sets are needed, to suit the Great Lakes Basin, and the Greater Toronto Area, in particular. Among the cost studies reviewed here, only the McAuley and Kesick research employs Canadian market cost data.

What's the "payback"?

In these studies, the case in favour of investing a capital cost premium (if there is one) in "green" design is put forward in a variety of ways – some traditional and some more creative. A more traditional argument is that the capital premium for "green building" will yield operating cost savings to the building owner-operator, within a reasonable time frame. The BNIM and Kats studies both employ this line of reasoning. McAuley extends their notion, arguing that the capital premium may enhance the resale value of a property.

A value of a different sort is seen in the potential of a design for a single green building to leverage a general societal benefit, "upstream". This type of benefit has, so far, been treated as an "externality", in the normal course of budgeting a capital project. Of late, many have suggested that such externalities ought to be "monetized" in keeping with the concept of "full cost accounting" (Hawken et. al. 1999).
As shown below, several of the "green" building cost studies have attempted to put a dollar value on "external costs to society", such as: reduced pollution, worker productivity, and occupant health – in addition to the more tangible and immediate matter of fuel cost savings.

In the BNIM study, the team estimated the savings in operating costs, associated with each level of energy-efficiency, and included these in a calculation of the net present value of each design option. While the cost premiums for "green" resulted in lowered grid reliance, and hence lowered operating costs, they also lowered the pollution emanating from the building (mainly in greenhouse gas emissions).

The team put a dollar value on the health benefits of reduced air pollution, in each design. The used factors, derived from the work of Harvard University professor Jonathan Levy, whose research inquiry is broadly described in Figure 3.6.3. Taking the direct cost savings, from lowered utility bills, and the societal cost savings (the "externalities") together, over 30-, 60- and 100-year horizons, the design team argued that the extra capital investment to attain each tier of additional "green" rating would realize an "added value" – to the Packard Foundation, and to the community as a whole (BNIM 2002). *

The Kats study also argued that the 20-year cost benefit – "to the state of California as a whole" is $50/sf, for a LEED Certified or Silver building, and $75/sf, for Gold and Platinum (2003, 98). These returns look very favorable against the $4/sf average cost premium that Kats claims is widely applicable. However, approximately 70% of the financial benefits estimated for "green" design, in this study, were related to employee productivity and health, while only 11% were related to energy cost savings (Kats 2003, 99). By its own admission, this study cautions that it is very challenging to estimate productivity gains with accuracy (1).

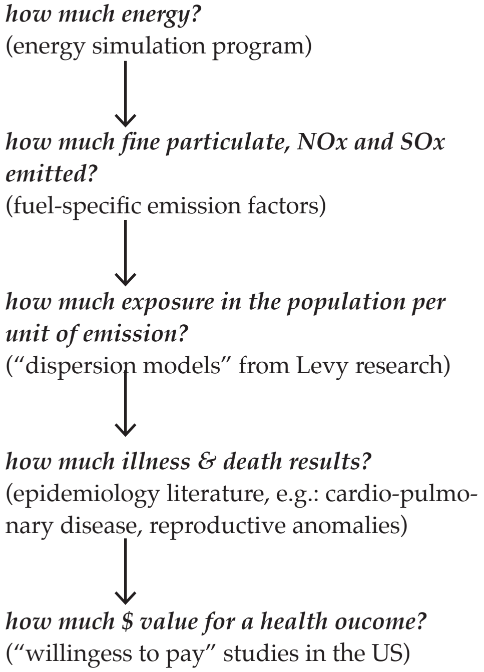


Figure 3.6.3
Process of analysis used to estimate "external costs to society", stemming from energy use

(after Levy et. al. 2003; O'Neill et. al. 2003)

McAuley argued that developers ought to acknowledge - and put a dollar value on - the potential of the LEED option to attract rent premiums and increased building occupancy, collectively termed "residual value premium". He estimated that the cases he studied would be worth an average of $258.75/m^2 GLA/annum more than conventionally constructed reference buildings. However, he concurred with the conclusions of other studies that *"choices that are made during the design process will ultimately determine whether a building will be sustainable, not the budget"* (McAuley 2007, 119; Matthiessen and Morris 2004, 27; 2007, 24). He also observed that:

> *"The payback calculations also focused on measurable returns to the developer. Although it is clear that there are many advantages to building in a more sustainable way, the most significant benefits are typically to the building occupants, where the traditional economic tools do not effectively express the advantages over conventional buildings" (McAuley 119).*

As in the BNIM and Kats studies, the Kesick study looks at the leverage potential of a series of individual buildings to a positive effect, upstream. Kesick estimated the potential cost-avoidance to

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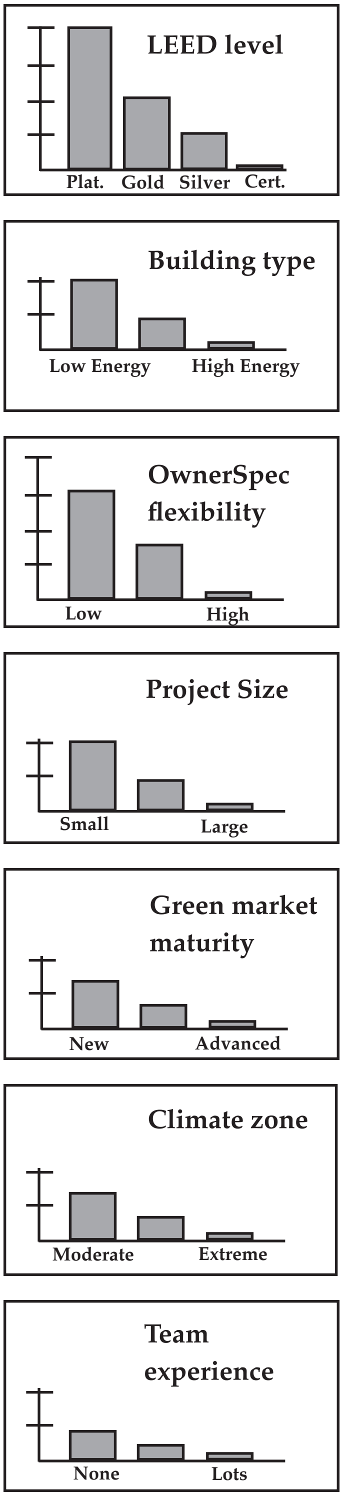
* Levy notes that this sort of calculation is complex, and that the factors are location-dependent, varying at every step, according to issues such as fuel mix and source, population density, population sensitivity to disease, and so on. The Packard study does not disclose what factors were used, or how they were tailored to the Los Altos Community.

Figure 3.6.4
Factors that influence the capital cost of a green building

(after Busby 2006)



municipalities in the Greater Toronto Area, from widespread adherence to lowered energy-intensity targets for office, retail, and multi-unit residential buildings. Upstream of all new construction projects, the cities would avoid cash outlays, at the power distribution plant, and in water-management infrastructure (Kesick 2008). Clearly the argument was well-received, as the Green Development Standard was voted into regulation in the fall of 2008.

At present the green design press is rife with articles exhorting architects to engage in life-cycle cost analyses, in order to show their clients the value of "green" building (see, for example Sherwin 2006; Wolff 2006). However, experience suggests that these complex analyses are not very often successful in decision-making. For a client, the design that keeps options open - for future alteration, expansion, or whatever - may be more important than any promise of monetary gain. The authors of *New Generation Whole-life Costing* suggest that "gut feel" trumps payback calculations more often than not:

> *"… although quantitative evaluation techniques are well known in the property and construction industry they are seldom applied … many decision-makers believed that the outcome of analysis often did not accord with their experience and gut feel – they did not have confidence in the results. … Quantified methods are useless or worse without insight and judgement, which are the hallmarks of gut feel. And gut feel is not the same as prejudice and complacency: at its best it is built up by constant enquiry and reflection and the consideration of all available information … Gut feel and quantified methods should be complementary aspects of top level decision-making." (Ellingham and Fawcett 2006)*

Gut feel and market influences

Rather than try to apply a "rule" from an unrelated project in a different market, a designer may turn back to conventional wisdom about the factors that influence the cost of a construction project. In a review of his experience, architect Peter Busby presents a graphic checklist to remind designers of ways in which market factors influence the capital cost of a green building (see Figure 3.6.4). This tool might help an architect and a client to gauge, early on, whether the cost premiums on a given project are likely to be "a little" or "a lot". This tool may even point to important gaps in knowledge that may be filled as the design develops.

Several of the factors in Figure 3.6.4 are nearly self-explanatory. Busby concurs with some of the others that there is a premium to be paid for a LEED design, and that the premium for a LEED Platinum design is likely to be greater than the premium for a LEED-Silver design. A flexible owner is likely to consider a design options that may save money, a large "green" project has economies of scale that a small "green" project does not, and the experience of both designers and bidders has an impact on capital costs. Two of the Busby factors may seem counter-intuitive at first. Building type and climate zone permit more significant "greening" at less cost if there is a lot of energy flowing in the "default" design, and thus more energy to be saved. Low energy buildings and benign climates, in Busby's opinion, offer the designer fewer opportunities to improve upon the performance of a building, and therefore it the premium to make a difference may be relatively high.

Busby's way of analyzing the issues has certain advantages. It shows very rough proportions, rather than precise percentages - which is appropriate to such a broad overview. Also, it looks at a combination of factors, which is realistic. In Section 4.7, Busby's hypothesis will be tested in a comparison of the capital costs of the "new normal" cases.

Summary

This comparison has shown that the "landmark" cost studies to date vary widely in quality. Some of the studies are more relevant than others, to practice in the cool-humid climates, and various construction markets that surround the Great Lakes Basin. The reference data is, in some cases inconsistent, the methods of analysis are fraught with problems, and therefore, fallacies – usually over-simplifications – are sometimes developed in their conclusions.

The problems, described in Section 3.4, arising from the gap between LEED level and "green-ness", are compounded in the cost studies. It is crucial to remember that all of this analysis (except for the Kesick study) was based on LEED buildings. Green building may cost more up front, but an estimate based on LEED level may be highly unreliable, because there are both "low-cost" and "higher-cost" ways of reaching the same LEED level. Every time one of these studies is cited as if it has created a universal "rule" – whether in the literature, or in consulting practice – someone is misled. This is dangerous to architects and to their clients.

While some studies persist in showing cost premiums for "green" design, others suggest that a "green" building may cost less than a "non-green" building, in some circumstances (US GSA 2004; Matthiessen and Morris 2004, 2007). All of the foregoing suggests that, when asked "how much will it cost to make this project green?" the most prudent answer for an architect to offer is, "it depends".

3.7 SUMMARY OF A PRACTITIONER'S INQUIRY INTO THE CURRENT ISSUES

The literature reviewed in this chapter records many voices, each concerned with a part of the challenge where climate change, energy and architecture intersect. The conclusions of the climate scientists, with regard to global warming, are in little doubt. Many scientists as well as business analysts are forecasting an unappealing trajectory for human society and the natural environment.

In their roles as advisors to clients, creative problem-solvers, coordinators of entire design teams, or public advocates, some architects wish to make a contribution to turning that trajectory toward a more "sustainable" direction. Others remain dis-interested, considering "environmental design" incompatible with their aesthetic predilection or being unwilling to invest he effort to acquire the knowledge and skills necessary to improve upon their default design approach.

To compound this challenge, the current "green building rating systems" do not give an accurate indication of the actual energy use, or greenhouse gas emissions, of a design. The studies of the cost to "green" a building have come to wildly contradictory conclusions - and, as a whole, they offer very poor support to an architect who wishes to give a client reliable advice. Meanwhile much is said, in the architectural press, about the power of an architect's primary decisions to lower the energy-intensity of a design.

As new information is gathered, analyzed and compared, suggestions are emerging as to how a choice made today ought to be different than the choices made in recent decades. In this light, the consulting designer continues to search for guidance. The summary of this inquiry is organized around six questions that are relevant to architectural consulting practice.

Is a change in design practice warranted?

In Section 3.1, reference is made to extensive scientific study, conducted over the last three decades, that shows that the combustion of fossil fuel is changing the Earth's climate. There is much evidence to suggest that the growing human population is consuming more and more energy every year. Both the quantity and the quality of this accelerated human activity seems to be affecting global climate patterns in a deleterious way. While absolute certainty is impossible to attain, it is difficult to dispute the evidence of changing atmospheric concentrations of CO_2 that is found in the ice cores taken in the high arctic. The global effects, described in abstract scientific terms also can be experienced at the local level, in daily life. Public opinion, at least in the industrialized world, has shifted to favour action to mitigate climate change – and the prevailing sense is that action is urgent. The debate now is about whether the damage already done may be repaired, and where, how, and how much to do – so that further damage may be averted.

One may ask, why not just “fix” the problem by applying new technologies in the developing world, and allow business to go on as-usual, in North America and Europe? As regions outside North America industrialize, the magnitude of fuel consumption and GHG emission will grow. Meanwhile, the fossil-fuel industry reports that the supply of its products – namely, conventional oil and gas - has passed its peak. Studies such as the Fourth Report of the Intergovernmental Panel on Climate Change (IPCC 2007), and the work of Robert Socolow (2007) suggest that conservation in the developing world will not suffice. The current rates in North America – whether measured per-capita or as absolute amounts – outpace the rates elsewhere by a factor of 5:1. Even if conserving technologies are deployed, as the developing world grows its economy and “quality of life”, there is still a need to curb consumption and emission in the already-developed world.

One may also ask, why not fix other heavy energy-consuming sectors – such as agriculture and transportation - first, and leave architecture as it is, to be fixed later, or not at all? Within North America, sectors other than the construction industry are responsible for a large share of the total energy-consumption and greenhouse gas-emission. The production of energy, at the refinery and power station, also is a major consumer and polluter in its own right. The literature shows that the mitigation of climate change requires the participation of all areas of human trade – and that the building sector is one of the top three contributors. Several studies propose ways to blend a series of initiatives from all sectors, pursuing them simultaneously – to bring consumption and emission closer to sustainable levels (e.g. Cretys et. al. 2007). Even if vehicle fuel economy and vehicle commuting patterns in North America were improved dramatically, there still would be a need to reduce the energy use within buildings.

Why are civic buildings an important subject for research? Within the building sector, institutional buildings represent approximately 10% of the dollar value of total construction starts, and hence draw on a small proportion of the overall energy-consumption pie. Abatement in civic buildings is said to be relatively easy. Design teams that are somewhat integrated, by virtue of the way they work with institutional clients who occupy their own buildings for generations, may make quicker headway than design teams who are accustomed to working in silos, for speculative developers. On the other hand, research into this subject lags far behind the research about residential buildings. Nevertheless, civic buildings are conspicuous. A province or municipality, through its choices when constructing its own buildings, reflects the values of the era – and may set an example of the most prudent route toward a result that performs well over time.

Thus, an objective review of the literature strongly indicates that the current state of the natural environmentdoes warrant a change in the design of civic buildings in North America. The climate and energy challenges cannot be mitigated by the building sector – let alone the institutional sub-sector – acting entirely on its own. Yet all speculative models of mitigation rely on the building sector for a contribution. The design of civic buildings can make a small contribution, which is needed as a practical and a symbolic gesture. The size of the overall contribution needed from the building sector – coupled with the availability of viable design strategies – suggests that great reductions in environmental loads must become the "new normal" – that is, everyday practice for an architect who designs for a civic clientele in the cool-humid climates surrounding the Great Lakes Basin.

Ought a building to be both low-load and high-satisfaction?

The review in Section 3.2. shows that many share the bias in favour of an architecture that is ***both*** low-load ***and*** high-satisfaction, and are working with an intense interest in realizing these "interlocking attributes". A three-month content review of over 9,600 headlines in the English-language news services revealed that, on average, 7% of daily items were concerned with climate change or the future energy supply. The public interest in lowering environmental loads exists – and political will is growing.

The act of building places many significant loads, of diverse kinds, upon natural systems. However, "low-load", in this study, means low in operating energy intensity. This load is the most easily measured, the most closely associated with greenhouse gas emissions, and – in current standard practice – it is far greater in magnitude than the energy embodied in the initial construction of a civic building. Also, operating energy is determined – to a significant degree – bydesign. That is, even the most watchful building operator is unlikely to coax greater performance out of a building than the architects and engineers envisioned, or allowed to take place.

Many current initiatives aim to inspire dramatic reductions in operating energy – including the 2030 Challenge, and programs that celebrate "Net zero" or "Carbon Neutral" schemes. On the other hand, creative architects, and design-conscious clients may perceive "zero" as a rather tiresome design goal. Some question how a "zero"-anything building would satisfy the expectations, in North American culture, for material luxury and infinite variety. Even though "low-load" may be gaining in popularity, many architects have expressed a desire to avoid simply "being less bad". Many architects agree that an "energy-efficient" architecture, that is to obtain and maintain wide acceptance, must also offer the most compelling qualities of all great design. "High satisfaction" has been defined (in Section 2.4) as "meaningful, enjoyable, beautiful, clever and natural".

The content review of the popular press shows how other challenges in society are perceived, these days, as "interlocking". The everyday headlines in 2007 made new linkages, such as global warming and terrorism, or town planning and obesity. Old adversaries – such as business and environmental interests – are joining to seek solutions that are beneficial to "people, planet and profit". To meet the challenges facing society today, an increasingly popular approach is one that involves a "dissolving of compartments".

A content review of the architectural press reveals that the profession is poised to mirror the more general trend. One educator has suggested that there are five reasons to pursue "environmental" design: intellectual, practical, technical, economic, and pedagogical.

In design practice, it once was possible to delegate "energy-efficiency" concerns to the engineering "sub-consultant". Now, architects face the challenge of finding an optimum balance, between "low load" and "high satisfaction", on their own drawing boards.

Which aspects of a consulting architect's role are at issue?

Section 3.3 confirms that several of a practicing architect's roles are put to a challenge, in the pursuit of "low-load + high-satisfaction" design. A few studies, reviewed in Section 3.3, have shown that there is a rising expectation, among clients and the public in general, that an architect ought to be able to give wise counsel, when it comes to considering "greener" aspects of design. While this may seem obvious from both points of view, it appears that public expectations, currently, are running ahead of the knowledge and skill set of the average design practitioner.

As strategic advisor to the client, an architect may choose an approach – between "pushing" at all costs for "green" design, and waiting passively for the client to define its goals in detail. Neither extreme is practical, and both are dangerous. Long-term "green" practitioners and professional liability insurers agree that there is a profound need to ask questions and to continue to search for better information. Even when a client-architect team enters new territory together, voluntarily, the prospect of raising unattainable expectations is present. There are several specific risks that are already producing claims of professional malpractice. Both rapid re-training and careful risk management are required.

As an imaginative designer in need of technical "know-how", an architect who pursues "low-load + high-satisfaction" design needs to learn how to understand climate as well as place, how to pursue energy-use performance without flinching, and how to integrate these new concerns with the many other goals that are part of a civic project. Sadly, one thing that is highlighted repeatedly in the literature is a lack of wide dissemination of practical "know-how" about "low-load" building, among architects. And, from outside the profession, a lack of knowledge in the building industry as a whole (including designers, builders, and developers) is seen as the most important barrier to progress toward the realization of more low-load buildings.

As co-ordinator of the design team, an architect who would achieve a truly low-load building may need to learn how to ask probing questions, particularly of the engineers who advise on energy-related matters, and choose climate-control systems. Although much has been written about the need for extended consultation with the balance of the design team, this enhanced practice ought to involve an "integrated design process" within the architect's own head. It also requires humility. Several practitioners, who have pursued low-load design for some time, have testified to the latter.

All of these ideas come together when an architect assumes the role of a "public advocate" for "sustainable design". The literature shows a strong sense, within the architectural fraternity, that a key role of a professional is to speak out about important issues. Evidence of this lies in positions that the licensing bodies in the U.S., U.K., and Canada have taken - stating that improvement of the natural environment is an ethical standard, to which members are encouraged to aspire. However, if taken to an extreme, advocacy may be perceived as zealotry. Concern is expressed, in the literature, that if "green advocacy" is espoused too easily or launched without support of adequate "know-how", then a very worthy goal – and those aspiring to reach it - may be discredited. The research in Chapters 4 and 5 are intended to help fill critical gaps in the “know-how” of those consulting architects who are sincere in their intentions.

Do the current rating systems help to create real results?

In Section 3.4, in a detailed analysis, the current yardsticks have been shown to be fraught with complications. An expectation raised by the “green building measurement tools”, is that they help an architect attest to the environmental impacts of a design. Time and effort are required to become adept at using these tools, and they measure different things, using different methods.

The systems that focus on energy use and pollution tend not to measure design quality, and vice-versa. The “whole building” rating systems - that purport to appraise both environmental load and design satisfactoriness - take measure of a very limited number of qualitative aspects of design. Usage of the tools that are most popular in North America today presents the following problems:

- buildings that are not very energy-efficient are celebrated as “green”,
- absolute energy use is often undetectable, behind the obscurity of a “per-cent-better-than” measurement,
- the greenhouse gas emissions of a building rarely are reported,
- the numeric score, given by these systems, is a poor indicator of design quality,
- climate-specific and location-specific challenges are not often acknowledged, and
- various rating systems give contradictory readings about the same building.

With respect to energy use and greenhouse gas emissions, the current green building rating systems – LEED, in particular - are rather lax. Too often, they allow credit to load-reduction in areas other than energy performance, and allow poor decision-making with respect to energy use, in the process.

Although touted as effecting “market transformation”, the overall track record of LEED is poor, with respect to actual energy performance. Other programs, such as the now-defunct CBIP caused deeper reductions in energy-use, involved more buildings, and may have resulted in more satisfying designs than LEED. The information reviewed in the scientific background, in Section 3.1, suggests that the next ten years of energy-reduction should be more aggressive than the ten years that have just passed – and in this light, the LEED rating system, as presently constituted, appears grossly insufficient.

There is a growing impression that, in order for a building to be really "sustainable", it must be "rated" through one of these systems. Yet none of today's popular rating systems supports a designer in both lowering greenhouse gas emissions and attaining satisfactory design quality. The number of projects being rated still is very small, in relation to the overall North American construction sector. And fewer than half of the participating projects are in climates comparable to the study area. For all of these reasons, the current rush to attain a third-party "green label" may be characterized as a gross distraction to consulting practice – taking countless precious hours away from the more important task of learning how to really reduce the environmental loads imposed by a design.

Does the architect "deals the cards", during the schematic stage?

The practice of viewing large buildings as entities through which energy flows is in its infancy. Yet, even from well outside the profession (as far away as the IPCC report), the literature is full of statements that architects, not mechanical engineers, make the decisions that have the greatest impact upon the energy use and greenhouse gas emissions of a building. In Section 3.5, representative clippings from the literature suggest that "building form" is "crucial" to environmental performance, and that "building orientation" drives heating and cooling loads strongly influences the behaviour of a building in all seasons, and provides significant opportunities to harvest site energy. These effects are argued irrespective of climate.

Despite the proclamations that form, orientation, and skin design matter more than any other design decision, very little exists to help an architect develop a working understanding of how much power each of these parameters wields, from one design scenario to the next. This is the gap to which the Study of Design Parameters, in Chapter 5 is specifically directed.

What are the cost implications of the "new normal"?

In Section 3.6, profoundly contradictory findings, by various cost analysts, are compared. A number of landmark studies, using LEED level as the basis for comparison, may be seen to be widely applicable to future cases. However, each of the studies considered "landmarks", to date, refers to a very small sample set of designs. Some mix buildings in various climates and bidding contexts together as if they were comparable. Many rely mainly on estimates rather than actual cost data. The findings with respect to capital cost are not often explicit about the market forces coming to bear on a particular scenario, or the architectural quality of the design. The findings with respect to "payback" are highly speculative, and always include large factors for externalities, such as "productivity" or public health.

The sorry state of the current cost studies suggests that an architect be very cautious, in practice, about repeating the "general rules", as if they apply to all cases – neither the scope nor the methods of analysis used in present studies are sufficiently robust to support such a notion.

In brief…

This review has answered a number of questions – confirming the need for a "new normal" in architecture, showing the significance of operating energy, and suggesting an emphasis on the "interlocking attributes" of "low-load + high-satisfaction". It also has shown that many architects need more comprehensive "know-how", when faced with the prospect of designing toward this "new normal".

A public client, who has elected to pursue "green building goals", might reasonably expect a design professional to be able to advise ***how to really*** lower the environmental loads of a proposed building. Such a client might also expect a design team to offer a reasonably reliable opinion about the potential cost implications of doing so.

Yet an architect who wishes to move forward, toward a "low-load + high satisfaction" design may well become troubled and dissatisfied by the support that currently is available. The application of an "easy" recipe – such as may be found through the "green building rating systems" does not necessarily work. The cost data that is available may have been derived through unusual methods, and may not be relevant to the project at hand. And - while statements that an architect's primary decisions affect the environmental load of a building run aplenty - thorough expositions of how that is so are sorely lacking.

These contradictions and gaps in the literature will inform the discussion, as the study continues - with an analysis of some successful "low-load + high-satisfaction" civic buildings, located in and near the Great Lakes Basin.

4

ANALYSIS OF CASE STUDIES

4.0 PRACTICE: WHAT IS A LOW-LOAD + HIGH-SATISFACTION BUILDING LIKE?

To discover how much an architect's primary decisions influence the environmental loads of a building, this phase of the research begins with a look at real, rather than theoretical, success. The cases were chosen for study here because even a cursory look at an existing report suggested ample success with respect to both energy-efficiency and other goals. They are located within the cool-humid climate, surrounding the Great Lakes Basin and along the Atlantic coast, and accommodate public functions and offices. Nineteen projects are compared, twelve of which were visited during the study period.

As shown in Section 2.2, few previous collections of case studies present actual, in-service energy use data, and few reflect the views

Figure 4.0.1
Questions posed in the
Analysis of Case Studies

1. **How much satisfaction can the design of a non-residential civic building, that is "low-load", offer?**

2. **How much lower than "normal" can the energy-intensity of non-residential civic building, in this climate, be?**

3. **Must "low-load" be at odds with "high satisfaction"?**

4. **Is there a particular combination of client disposition, mode of architectural practice, and physical context - that is most likely to lead to a richly satisfying and environmentally responsive design?**

5. **Must "low-load + high-satisfaction" mean "more cost"?**

6. **What are the essential "best practices" toward lowering energy use, in the Great Lakes Basin?**

of building occupants or neighbours. The rare studies that do present energy data or post-occupancy evaluations tend to focus on one side of the equation or the other. To address these gaps, several "new-normal" buildings were visited, first-hand, and data from utility bills was collected.

The analysis here is both quantitative and qualitative, and the qualitative aspects of design are discussed in relation to quantifiable energy intensity. Many existing studies approach, but do not entirely answer, questions about this relationship. Also, many focus on "green elements" and avoid questions of strategic approach. Here, "green components" are noted, but the emphasis is on their arrangement - that is, on the "architecture". Figure 4.0.1 highlights the questions that are asked about the designs, in this Chapter.

In Section 4.1, the projects are introduced. In Section 4.2, the exceptional achievements with respect to design quality are highlighted, and a comparative discussion touches on issues of aesthetic sensibility, physical context, and material palette.

In Section 4.3, all of the case study buildings are arrayed on the Intensometer, showing their performance relative to current "norms". In Section 4.4, the analysis inquires whether there is an "ideal" combination of client disposition, mode of architectural practice, and physical context that leads to a "low-load + high-satisfaction" design.

In Section 4.5, seven of the "high-performance" case studies are compared to three "GTA default" designs - an office building, an assembly building, and an elementary school. More specific questions are formulated, about the power of particular architectural strategies.

A designer then may wonder, in what instances might "low-load" and "high-satisfaction" goals be at odds? In Section 4.6, risks, mitigating strategies, and potential synergies are identified.

In Section 4.7, using methods introduced in Section 3.6, there is a brief discussion about the influence of market forces on the cost of designs that address environmental concerns.

Since the circumstances vary greatly from one project to the next, the case study approach may yield imprecise conclusions. However, looking at real projects reveals an inspiring range of achievement, and it highlights an array of design approaches strategies that can be used immediately in practice.

4.1 INTRODUCING THE CASE STUDY BUILDINGS

The nineteen projects reviewed here stem from diverse locations, and are the work of architects who place emphasis on various aspects of practice. Under the umbrella of "civic building", the cases illustrate an array of design approaches; they respond to particular site topographies, accommodate diverse client priorities, and display a range of architectural styles. A "short-list", from which the final choice of projects for study was made, is in Appendix 4.

Seven of the nineteen projects are appraised fully and then compared in detail to three "control" cases. Published reports about nine additional projects was surveyed, to round out the analysis of "best practices".

Seven "new normal" cases, fully appraised

During field visits, informal interviews were conducted with building occupants, construction documents were studied, and the researcher's impressions were noted, in relation to the Questions of Design Quality (QDQ). Later, in some cases, a member of the design team was consulted as well. (These sessions are noted in the List of References). The qualitative and quantitative appraisals are presented in Sections 4.2 and 4.3 respectively.

Three "GTA default" designs

Each of the three categories of "civic" building are represented by one design that represents many others of its type; there is an elementary school, a police station (which contains mainly administrative offices), and an adaptive re-use project that houses both education and public-assembly functions. Although they represent "better-than-average" practice at the time of their construction, none of the three was designed with primary emphasis on “green” goals. Two were designed in the researcher’s former practice, and the third accommodates the School in which the research took place. As such, these projects establish a baseline of expectation of “normal” practice to date.

Nine additional “green” cases, compared for best practices
An additional nine projects serve to amplify the Intensometers in Section 4.3 and the search for “best practices” that lower energy use, in Section 4.5. The information regarding these cases is drawn from the published literature only. Where the data is incomplete, the gaps are noted. First-hand visits were made to only two of these projects, but interviews were not conducted, nor were drawings reviewed, or QDQs applied.

Use: Assembly, Administration and Education
Under the banner of “civic” buildings, this study examines three subcategories of building function. In the whole list, there are eight office, six public assembly, and five education cases. Because the researcher’s primary interest is with office and assembly buildings, the set of seven fully-appraised cases comprises three office buildings, three public assembly buildings, and only one education building.

Locations
The majority of the case study buildings lie within a zone called “Continental” by Lloyd-Jones (1998), and “Cold” by IECC (2006). In this study, this region is called “cool-humid”. Three cases are close to the boundary with the zone called “Mixed-Humid” by IECC, and three lie in the “Very Cold” zone.

All of the cases are in four-season zones, in which temperature variations, through the year, are extreme. Winters are long and cold; summers are short, but very hot and humid. For comparison to those in the Great Lakes Basin, a few projects in more northerly locations (Saskatoon, PEI and Newfoundland) are included. These climates are cool enough that avoidance of refrigerant-based cooling is considered viable, in an office or public assembly building and, with the exception of Saskatoon, are still quite humid, with average precipitation of approximately 800 mm. Section 4.2 also presents a qualitative description of the regions in which the seven fully-appraised cases are located. More complete climate data for all locations is presented in Figure 4.5.2 and 4.5.3. The projects are introduced in Figure 4.1.1, with a brief statement of the relevance of the seven “new normal” and three “GTA default” designs to the study.

Figure 4.1.1
Map of new-normal and GTA default cases

(for photo credits see Figures 4.2.1 through 4.2.83)

The **Headquarters of SAS Institute (Canada)**, in Toronto, Ontario, is owned and occupied by a multinational provider of business intelligence software. SAS asked its design team, led by **NORR Architects**, for iconic architecture that would speak to its Fortune 500 clients in the financial core, just blocks away. SAS adopted its "green agenda" out of its interest in creating an enjoyable office, to attract and retain knowledge workers.

SAS

St. Gabriel's

St. Gabriel's Passionist Church, in Toronto, embodies the ideas of the theologian Thomas Berry, who advocated environmental stewardship as a key aspect of the Christian faith. **Larkin Architects** conveyed this philosophy through the arrangement of the plan, and by using art installations in each major worship space. The technical aspects of the overall design approach would be applicable to a secular civic building, just as they are to a place of worship.

Alice Turner Library, Saskatoon, SK

GTA-Police

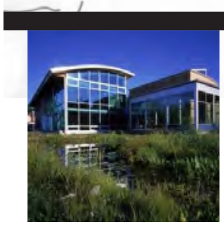
The GTA Police Station is one of seven of its type, designed by **Carruthers Shaw and Partners Limited, Architects,** for municipal police services in the suburbs of Toronto.

GTA-SAC

The School of Architecture in Cambridge is an example of the adaptive re-use of a former industrial building into "artists' lofts", designed by **Levitt Goodman Architects.**

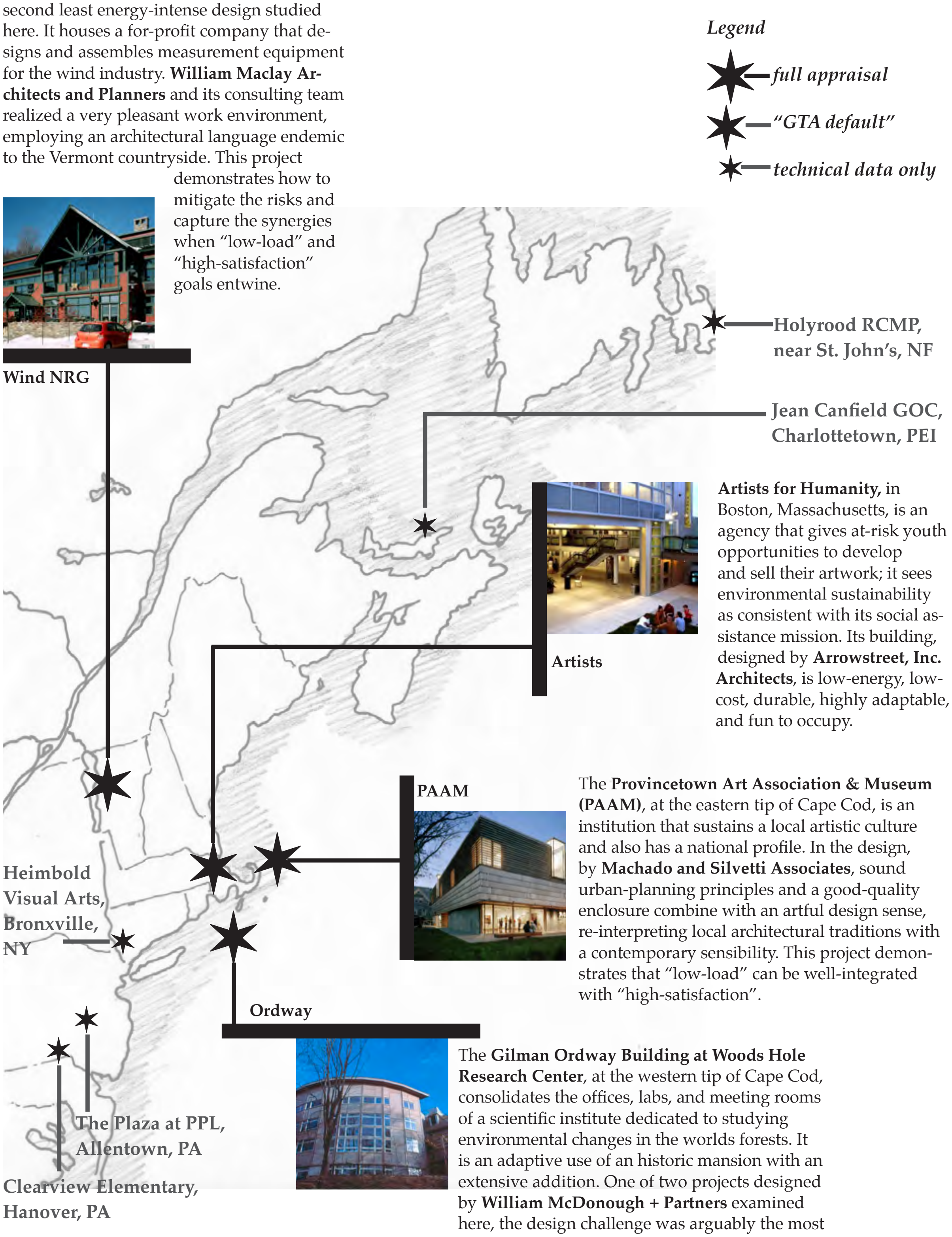
GTA-School

The GTA Elementary School is a "repeat" design by **Carruthers Shaw and Partners Limited, Architects,** used by two public Boards undergoing rapid expansion.



The **Adam Joseph Lewis Center at Oberlin College,** in Oberlin, Ohio, is an architectural essay on environmental footprint, designed by **William McDonough + Partners** as a "living lab" for the Environmental Studies Program. Its didactic elements extend from the roots of the marsh plants outside the front door to the PV panels on the roof. Costly to produce, it is arguably the most-analyzed non-residential "green" building in the northern U.S.

The **Wind NRG Office & Warehouse, in** Hinesburg (near Burlington), Vermont, is the second least energy-intense design studied here. It houses a for-profit company that designs and assembles measurement equipment for the wind industry. **William Maclay Architects and Planners** and its consulting team realized a very pleasant work environment, employing an architectural language endemic to the Vermont countryside. This project demonstrates how to mitigate the risks and capture the synergies when "low-load" and "high-satisfaction" goals entwine.



Artists for Humanity, in Boston, Massachusetts, is an agency that gives at-risk youth opportunities to develop and sell their artwork; it sees environmental sustainability as consistent with its social assistance mission. Its building, designed by **Arrowstreet, Inc. Architects**, is low-energy, low-cost, durable, highly adaptable, and fun to occupy.

The **Provincetown Art Association & Museum (PAAM)**, at the eastern tip of Cape Cod, is an institution that sustains a local artistic culture and also has a national profile. In the design, by **Machado and Silvetti Associates**, sound urban-planning principles and a good-quality enclosure combine with an artful design sense, re-interpreting local architectural traditions with a contemporary sensibility. This project demonstrates that "low-load" can be well-integrated with "high-satisfaction".

The **Gilman Ordway Building at Woods Hole Research Center**, at the western tip of Cape Cod, consolidates the offices, labs, and meeting rooms of a scientific institute dedicated to studying environmental changes in the worlds forests. It is an adaptive use of an historic mansion with an extensive addition. One of two projects designed by **William McDonough + Partners** examined here, the design challenge was arguably the most complex of any studied to date, and the result is the least energy-intense of all.

4.2 APPRAISALS OF "SATISFACTORINESS"

Here, it is assumed that an architect who works for public clients, is expected to propose designs that are meaningful, enjoyable, beautiful, and at least a little bit clever - even as the thresholds of resource use are significantly altered. These are the aspects of the researcher's expectation of a "high-quality" design that are presented in Section 2.4, as the Questions of Design Quality (QDQ). The detailed appraisals of seven "new normal" designs address the question, "what are the issues in lowering environmental loads, while continuing to satisfy a range of human desires?"

The designers of the seven "new normal" buildings were faced with certain common challenges. Human and environmental interests were to be balanced: between energy-efficiency initiatives and other design strategies there lie opportunities and potential risks. On the one hand, there are synergies to be captured; on the other, there are potential collisions that can be named - points where satisfying one set of goals may mean compromising others. Each designer also faced challenges that are unique to each client and each place – such as how best to fit the building into its particular context, and how to keep the project within the limits of its budget.

In the following pages, three "Administration" buildings, three "Public Assembly" buildings, and one "Education" building are appraised. The Administrative, or office buildings may be publicly or privately owned. The Public Assembly group includes an academic building, a church, and two buildings containing art galleries and studios. The Education building is at a liberal arts college; it contains classrooms and a lecture hall. Three "GTA default" designs (an office building, an assembly building, and an elementary school) are introduced briefly, alongside the seven "new normal" designs. All twenty-one questions in the QDQ are applied to each of the "new normal" cases, in turn. For the GTA default" cases, there is a summary discussion, using the most relevant of the QDQ. *

To make a fair appraisal of the architectural quality, and to observe, directly, the ways in which these very energy-efficient designs also satisfy many other diverse goals, a first-hand experience was deemed essential. In most cases, at least two studies of a general nature had been published, but these were not sufficient to convey the full context or true flavour of any of the projects.

Everyone who was asked about these projects welcomed the inquiry; in no case was the researcher turned away. The owners gave unfettered access to the buildings and answered all of the questions that were asked. The consultants - once the owners had given permission - also shared information and reflections about why certain design decisions were made.

Very often, during the interview with an owner, an unpublished study was proffered – in the form of a commissioning report, a third-party energy audit or a post-occupancy evaluation. Key findings from these reports are noted, where relevant, usually within the appraisal of "enjoyable" factors.

The purpose of this exercise is not to laud one design as superior to another; all of the projects were selected because they are highly successful. However, "success" has particular characteristics in each case. The goal, in the following appraisals, is to reveal issues that the projects contain, that might inform future design opportunities. This section closes with a some reflective comments on the standard of expectation itself, and on how it might be used to stimulate discussion with a future client. Also, a few questions are posed, for future research.

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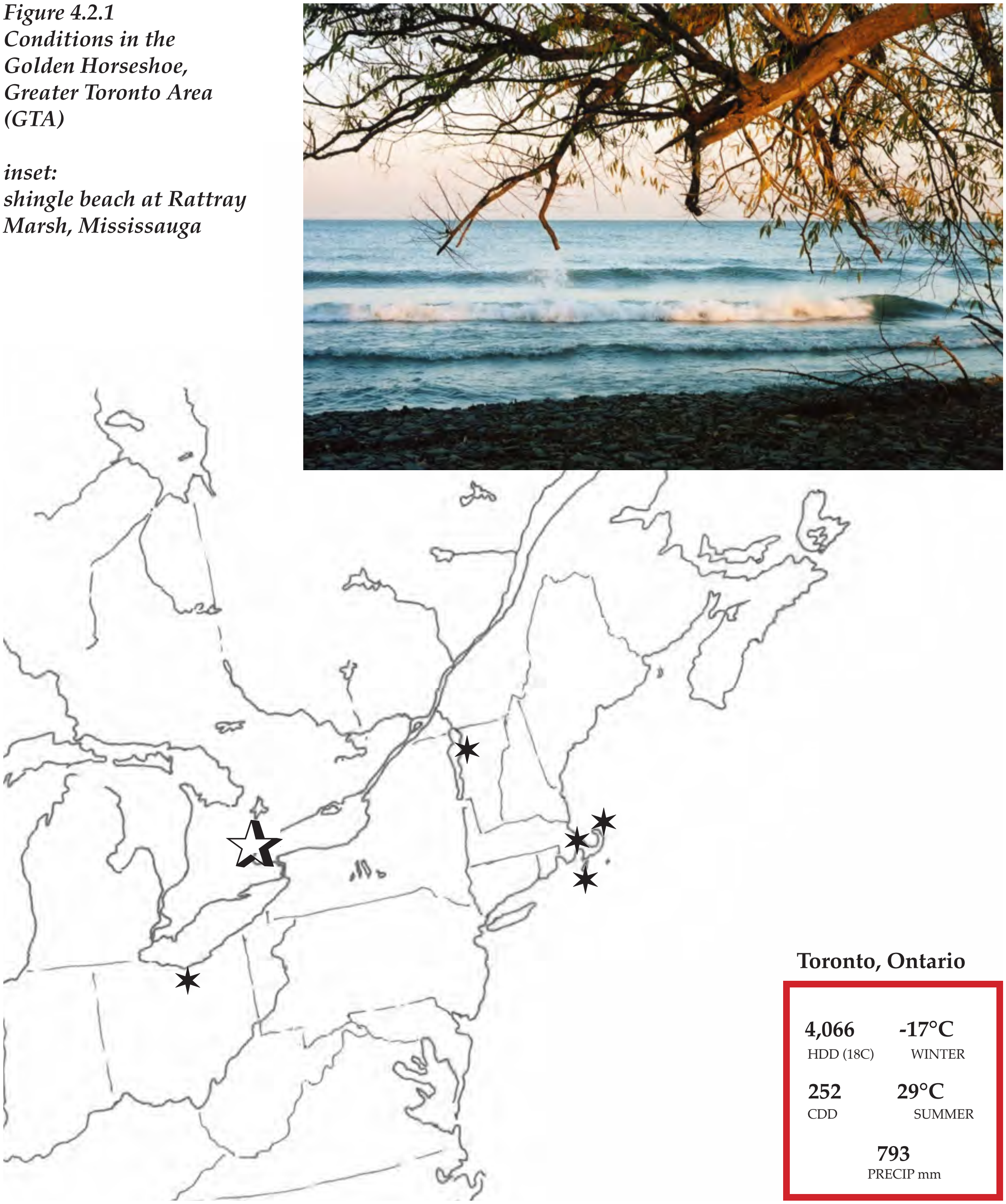
*Sources are listed for each building at the end of the List of References

Figure 4.2.1
Conditions in the Golden Horseshoe, Greater Toronto Area (GTA)

inset:
shingle beach at Rattray Marsh, Mississauga



Toronto, Ontario

4,066 HDD (18C)
-17°C WINTER
252 CDD
29°C SUMMER
793 PRECIP mm

Golden Horseshoe

Another city may have its “golden mile”, but the Greater Toronto Area (GTA) is connected to a “golden horseshoe”. The western end of Lake Ontario is known as a lucky place to settle - offering Canada’s richest agricultural land and, arguably, one of its most benign climates. The horseshoe can be seen, from atop a rise of land, a few kilometers back from the shoreline. Below this escarpment lie the original settlements - on rich, nearly-flat terrain, crossed by narrow ravines - connected by rail and road to the regional gateways at Montreal and Buffalo.

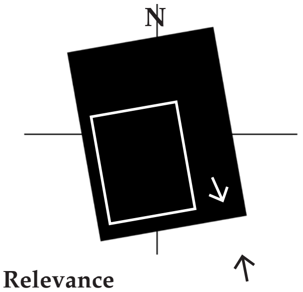
On a summer afternoon, conditions are cooler in this verge, that further upland, and tempered by breezes from the shore. And, on a winter morning, they are milder, due to the “lake effect”. In this narrow band, the southern hardwood forests of the Carolinas, at the limit of their range, meet with more northerly species. The tall, high-crowned forests have a lacy quality - sycamore, butternut, oak, sassafras and locust are adorned with a colourful understory of red-bud and flowering dogwood. Many varieties of birds make the forests and wetlands their home. The sky has a slightly hazy quality.

Originally, the sand and limestone soils in this crescent were used to develop fruit orchards, and these areas lately have evolved into a premiere wine region. Right next-door are the large industrial ports at Hamilton and Toronto. Smaller ports - such as those at the outflow of the Credit River, and the 16-Mile Creek - now are havens for recreational boaters and sought-after places to live.

The City of Toronto began as a fortified camp, sheltered by a large barrier island. Its financial core rose, paces from the docks, and placed its feet firmly in the stratified shale between the Don and Humber Rivers. At the brow of the escarpment, the wealthier burghers placed their houses and schools, with their backs sheltered by the hill, and their fronts facing the breezes and the views. Today, the city sprawls in all directions. Yet the core retains the memory of the sheltered plain the Mohawk called “where there are trees standing in the water”.

St. Gabriel’s Passionist Church
Toronto, Ontario

Figure 4.2.2 South facade
Figure 4.2.3 Orientation



Relevance
Climate: Cool-humid Grt. Lakes

Site Context:
gently rolling terrain (former mixed forest), 10-min. walk to nearest rapid transit, alongside busy 6-lane arterial road, neighbours are 14-storey condominiums (under construction)

Project Goals:
Redefine the typology of space for Christian worship, to convey the functional cosmology of Thomas Berry.

Density: SUBURBAN
FloorArea: 25,000 sf
Occupied: 2007
Capital Cost: $10,500,000

Awards:
...Interfaith Forum on Relig. Art & Arch’re (Faith+Forum, 2008)
...Poster at iGBC, 2008
...Toronto Green Design, 2007,
...Ontario Concrete Award, 2007
...LEED Gold

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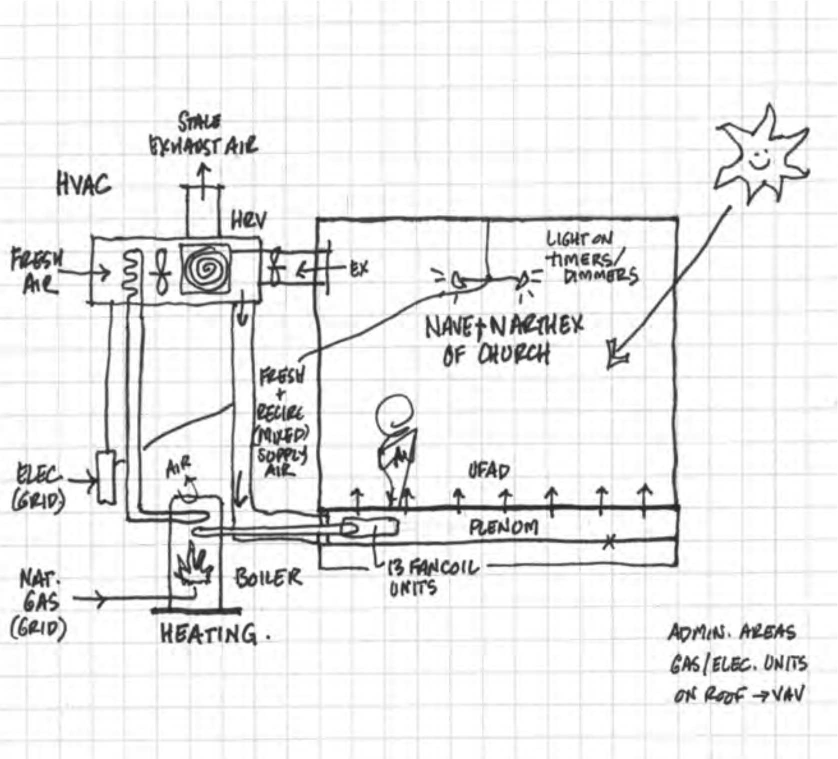
all images in Section 4.2 B. M. Ross unless otherwise noted

Context, Form & Orientation

Height: 1-storey with 1 level below-grade (parking garage)
Plan Aspect 1:1.3, *Facade:GFA* 1:2.21, *Surface (incl. roof):GFA* 1:1.19
Form driven by: site redevelopment plan, negotiated with City Council, southward orientation of glass wall for solar gain

Enclosure

Walls: Tyndall stone on insulated cavity on in-situ concrete
Windows: K7500 curtainwall w/”heat mirror” 2LowE, krypton, R7
Roof: Mod. bit. + 5” polyiso + steel (nave) or conc (ad/narth)
Window-wall ratios: o/a 30%*; north* 15%*; east* 38%*; south* 56%*; west* 10%
Daylight: abundant, and of very special quality (see “Fit”)



Notes:

Figure 4.2.4 Climate control systems

Figure 4.2.5
Looking south from within the narthex

FIT

What does this place allow us to do?

- silty soils allow construction of a below-grade structure
- flat terrain allows any building orientation
- micro-climate is slightly more extreme than 2 km.. south, below the escarpment

What does this place help us to do?

- harvest rainfall from the roof to irrigate the garden
- harvest natural light (year-round) and solar heat gain (in winter)
- access to direct sunshine allows appreciation of the earth, turning on its axis, through the movement of the pattern of coloured light on the walls of the nave.

What does this place require us to do?

- re-introduce full-spectrum habitat (birds and small animals)
- remind local consumer culture of spiritual values re nature

BALANCE

Can a natural system gain, by satisfying a human desire, here?

- watershed challenged by sudden run-off gains because rainwater is harvested for the garden (enjoyed by visitors and congregation)
- birds and small animals crowded out by rampant development given a small patch of habitat (enjoyable for viewing)
- larger systems in more remote places may gain from the examples here - both in spiritual practice and in practical operation

NATURAL SOLUTION

How durable, adaptable, replicable, and fecund is the design?

- solid structure and enclosure are likely to endure
- simple configuration of spaces support full range of functions
- design would be replicable on any site with access to sunlight

SOCIAL BENEFIT

Is it good for the community?

- yes, good for the parish members to experience & relate to
- yes, logical resolution of public space for neighbourhood

INPUT PER OUTPUT

Are the inputs low, for a given unit of output?

- operating energy is fairly low, and space is high-quality (see right)
- capital cost is slightly higher than average for a church at the time

CONDITIONS OF SUSTAINABILITY

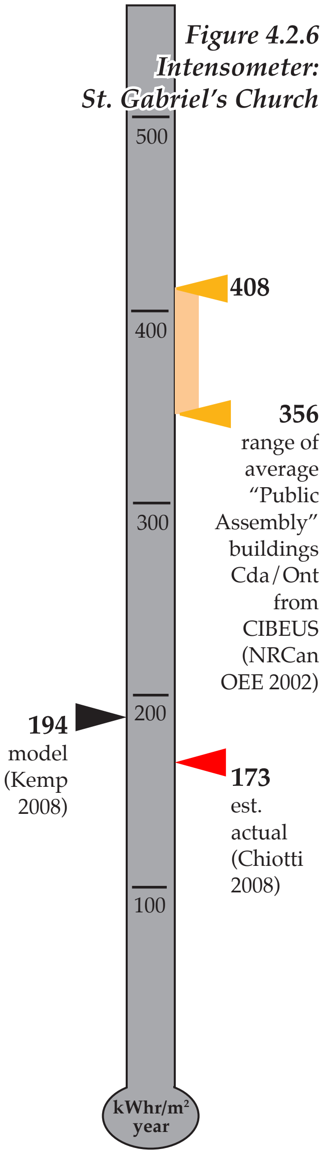


Figure 4.2.6
Intensometer:
St. Gabriel's Church

St. Gabriel's Church

CONDITIONS
OF
EFFECTIVE DESIGN

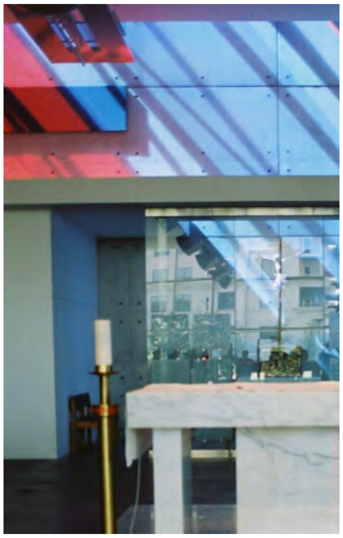


Figure 4.2.7 MEANINGFUL

Figure 4.2.8 ENJOYABLE

MEANINGFUL

What is the strongest message of the design?
To members of the congregation, the design says "behold the mystery and wonder of creation", to neighbours and visitors it says "a religious order is very concerned about the relationship between humankind and natural systems".

Does the design express belonging to the local community?
Yes, to a degree. The neighbourhood is transforming from very low-density, mixed use, to higher-density, mixed use; yet it remains an arterial-road-related suburb. The design has its own iconography that is neither driven by the form of near neighbours, nor at odds with it.

Does it imply renewed community vitality?
Yes, clearly. The "newness" of the design implies renewal within the church-going community, and within the physical surroundings.

Does it say "welcome" and/or express stability and sound governance?
Yes, clearly. The large roof overhang on the south side suggests shelter. The large door openings on the east side signal the potential for a whole congregation to enter at once. The expression of the north side (clad in attractive, but humble oxidized sheet metal) speaks of the modesty of the "business" spaces - in contrast to the overarching significance of the spaces for communal gathering and worship.

Is there a future vision - about humanity & nature - implied by this design?
Yes, clearly. Although, some of the messages are rather disturbing. For instance, the cross pinned to a dead tree - signifying the "crucifixion of creation" (see Figure 4.2.5).

ENJOYABLE

Does the design suggest that the owners care for the health of occupants?
Yes, clearly. The design of the garden, the size and position of the "living wall" (see Figure 4.2.8), and the overall impression of spaciousness, abundance of light and cleanliness communicate a sense of being able to breathe and become more calm, on entering the building.

Is it comfortable? (thermally, acoustically, visually)
Yes, clearly. The acoustics in the Nave (during Doors Open, when the room was just 1/3 full) were surprisingly warm.

Does the space planning work superbly?
Yes, clearly. Space planning is used to communicate ideas about worship. The Nave is organized with antiphonal seating, on either side of an axis that connects the tabernacle, altar, ambo, baptismal font, and garden. In keeping with the "functional cosmology" of T. Berry, this is a reminder, during the experience of worship, of the baptismal covenant as a welcome into a life within natural systems on Earth.

Does the design lift the spirit?
Yes, clearly. Its central goal is to affect the spirit. Alternately encouraging, provocative, and poignant - the design induces a prayerful state.

BEAUTIFUL

Does the design extensively employ daylight?
Yes, clearly. Daylight is functional (greatly reducing energy use) and also is the primary conveyor of meaning in this design. Through the play of daylight on the walls of the nave, the movements in nature - of the clouds through the atmosphere and the earth on its axis - are brought into the experience of worship (see Figures 4.2.7 & 4.2.9).

Are materials, lighting and space arranged in a way that is interesting, appealing, and memorable?
Yes, clearly. Spaces are few, simple, and clearly defined.

Is the design a strong exemplar of the sensibilities prevailing at the place and time in which it was created?
Yes, clearly. The Nave is fully linked to the public garden. Contrasts in surface textures are present, such as: rough/smooth (Tyndall stone with fossils/smooth insitu concrete), old/new and warm/cool (wood pews and brass plaques/terrazzo floor and white ceiling), and dark/light (living wall/all other interior surfaces). The vertical cant of the glass wall, and the shape of the large canopy are "free" forms. Handcraft is present in decorative pieces salvaged from the original church, and in new etched glass (on the main door and at the tabernacle).

CLEVER

Is unusual technology - emerging or re-emerging - applied in this design?
Yes, clearly. Technologies include high-performance windows, high thermal mass, displacement ventilation, lighting controls, and purchased green power.

Do technical strategies drive the form?
Yes, to a degree. The form was intended, in part, to capture solar heat gain passively and store it in a heavy structure (see Figure 4.2.10).

Does the design attain a measurable superlative (e.g. biggest, most, first ...)?
Yes, clearly. This is the first church in North America to embody T. Berry's cosmology, and (much less significantly) the first church in Canada to achieve LEED Gold certification.

Are the key design strategies well integrated with one another?
Yes, clearly. The small boiler and right-sized HVAC systems are products of the exemplary thermal performance of the enclosure.

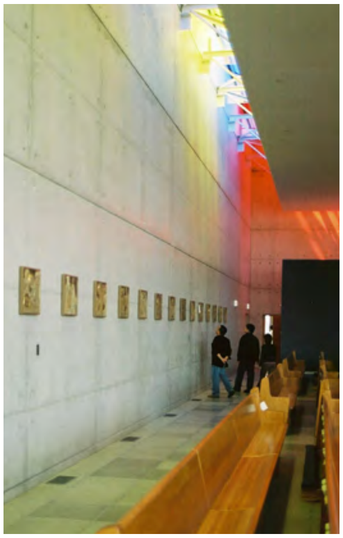
SUMMATION

This design is strong in all categories, and is a particularly strong example of a meaningful use of daylight. It is exemplary in its deep integration and the absence of extraneous details. There are no gratuitous decisions; every element and choice is in obvious service of the message, of real environmental stewardship, and sound building science. The passive solar gain combined with high thermal mass, inside a high performance enclosure is a unique approach, among the case studies reviewed here. Such an approach is ideally suited to any civic building - even those meant for secular assembly - in Great Lakes Basin.

CONDITIONS OF EFFECTIVE DESIGN

Figure 4.2.9 BEAUTIFUL

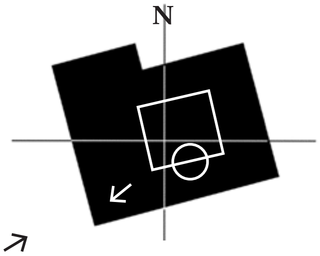
Figure 4.2.10 CLEVER



SAS Institute (Canada)
Toronto, Ontario

Figure 4.2.11 Southwest corner

Figure 4.2.12 Orientation



Relevance
Climate: Cool-humid Grt. Lakes

Site Context:
East side of downtown core, 10 min. walk to industrial harbour and farmer's market. Shale soils to lake edge. In transition from industrial to commercial, closest neighbours are newspaper and street retail shops.

Project Goals:
Create "a distinct modern building". Use ownership to advantage (financial and qualitative). Attain "as many employee amenities as possible", to attract and retain talent.

Density: URBAN
FloorArea: 145,000 sf (25, u/g in)
Occupied: 2005
Capital Cost: $26,000,000

Awards:
...LEED Silver

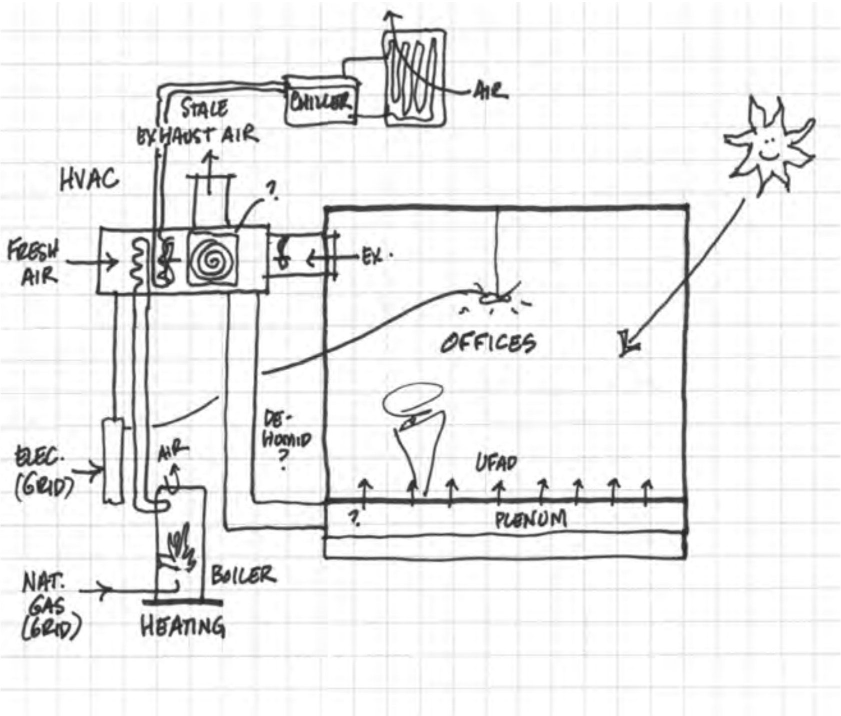
Image credits:
4.2.11 Steven Evans

Context, Form & Orientation

Height: 8 storeys
Plan Aspect 1: 1.28 *Facade:GFA* 1: 2.44 *Surface (incl. roof):GFA* 1: 1.85
Form driven by: fills available buildable footprint to property/setback lines

Enclosure

Walls: aluminum panel system
Windows: alum curtainwall, double-gl w/tb blue tinted LowE
Roof: white PVC membrane
Window-wall ratios: o/a 40%; *north* 4% ; *east* 6% ; *south* 80% ; *west*71%
Daylight: ample on all floors; abundant in top 3 flrs, around atrium



Notes:

Figure 4.2.13 Climate control systems

Figure 4.2.14
Looking westward from the sixth-floor terrace

FIT

What does this place allow us to do?

- loadbearing shale soils allow multi-storey construction
- despite favourable climate, spring and fall, the urban location, at present, does not support natural ventilation (it would be noisy, and not so fresh)

What does this place help us to do?

- harvest rainfall for flushing toilets
- shade from taller building to the west allows large expanse of glass

What does this place require us to do?

- re-invigorate a facing urban area, with diverse activities

BALANCE

Can a natural system gain, by satisfying a human desire, here?

- a satisfying urban infill project, with amenities expected of a high-functioning downtown core, reduces sprawl elsewhere
- water quality in Lake Ontario may be very slightly improved, through the reduction of sudden run-off
- this building implies many potential others with similar features

NATURAL SOLUTION

How durable, adaptable, replicable, and fecund is the design?

- structure is durable, enclosure less so
- the opportunity to stand on the terrace and look at the condition of the city may foster a sense of stewardship

SOCIAL BENEFIT

Is it good for the community?

- yes - the injection of new-style commercial activity is welcome in this neighbourhood

INPUT PER OUTPUT

Are the inputs low, for a given unit of output?

- operating inputs are less than average (see right)
- capital money inputs also were low, for a custom office building

CONDITIONS
OF
SUSTAINABILITY

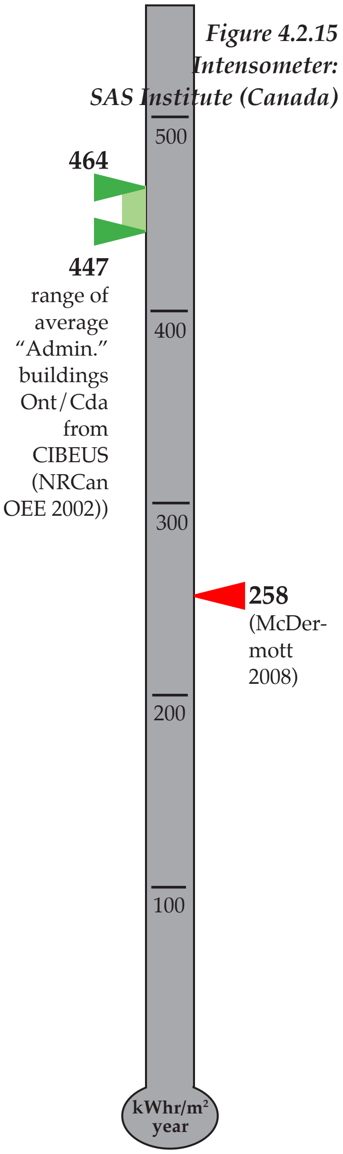


Figure 4.2.15
Intensometer:
SAS Institute (Canada)

SAS Institute (Canada)

CONDITIONS OF EFFECTIVE DESIGN

Figure 4.2.16 MEANINGFUL

Figure 4.2.17 ENJOYABLE

MEANINGFUL

What is the strongest message of the design?
To employees, the design says "you can be both stimulated and at ease, working here", to neighbours, visitors and clients, it says "we are an enlightened firm - a major player in the new knowledge economy".

Does the design express belonging to the local community?
Yes, to a degree. The design belongs to a new generation, that contrasts - but is compatible - with the 19th century brick warehouses nearby. It is clad in "machined" materials and it is taller than the adjacent buildings to the north and east.

Does it imply renewed community vitality?
Yes, clearly. The neighbourhood has been in slow transition, for 30 years, from post-industrial to mixed commercial and residential - becoming more densely populated with the change. The design signals a change in type and density of development.

Does it say "welcome" and/or express stability and sound governance?
Yes, clearly. From a few blocks away, the canopy atop the building invites curiosity (see Figure 4.2.16). From the sidewalk, the front doorway offers an easy-to-find, transparent invitation to enter.

Is there a future vision - about humanity & nature - implied by this design?
Yes, clearly. The shape of the high canopy is unique in the area. A rare form, it is used here for several purposes: it is a rainwater catchment, and a shelter for the terrace. Also - being visible from the downtown core, where SAS's clients have their offices - it is the primary "icon" of the building and, hence of the company it houses.

ENJOYABLE

Does the design suggest that the owners care for the health of occupants?
Yes, clearly. Local controls of ventilation and temperature give users the option to manage their environment. Ergonomic workstations adjust to individual needs.

Is it comfortable? (thermally, acoustically, visually)
Yes, to a degree? Delivery of moderate-temperature air in cooling season) through UFAD system is reportedly more comfortable than the ceiling-mounted VAV system in the owner's previous (leased) space. Despite the exposed structure (and lack of lay-in acoustic ceiling panels), the workspaces are acoustically comfortable. Glare is controlled by operable interior blinds.

Does the space planning work superbly?
Yes, clearly? For instance, the central meeting space and terrace accommodate either communal gathering or private work, away from the office cubicle (see Figures 4.2.17 & 4.2.18).

Does the design lift the spirit?
Yes, clearly. The owner group reports a high level of satisfaction with the exuberance of the exterior expression. And, during a public tour ("Doors Open Toronto, 2007), after seeing the atrium floors and terrace, and experience the quality of the interior space, visitors were overheard asking questions like "how can I apply for a job here?".

BEAUTIFUL

Does the design extensively employ daylight?
Yes, clearly. The floor plate affords views mainly on the two street sides (west and south). Although the service core could have been centred, instead it is shifted to the north wall - making way for the atrium, which serves the top three floors.

Are materials, lighting and space arranged in a way that is interesting, appealing, and memorable?
Yes, clearly. The street facades are detailed in a Modern idiom, with far more care that usually is present in a "standard" curtain-wall office building - e.g. cornices and vertical bands at the corners of the curtain wall. Interior spaces are arranged simply and clearly.

Is the design a strong exemplar of the sensibilities - prevailing at the place and time in which it was created?
Yes, to a degree. The design engages the street, where storefronts are set back, forming a sheltered collonade. Otherwise, the building does not make internal activities visible to passersby. The palette of surface textures does not include as wide contrasts as many other buildings of this era, and handcraft is not in evidence. However, the facade composition uses a late 20th century vocabulary. Non-rectilinear forms include the inverted V-roof and the circular grille/skylight within it.

CLEVER

Is unusual technology - emerging or re-emerging - applied in this design?
Yes, clearly. UFAD, HRV, rainwater harvesting, daylight and occupancy sensors on lights are all employed, with reasonable success.

Do technical strategies drive the form?
Yes, to a degree. The form is mainly driven by the decision to fill out the available footprint.

Does the design attain a measurable superlative (e.g. biggest, most, first ...)?
No, not really. This is the first commercial office buildings to be constructed within the downtown core in over 20 years, and it is the first building for which SAS pursued LEED certification. Annual energy use is much lower that other SAS buildings in the US, but not as low as several of the other cases in this study.

Are the key design strategies well integrated with one another?
Yes, to a degree. The key strategies are the location of the service core, decision to include a skylit atrium, inclusion of UFAD and exclusion of lay-in ceilings, facade detailing, and the choice of climate control systems. These strategies work "as a piece"; a change in any one of these would affect at least two of the others.

SUMMATION

This design is particularly strong by virtue of the iconic power of the roof form, that also has a practical, "environmental-protection" function. Slight weaknesses exist with respect to comfort (humidity control) and in the degree of energy-efficiency (which is good, but not as exemplary as others in this group). The specific tactics employ readily available technology and commonly available commercial building materials. Loads are reduced through a well-detailed and carefully specified enclosure. This general design approach easily could be applied to a civic administration building in the Great Lakes Basin.

CONDITIONS OF EFFECTIVE DESIGN

Figure 4.2.18 BEAUTIFUL

Figure 4.2.19 CLEVER

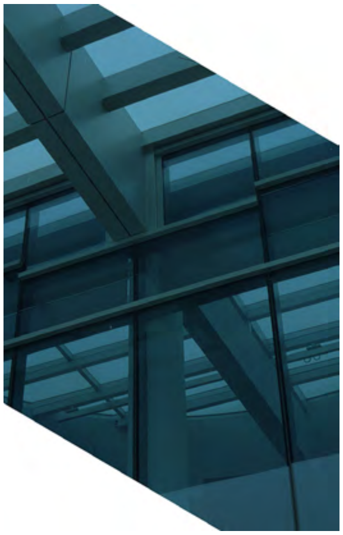
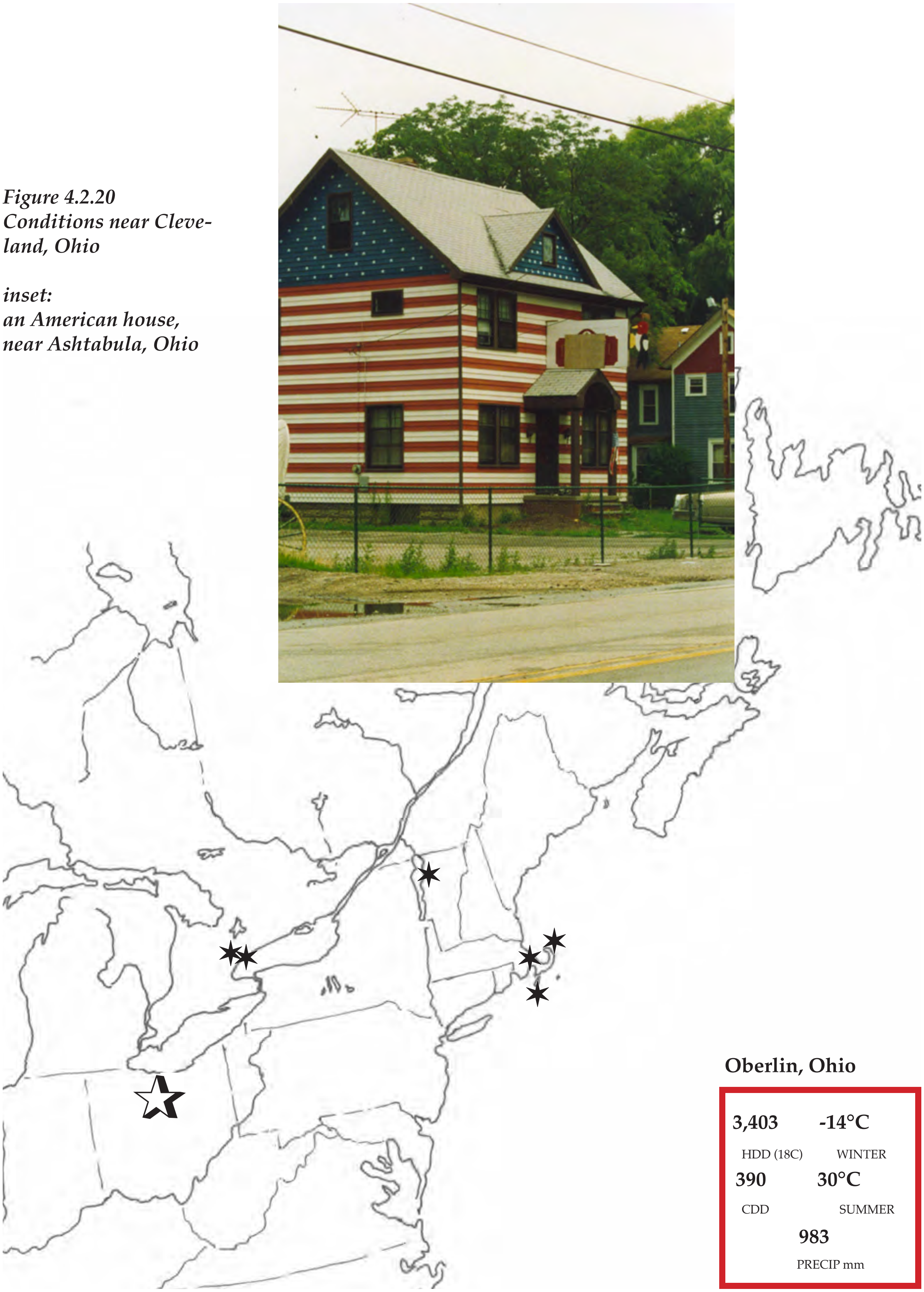


Figure 4.2.20
Conditions near Cleveland, Ohio

inset:
an American house, near Ashtabula, Ohio



Oberlin, Ohio

3,403	**-14°C**
HDD (18C)	WINTER
390	**30°C**
CDD	SUMMER
983	
PRECIP mm	

Lake Erie Basin

When the ancient glaciers receded, they graded the land around the inland, freshwater seas, known as the Great Lakes, and left a heavy clay bed – mineral-rich and good for growing food. On the south shores of the Lake Erie Basin, small creeks – with names like Killbuck and Chippewa – wind to the shore.

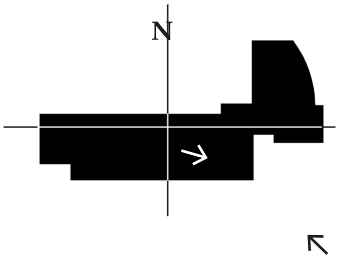
Throughout Ohio, a square grid of county roads, aligned to the cardinal directions of the compass, describes a settled rural landscape of family farms, in which the fields are interspersed with rows of birch, pine and lilac. From April to October, there is enough warmth and sunshine to keep fields of grain and vegetables in production, supplying food to nearby cities. The shores are sandy summer playgrounds, where Carolinian trees, agave, and ground-hugging prickly pear cactus grow, despite the winter frosts.

In the settled rural counties, enough natural habitat remains to sustain native species, including song-birds and deer, fox, and coyote. Yet parts of the south shore have been given over to very heavy industry. Since the early decades of the 20th century, iron ore has been shipped from the rocky lands north of Lake Superior to the rail-yards of Cleveland - bound to meet coal from the Appalachian ranges in the furnaces at Pittsburgh. The towns and cities – Youngstown, Ashtabula, and Toledo – look like “Anywhere, U.S.A.”. And here, the industries that feed on steel flourished for many years. But the Ohio Valley seems to be quieting down. Much of the activity has moved to distant continents, and the ways of life here may be changing.

Twelve miles south of the Erie shore, Oberlin forms a square-grid, around a large, flat green park. A landscape of neat green lawns and picket fences predominates, as it does throughout the Basin. The College and the town are one - and, though the pace is different, the rhythms are as all-pervasive as they are, in any company town. Yet, from the highway the summer sky – hazy by nature – still is smudged by heavy industry, particularly the effluents of coal-fired generation of electricity.

The Adam Joseph Lewis Center, Oberlin, Ohio

Figure 4.2.21 Southeast corner
Figure 4.2.22 Orientation



Relevance
Climate: Cool-humid Grt. Lakes

Site Context:
On a campus, which comprises street-related pavillions at the centre of a small town. Heavy clay soils under flat terrain, flood easily.

Project Goals:
Test if it is possible, in this climate, to operate only on current sunlight, avoid compromising the health of any natural system. Help drive campus policies.

Density: SUBURBAN
FloorArea: 13,600 sf
Occupied: 2000
Capital Cost: $4,854,600 constr.

Awards:
...AIA Top Ten Green 2002
...US rep to iGBC 2000
...AIA COE 1999
...Chicago Athenaeum 1999
...Milestone Building of the 20th century (1 of 30), US DOE
Image credits:
all images B.M. Ross

Context, Form & Orientation

Height: 2-storeys, no basement

Plan Aspect 1: 3.27 *Facade:GFA* 1: 1.17 *Surface (incl. roof):GFA* 1: 1.32

Form driven by: street edge, solar orientation, program, extensive study of alternatives in committee setting

Enclosure

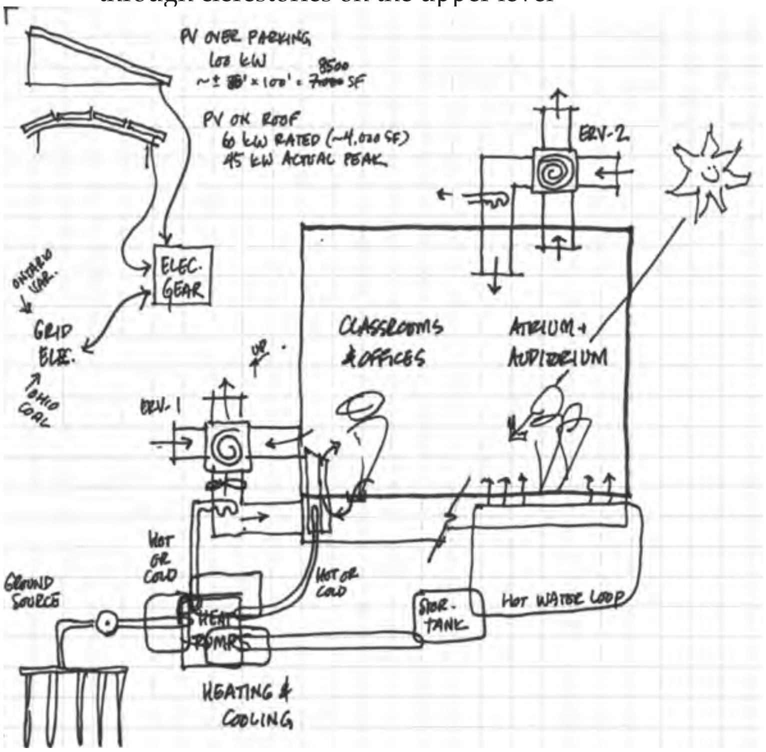
Walls: cavity wall, clay brick over concrete block

Windows: double-glazed in aluminum frames; triple-gl in atrium

Roof:

Window-wall ratios: o/a 36% *; north* 37%*; east* 72% *; south* 57% *; west* 17%

Daylight: adequate on the ground floor level; abundant and varied through clerestories on the upper level



Notes:

Figure 4.2.23 Climate control systems

Figure 4.2.24
Looking east through the atrium

FIT

What does this place allow us to do?

- flat terrain allows easy construction
- open site, low tree cover allows active and passive solar gains in the building

What does this place help us to do?

- clay soils help retain a pond
- sunshine helps generate power
- sun, rain, soils help grow grain, fruit, and vegetables

What does this place require us to do?

- restore the memory of natural ecosystems in community members and visitors

BALANCE

Can a natural system gain, by satisfying a human desire, here?

- air quality is gaining by heightened awareness of the issues with coal generation (the town recently voted against the construction of a new generating station)
- the small restored wetland regains a "toe-hold" (satisfying the curiosity of some; irritating others)
- fresh vegetables and fruit feed several students

NATURAL SOLUTION

How durable, adaptable, replicable, and fecund is the design?

- the structure and solid enclosure are extremely durable (although a few roof leaks persist)
- the layout is adaptable and replicable
- observation of the building, as a "living lab", informs students

SOCIAL BENEFIT

Is it good for the community?

- yes - used frequently by community groups
- also the landscape invites comment, use, and thought

INPUT PER OUTPUT

Are the inputs low, for a given unit of output?

- operating energy is very low (see diagram, right)
- the capital cost was approx. 200% of "going rate" at the time

CONDITIONS OF SUSTAINABILITY

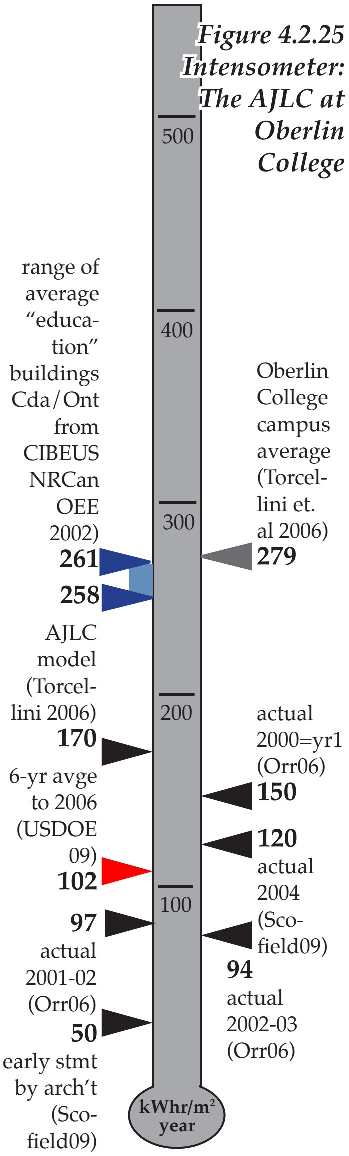


Figure 4.2.25 Intensometer: The AJLC at Oberlin College

The AJLC, Oberlin College

CONDITIONS
OF
EFFECTIVE DESIGN

Figure 4.2.26 MEANINGFUL

Figure 4.2.27 ENJOYABLE

MEANINGFUL

What is the strongest message of the design?
To occupants, the design says "this building works completely differently than all others", to neighbours and visitors it says "a new relationship between humankind and nature is in order".

Does the design express belonging to the local community?
No, not really. The general pattern of the surrounding blocks are built up with "pavilion" buildings, each sitting on flat ground, surrounded by neatly clipped turf grass lawns. It follows, but is unique in style, cladding and extent of glass. The landscape contrasts sharply with the neighbours - very "wild", at the east end, and "agrarian" to the north.

Does it imply renewed community vitality?
Yes, clearly. The exuberance of the building (atrium, curved roof) and the landscape - all suggest "something is happening here". Activities such as examining the sundial, reading signage at the pond, and picking fruit, are possible. The atrium regularly is reserved by community groups (e.g. Shaker Friends) for meetings and special events.

Does it say "welcome" and/or express stability and sound governance?
Yes, to a degree. The front door and activities in the atrium are visible from the street. Yet other elements (e.g. pond, gnomon, displays indoors, living machine) are as challenging to the visitor as the "prickly pear" in Figure 4.2.26. The whole is a critique of the status quo - not overly ostentatious (in this sense it resembles a civic building of its era), but it was relatively costly.

Is there a future vision - about humanity & nature - implied by this design?
Yes, clearly. The didactic program of the design over-shadows all other purposes. The vision - of a free-standing building, independent from all infrastructure, yet it the middle of a town - is inescapable.

ENJOYABLE

Does the design suggest that the owners care for the health of occupants?
Yes, to a degree. The logic of an all-electric design in a state that generates mostly in dirty-coal plants (that create smog) has been questioned. Nevertheless, the amounts drawn are a fraction of the norm.

Is it comfortable? (thermally, acoustically, visually)
Yes, to a degree. Temperatures throughout the building are reported as "uneven", with not enough heat during winter, in the small rooms. During the tour, acoustic and visual comfort were well above average.

Does the space planning work superbly?
No, not really. The atrium works well, but seems over-sized. Labs and faculty offices have overflown into the "Annex" - a crudely adapted 2-storey house, on the adjacent property (right side of Figure 4.2.27).

Does the design lift the spirit?
Yes, to a degree. The design has been the subject of extensive reflection, continues to provoke thought, and may even stimulate action. But experiencing it left a certain bitter taste. It is neither a calming nor an encouraging building;

the overwhelming sense is that it was realized - and that such a building again might be realized - "against all odds", and that the results of such a struggle are likely to be rather uneven.

BEAUTIFUL

Does the design extensively employ daylight?

Yes, clearly. Daylight enters L2 spaces from many directions (see Figure 4.2.28). Classrooms on L1 are amply illuminated, from the south.

Are materials, lighting and space arranged in a way that is interesting, appealing, and memorable?

Yes, clearly. The layout is clear as soon as one enters the building (from any of three alternative directions). The wood structure, trim, and brick give the second floor a warmth that the ground floor lacks. The detailing of the steel frame and perforated ceiling panels is less successful.

Is the design a strong exemplar of the sensibilities prevailing at the place and time in which it was created?

Yes, to a degree. The display of activities to the street, the curved roof shape and "striped" brick coursing are typical of the 1990s. Other contemporary sensibilities - e.g. a contrast of textures, use of "found" materials, and handcraft - are not extensive.

CLEVER

Is unusual technology - emerging or re-emerging - applied in this design?

Yes, clearly. From the PV-covered roof to the "Living Machine" (Figure 4.2.29), this design is replete with "green" devices.

Do technical strategies drive the form?

No, not really. To the contrary - the roof shape might have been altered to prevent PV panels from being oriented northward or horizontally.

Does the design attain a measurable superlative (e.g. biggest, most, first ...)?

Yes, clearly. It is the subject of more published reflections by project participants than any other case, particularly with respect to design process and actual, in-service energy use. (Early, very low energy intensity.)

Are the key design strategies well integrated with one another?

Yes, to a degree. Preventative maintenance of the heat pump units is difficult, because they are partly submerged below the raised floor.

SUMMATION

This design is controversial, signalling a future vision, never easing its criticism of the status quo, and acting as and catalyst for re-thinking. It also is contradictory: off-the-grid, but in the centre of town, suggesting vitality, but not entirely belonging. It displays a few severe weaknesses: in co-ordination of details, and in a conflict between formal preferences and technical requirements (curved roof and PV). Many of the tactics are widely applicable to civic building in Great Lakes Basin. Yet the AJLC likely will retain a unique status as a "living laboratory", in contrast to projects that must meet a wider range of goals.

CONDITIONS OF EFFECTIVE DESIGN

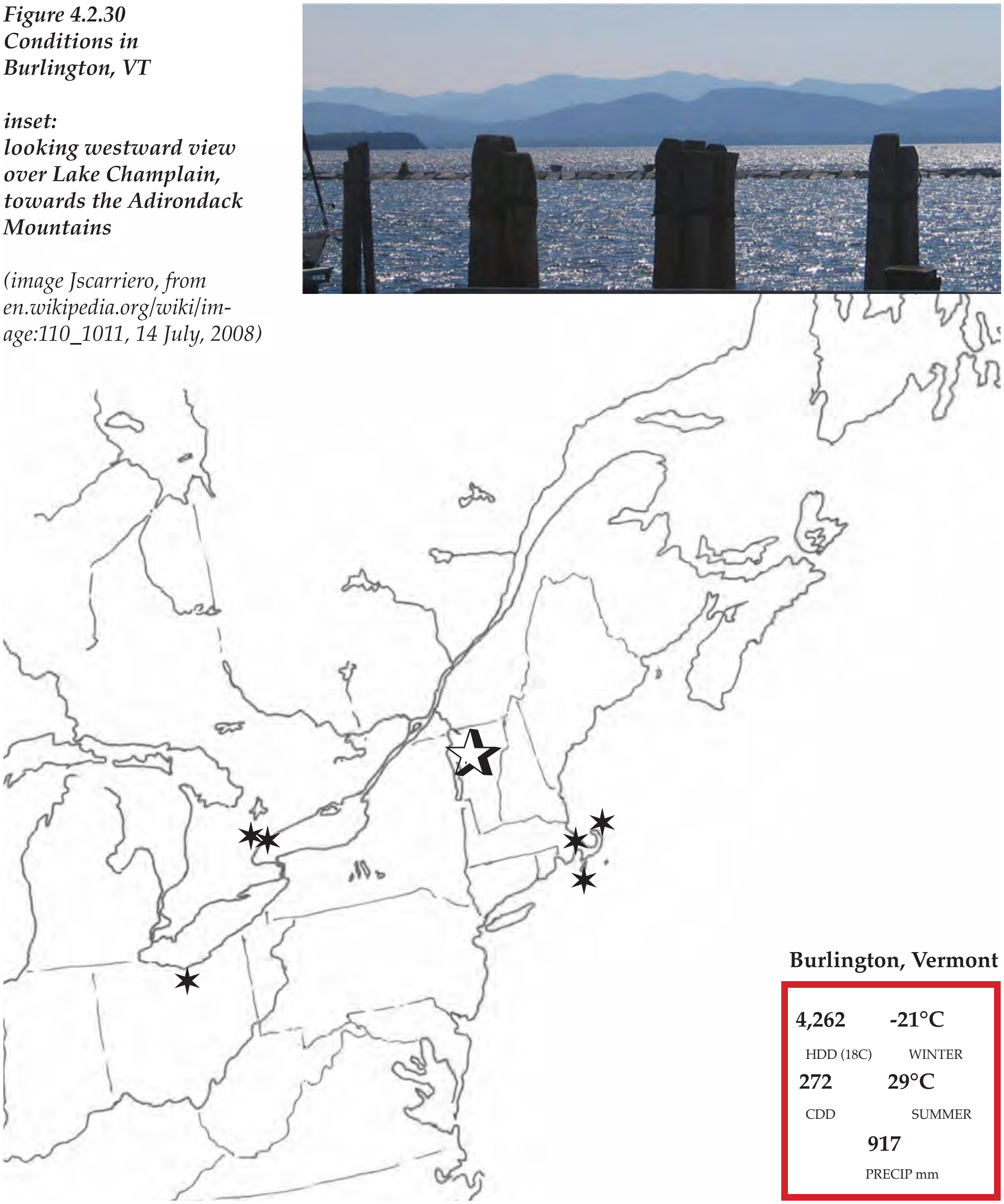
Figure 4.2.28 ***BEAUTIFUL***

Figure 4.2.29 ***CLEVER***

Figure 4.2.30
Conditions in Burlington, VT

inset:
looking westward view over Lake Champlain, towards the Adirondack Mountains

(*image Jscarriero, from en.wikipedia.org/wiki/image:110_1011, 14 July, 2008*)



Burlington, Vermont

4,262	**-21°C**
HDD (18C)	WINTER
272	**29°C**
CDD	SUMMER

917
PRECIP mm

Northern Vermont

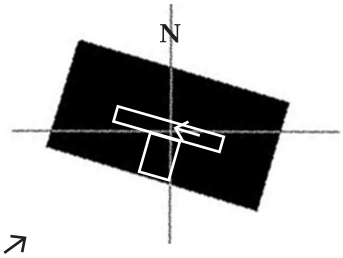
For the first hour, driving south from Montreal, the land is flat. On the eastern horizon are the foothills of the Adirondack-Laurentian mountain ranges, to the west are gullies, carved out of the plain, feeding toward Lake Champlain. The road runs among fields of dry and golden straw that is dusted with snow, and becomes the main street of one farming hamlet after another. Intermittently, there's a gas station, a tin-shingled church, a cluster of houses, and then the open road again.

After crossing the river at St-Jean sur Richelieu, the road winds up toward the hills. The fields give way to forest, and the view opens out over a valley, dotted with dwellings and hedgerows. Further toward the Green Mountains, the road begins to curl around in the terrain. Here are the red barns of New England, and the worn fence-rails of small family farms. In the early twilight of a February day, a bright moon rises – freakishly large against the sculpted folds of gray-blue peaks. I will be told this is a normal sight, an illusion of full moon and horizon, but it seems portentous.

Burlington is a pleasant town, consisting of a grid of streets, draped over the precipice, and down the slope, to the water's edge. All views are westward, to the open water, and to the mountains rising above the far shore. This is a college town, that is home to a range of small businesses, and also hosts year-round vacationers: boaters in summer, and skiers in winter. On a winter night, a Mozart concerto is heard along the sidewalk, which is busy with restaurant-goers, pausing in the falling snow to look in bright shop windows. And, behind each one, there is the promise of a welcoming conversation. The sushi man laughs as he relates, this is a quiet part of America, that is home to more cows than people!

Wind NRG Office & Warehouse
Hinesburg, Vermont

Figure 4.2.31 South facade
Figure 4.2.32 Orientation



Relevance
Climate: COLD-HUMID

Site Context:
rolling glacial foothills of the Green (Appalachian) Mountains., heavy wet clay soils, dairy farms, & hardwood forests, site is 1 km. from town (pop. 3,000), along a 2-lane country road

Project Goals:
Establish a healthy, productive and beautiful workplace. Further the use of renewable energy. Preserve native vegetation & habitat, as well as local recreation and agriculture.

Density: RURAL
FloorArea: 46,500 sf
Occupied: 2004
Capital Cost: $5,500,000 constr.

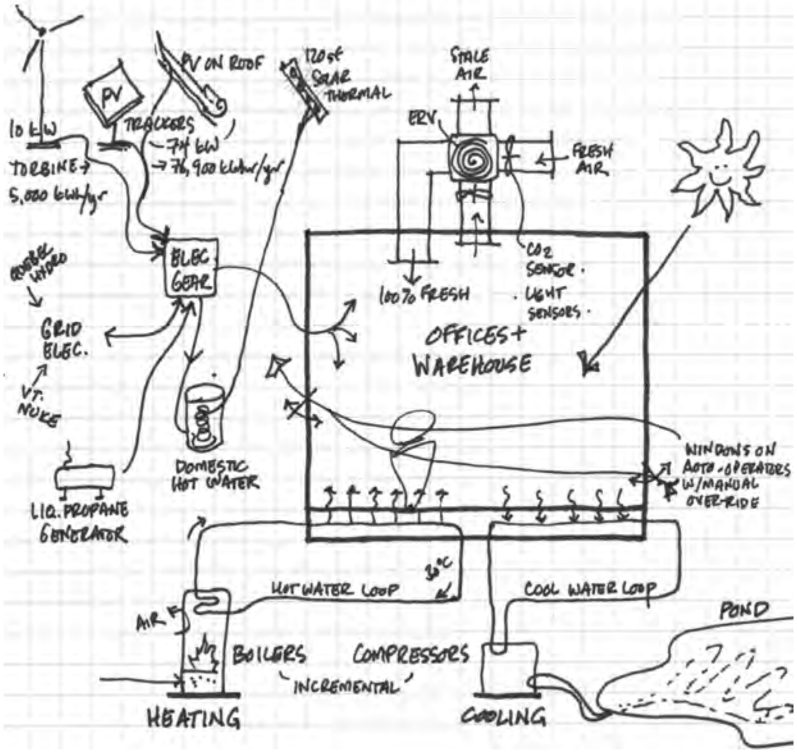
Awards:
...Honor, AIA VT Chapter, 2004
...Amer. Psych. Ass., Nat. Psy'ly Healthy Workplace, 2006
...Compreh., Efficiency VT, 2005
...IES Award of Merit, 2005
...LEED Gold, 2005
Image credits:
4.2.31 & 4.2.34 Carolyn L. Bates, from US DOE

Context, Form & Orientation

Height: 2 storeys
Plan Aspect 1: 2.04 *Facade:GFA* 1: 2.86 *Surface (incl. roof):GFA* 1:0.98
Form driven by: natural hillside (at rear), county road (pond is artificial), PV and office to windows face nearly south

Enclosure

Walls: insul. metal wall panels + insul + st. stud, assembly R20
Windows: fibreglass frame, triple-glazed w / t.b. 2x low-E Argon, R5
Roof: white TPO membrane + R40 insul on steel deck
Window-wall ratios: o/a 29%; *north* 43% ; *east* 17% ; *south* 36% ; *west* 16%
Daylight: abundant from skylights & clerestories (see "Enjoyable")



Notes: heats or cools; wood-pellets (by-product of local mill)

Figure 4.2.33 Climate control systems

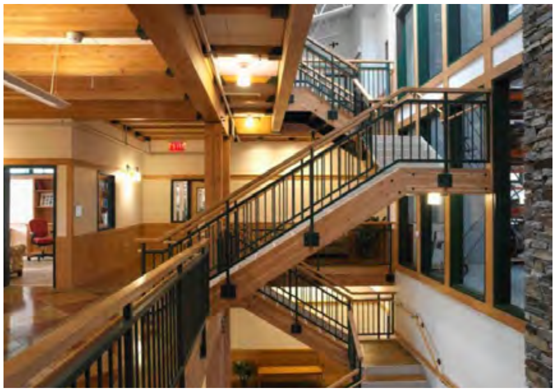


Figure 4.2.34
Looking west through the interior commons

FIT

What does this place allow us to do?

- available land allows installation of PV "trackers" on the site
- rolling terrain allows construction at various elevations, facing various directions (Town allowed development of 9.5/56 acres)

What does this place help us to do?

- hill (at rear) helps operation of wind turbine
- clay soils help stabilize and fill the artificial pond without a liner
- spring-fed well will help cool the Phase 2 building
- fresh air and breeze help ventilate the building, most seasons

What does this place require us to do?

- the limited available energy infrastructure in this rural location suggests that the building should operate independently of distant energy sources

BALANCE

Can a natural system gain, by satisfying a human desire, here?

- natural systems may be challenged by the human desire to settle on a hillside, away from confines of the town
- however, the design proves that comfort and functionality are attainable at a fraction of today's current loads - visitors, from the company's customers in 120 countries, witnessing this proof may be inspired to do likewise at home.

NATURAL SOLUTION

How durable, adaptable, replicable, and fecund is the design?

- exterior wall panels may show wear, long-term, particularly near grade
- travel to/from may become a challenge (now, many employees live between 20 and 40 miles away, and carpooling is encouraged)

SOCIAL BENEFIT

Is it good for the community?

- major employer - the largest building in Hinesburg
- attracts frequent tours (e.g. to local school & community groups)

INPUT PER OUTPUT

Are the inputs low, for a given unit of output?

- Yes - both operating energy and capital cost are VERY LOW, relative to averages, when the building was designed

CONDITIONS OF SUSTAINABILITY

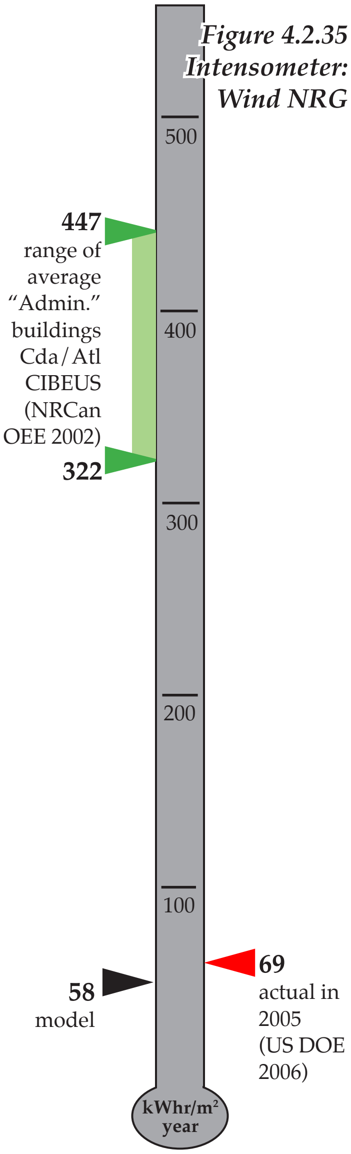


Figure 4.2.35
Intensometer:
Wind NRG

Wind NRG

CONDITIONS
OF
EFFECTIVE DESIGN

Figure 4.2.36 MEANINGFUL

Figure 4.2.37 ENJOYABLE

MEANINGFUL

What is the strongest message of the design?
To employees, the design says "this workplace is comfortable", to neighbours and visitors it says "our business is thriving".

Does the design express belonging to the local community?
Yes, clearly. The overall character is similar to a ski lodge, found in the mountains just 20 minutes away. The red colour is characteristic of traditional buildings in rural Vermont, such as barns and bridges.

Does it imply renewed community vitality?
Yes, to a degree. The choice to locate here - rather than in another town nearby - is a significant investment in this locale. However, the building is 200-300% larger than any other building in Hinesburg. Sitting at a short distance from the town, it may be perceived, by some, as a competing nexus of activity.

Does it say "welcome" and/or express stability and sound governance?
Yes, clearly. The central gable, clearly visible from the highway, contains the front door and major assembly spaces (see Figure 4.2.36). The building looks "a cut above" the average warehouse, but it is not overly ostentatious.

Is there a future vision - about humanity & nature - implied by this design?
Yes, clearly. Power generation is very evident on the site: PV panels sit in front of the building and a windmill atop the hill behind. But the building does not look "strangely futuristic". In this design, a high-tech industry thrives, imposing minimal loads on the environment, in a setting that is comfortable and familiar to workers.

ENJOYABLE

Does the design suggest that the owners care for the health of occupants?
Yes, clearly. The evidence is in the avoidance of recirculated air, a large kitchen at the heart of the building, and a fitness room with a view.

Is it comfortable? (thermally, acoustically, visually)
Yes, to a degree. In a survey of all staff (Baird, 2006), the building scored higher than benchmarks in the consultant's database - with respect to most comfort indicators. However, the score was significantly below the benchmark with respect to thermal comfort in the summer (too hot, humid and still), noise (from colleagues and from outside), perception of appropriate balance between natural and artificial light, and perceived control (of heating, cooling, ventilation and lighting).

Does the space planning work superbly?
Yes, clearly. Circulation space is minimal and very effective - the central space knits together offices, warehouse and communal rooms. Orientation and wayfinding are excellent. In the Baird survey, a majority of respondents complained of too little space at the desk. Nevertheless, during the tour, 97 staff were working in a space designed for 40.

Does the design lift the spirit?
Yes, clearly. The first sighting was at dusk on a cold day in winter, following a 10-hour journey overland. The warmth of the red walls, the ease of access, and the open appearance were heartening. The following day was cold, and bright. During the tour, workers were alert and active, while the "company cat" basked in the sunshine (Fig. 4.2.37).

BEAUTIFUL

Does the design extensively employ daylight?
Yes, clearly. Natural light enters every occupied space from at least two directions.

Are materials, lighting and space arranged in a way that is interesting, appealing, and memorable?
Yes, clearly. A warm material palette is consistent throughout all office spaces (see Figure 4.2.38). From every space, other spaces can be seen - and there is a great variety in ceiling height and shape of space.

Is the design a strong exemplar of the sensibilities - prevailing at the place and time in which it was created?
Yes, to a degree. Even though this is a rural building, it does engage its own "street". Public rooms are situated under the centre front gable. At night, occupancy of the staff room (on the ground floor) or the conference room (above) is visible from the parking lot. The design does not make extensive use of devices or forms popular in 2004 - such as contrast of surface textures (rough/smooth or natural/machined), the use of "found" (borrowed, out-of-place, out-of-scale) materials, curved roofs or free-forms. However, the extensive use of clear-finished wood and handcraft (e.g. floor paintings, wood furniture, stone chimney, quilt) are characteristic of this part of northern Vermont.

CLEVER

Is unusual technology - emerging or re-emerging - applied in this design?
Yes, clearly. Radiant in-slab heating, heat-recovery ventilation, solar and wind energy are integrated into the design (see Figure 4.2.39).

Do technical strategies drive the form?
Yes, to a degree. The building form and orientation are designed to capture sunlight, take advantage of the breeze, and support energy-producing devices. The requirements of PV panels established the roof slope, and the clerestory allows daylight deep into the plan.

Does the design attain a measurable superlative (e.g. biggest, most, first ...)?
Yes, clearly. Alongside Gilman Ordway, this is the least energy-intense design among the case studies, and this is the lowest-level of energy use for any office building encountered in the research, to date.

Are the key design strategies well integrated with one another?
Yes, clearly. See "drive the form", above.

SUMMATION

This project is very strong in all categories, and is a particularly good example of both "Enjoyable" and "Clever". It has no severe weaknesses. Very slight weaknesses exist in relation to community vitality (perception), contemporary sensibilities, and thermal comfort. The "contemporaneity" issue is mitigated by the tasteful use of elements with a strong local character.

While the specific tactics are (at present) somewhat unusual, the strategic approach taken by the design team is highly applicable to a civic building in this region. This project shows what can be achieved by using energy-reduction operations, while continuing to put a priority on human needs.

CONDITIONS OF EFFECTIVE DESIGN

Figure 4.2.38 BEAUTIFUL

Figure 4.2.39 CLEVER

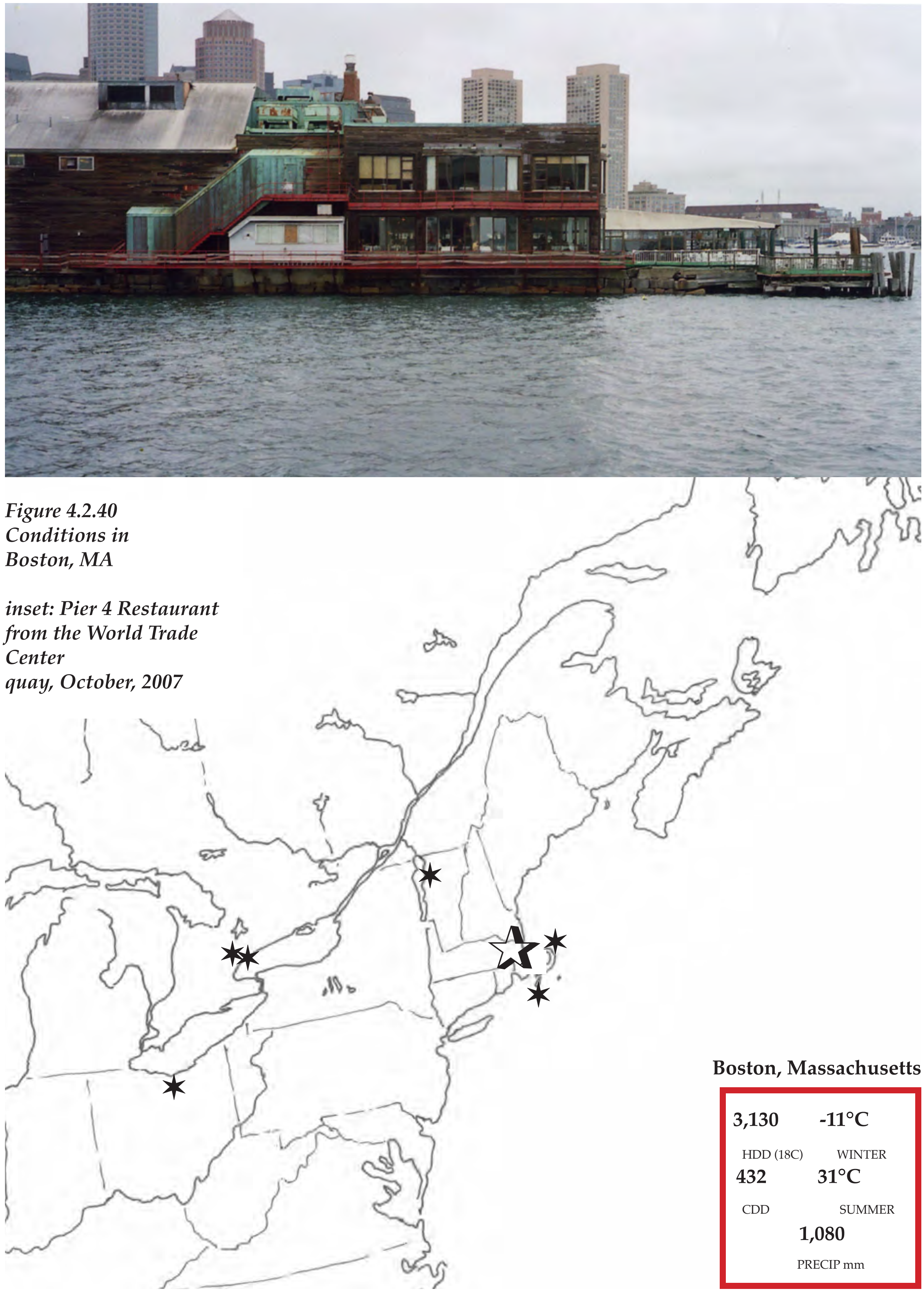


Figure 4.2.40
Conditions in
Boston, MA

inset: Pier 4 Restaurant
from the World Trade
Center
quay, October, 2007

Boston, Massachusetts

3,130 HDD (18C)
-11°C WINTER
432 CDD
31°C SUMMER
1,080 PRECIP mm

Boston

A salty breeze, that cools and calms, also brings with it the city smells of coffee and construction. And it bears the aromas that belong to especially to this place – seafood and the cool damp from between the crevices where pavement meets old brick.

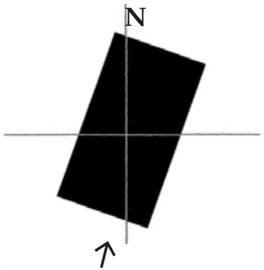
This is a busy city, at work in commerce and ever re-building. And it revels in its seasons. On the day of a fall football game, people across the continent - especially those that are bolstering for an early winter frost - prepare baked beans and think of Boston. And, as they say, "it's not sweetheart weather here", in winter either – as biting winds from the North Atlantic drive in against the towers.

On the other hand, a Boston summer Sunday is quiet and sublime. After church (this town goes to church) the whole day may be spent in the garden with the paper, or walking with the tourists around Faneuil Hall, or cycling on the flat ground beside the river Charles, looking westward to the rowing eights gliding on the water. In September, the crisp and clear blue-sky days bring back a sense of focus. The colours of the landscape change from green to flaming red and gold, as the sugar maples, birch, and oak declare the changing of the seasons.

There is no gridiron plan in Boston - the city blocks radiate outward, from the earliest settlements, as they do in Europe. Only here, they are extruded skyward. The clang-clang of a pile driver, the shout of a foreman, and the signal of a truck backing up may be heard around any corner. Yet this place beside the ocean is ever more relaxed than many others. And on the sidewalk, or in the oyster house, there is the broad speech of the real Bostonian – "have you evah been to Bah Hahbah?"

Artists for Humanity EpiCenter
Boston, Massachusetts

Figure 4.2.41 South facade
Figure 4.2.42 Orientation



Relevance
Climate: New England

Site Context:
East side of downtown core, immediate neighbours are large-scale industries (Gillette factories). Feels “tough” for a pedestrian. Site is former livery garage.

Project Goals:
Establish owned site, and avoid future move due to gentrification. Build public awareness of sustainability (environ’l and social). Make use of available grants (public & private).

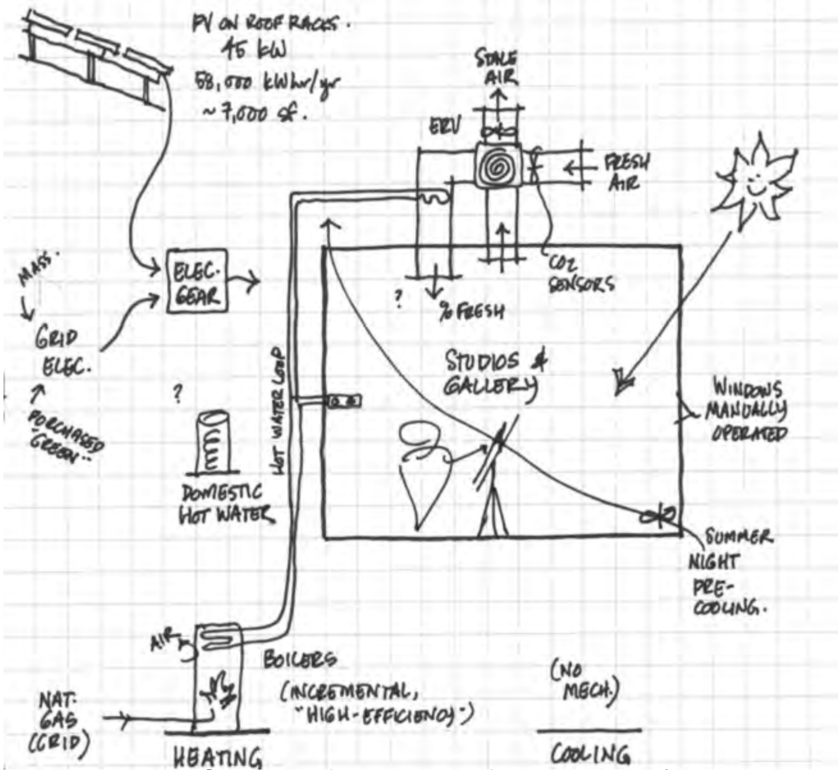
Density: URBAN
FloorArea: 23,500 sf
Occupied: 2004
Capital Cost: $4,300,000

Awards:
...AIA COTE Top Ten Green ‘07
...K-12 Honor Award, Boston Society of Architects & AIA NY Chapter, 2005
...LEED Platinum

Image credits:
Fig. 4.2.41 Richard Mandelkorn
Fig. 4.2.46 USGBC 2008, Oct ‘06

Context, Form & Orientation
Height: 3 storeys plus mezzanine
Plan Aspect: 1:1.79 *Facade:GFA* 1:1.94 *Surface (incl. roof):GFA* 1:1.22
Form driven by: fills property to maximium allowable footprint

Enclosure
Walls: corrugated steel siding on insul. st. studs, gyp. rock
Windows: curtain wall
Roof: grey membrane roof
Window-wall ratios: o/a 22% ; *north* 59%; *east*2% ; *south* 59% ; *west* 0%
Daylight: abundant from north & south; none from east or west



Notes: night pre-cooling using ambient air; no refrigeration; purchased green power

Figure 4.2.43 Climate control systems

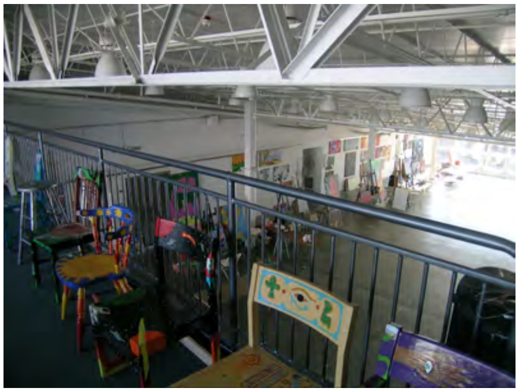


Figure 4.2.44
Looking south from the mezzanine into the studio

FIT

What does this place allow us to do?

- low-rise urban development, with wide streets, allows PV installation on the roof (to capture solar radiation) and allows sunlight to penetrate fully, through south-facing windows

What does this place help us to do?

- slope helps create 2-story space, at the lowest level
- wind-generated power in the grid (from nearby towers on the Atlantic shore), combined with PV, allows zero-footprint electricity
- cold north Atlantic affords some cooling breezes on hot summer nights - allows elimination of mechanical cooling

What does this place require us to do?

- re-invigorate an urban area with diverse activities
- seed an awareness of natural systems, in urban youth

BALANCE

Can a natural system gain, by satisfying a human desire, here?

- viewing humanity as a part of nature, and the city as humanity's creation and its home, then yes - society is more peaceful, productive and interesting because of the work of this agency- to the extent that its "headquarters" supports that work, individual artists, commerical customers, and the city as a whole gain - perhaps that spills over into wider perceptions of non-human systems

NATURAL SOLUTION

How durable, adaptable, replicable, and fecund is the design?

- durable enclosure, and simple, adaptable "barn-like" volumes
- parts are replicable,e.g. as climate control and enclosure systems
- information about the building is displayed on the walls, for school tours

SOCIAL BENEFIT

Is it good for the community?

- introducing a public use adds variety to the neighbourhood - may leverage more diversity in future
- agency serves at-risk youth throughout Boston

INPUT PER OUTPUT

Are the inputs low, for a given unit of output?

- both operating energy use and capital cost are very low, relative to comparable projects

CONDITIONS OF SUSTAINABILITY

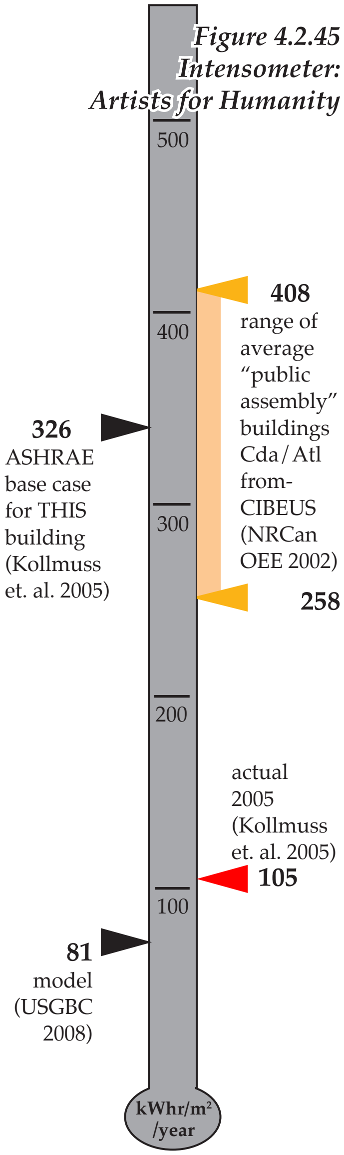


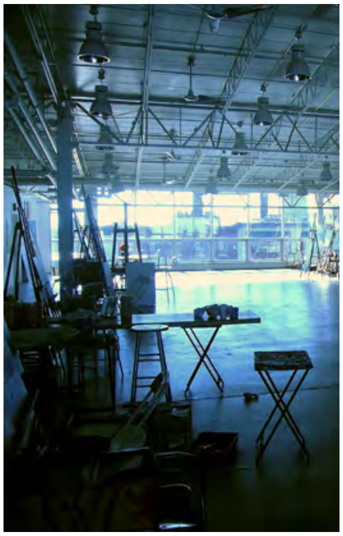
Figure 4.2.45
Intensometer:
Artists for Humanity

Artists for Humanity

CONDITIONS OF EFFECTIVE DESIGN

Figure 4.2.46 MEANINGFUL

Figure 4.2.47 ENJOYABLE



MEANINGFUL

What is the strongest message of the design?
To employees and student artists, the design says “you are welcome here, and yes, you can express yourself”, to neighbours and visitors it says “we are making this city more interesting”.

Does the design express belonging to the local community?
Yes, clearly. The corrugated steel siding is typical of the neighbouring industrial buildings, but re-interpreted in this design.

Does it imply renewed community vitality?
Yes, clearly. The building is more pedestrian-friendly, and reveals more of its inner activities than the neighbouring warehouses.

Does it say “welcome” and/or express stability and sound governance?
Yes, to a degree. The design is welcoming; locating the front door is easy, and, on many days and evenings, the lower floor gallery is open to the street (see Figure 4.2.46). However, stability and sound governance are neither strongly expressed nor contradicted; the design is neutral in this respect.

Is there a future vision - about humanity & nature - implied by this design?
Yes, to a degree. The small patch of turf grass (while not natural) is an unusual sight in this neighbourhood, and it is associated, here, with human leisure. The design is noticeably “green” to those who can look over the roof (from a few blocks away).

ENJOYABLE

Does the design suggest that the owners care for the health of occupants?
Yes, to a degree. The spaciousness, and allocation of equipment to activity areas (such as print-making) speak of care in making appropriate accommodation for processes that may make a mess, or create fumes.

Is it comfortable? (thermally, acoustically, visually)
Yes, to a degree. In the studio spaces, a wider range of temperatures is tolerated than typically might be, were the occupants less active. A steep temperature gradient (7°F) exists on a sunny day at the south end of the studio, between the floor area in sunshine and the floor area in shade (see photo, lower left). Acoustics are fairly “live”, yet this, too, is tolerable given the nature of the building users and their patterns. Southward facing spaces (including the administrative offices) experience high levels of glare. A solar shading device, originally planned for the south facade, but deleted in favour of cost control, is listed by the owner as a highly desirable retrofit.

Does the space planning work superbly?
Yes, clearly. The building, though newly constructed, is designed as a “loft” - with washrooms, elevator and stairs along the east wall, and “barn-like”, fully flexible rooms filling most of the plan.

Does the design lift the spirit?
Yes, clearly. In creating strong, simple spaces, with minimal accessories

(finishes, details), the design offers an open setting that invites exploration through creating artwork (see Figure 4.2.47).

BEAUTIFUL

Does the design extensively employ daylight?
Yes, to a degree. The floor-to-floor height allows deep penetration of daylight into the plan. However, light is admitted only from the north and south. There are no skylights. (see Figure 4.2.48)

Are materials, lighting and space arranged in a way that is interesting, appealing, and memorable?
Yes, clearly. (see "lift the spirit", above)

Is the design a strong exemplar of the sensibilities prevailing at the place and time in which it was created?
Yes, clearly. The design of the south facade connects internal activities and outdoor public space (e.g. on approach, a worker in the office easily can be hailed from the sidewalk). There is some contrast of surface textures - between the hard smooth textures of the floor and steel siding, and the softer, rougher textures in most of the art. "Found" (out-of-place) materials are present in the used windshields that form guards under the handrail at the mezzanine around the lower level (this installation was designed and fabricated by an artist. Free-form is not in evidence, other than the cant on the high roof (to raise the PV panels to a favourable tilt).

CLEVER

Is unusual technology - emerging or re-emerging - applied in this design?
Yes, clearly - PV, DOAS, and ERV.

Do technical strategies drive the form?
Yes, to a degree. The floor-to-floor height was chosen, in part, to admit daylight, and the roof slope supports PV panels (see Figure 4.2.49).

Does the design attain a measurable superlative (e.g. biggest, most, first ...)?
Yes, clearly. It is the largest PV installation at a single building in Massachusetts, and the building has been certified LEED Platinum.

Are the key design strategies well integrated with one another?
Yes, clearly.

SUMMATION

This is a very good example of a practical and flexible design, that is likely to endure, under fairly heavy use, for a long time. It relies on a high-performance enclosure (with few moving parts) to achieve very low energy-intensity. It was designed by a community-based architect, in collaboration with a construction manager, who emphasized the need for clear bid documents. There are slight weaknesses with respect to thermal comfort and glare. Most of the tactics could be applied to a civic building in Great Lakes-St. Lawrence Basin, although the absence of refrigerant-based mechanical cooling would not be acceptable.

CONDITIONS
OF
EFFECTIVE DESIGN

Figure 4.2.48 BEAUTIFUL

Figure 4.2.49 CLEVER

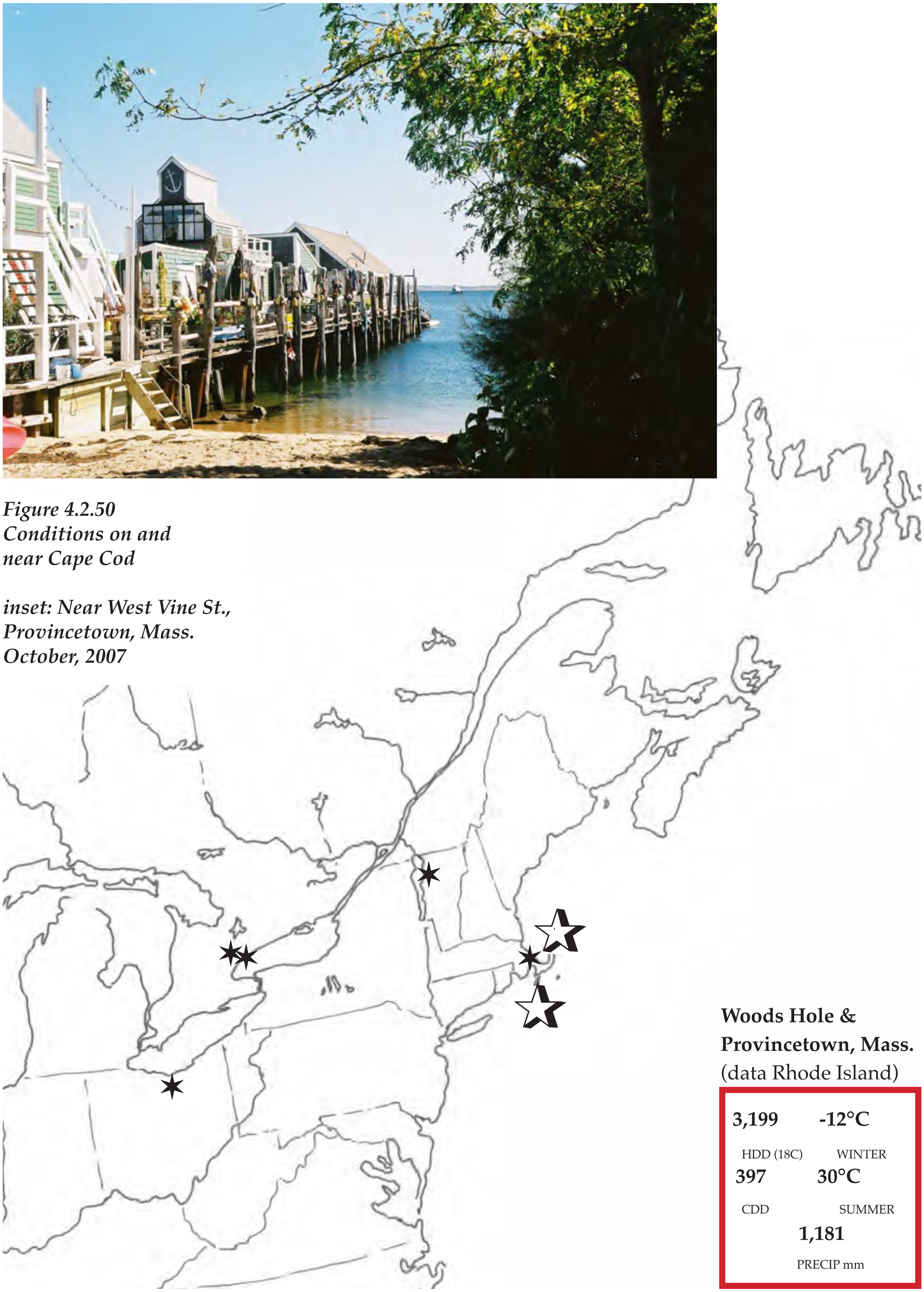


Figure 4.2.50
Conditions on and
near Cape Cod

inset: Near West Vine St.,
Provincetown, Mass.
October, 2007

Woods Hole &
Provincetown, Mass.
(data Rhode Island)

3,199 **-12°C**
HDD (18C) WINTER
397 **30°C**
CDD SUMMER
1,181
PRECIP mm

Cape Cod

On the boat, bound for Provincetown, the passage was rough. The sky and water had turned steely grey, and the seas were very choppy. The cracking deep ultramarine blue of a clear morning at the seashore seemed a lifetime away.

The waters here are cold, and the fish still plentiful. And - starting with the early days of April and up until the last sweet sunny afternoon in October - small sailboats launch from the many little ports to play among the harbour ferries.

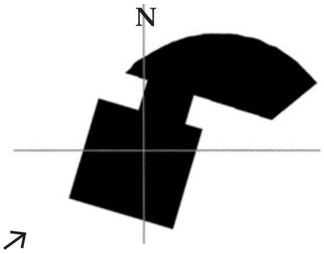
Being so far east, this is one of the first places in North America that the European settlers landed. In Provincetown Harbour, in 1620, after crossing the Atlantic Ocean, the passengers of a small English ship paused before setting foot on the shores of the new continent. Here, they would sign the Mayflower Compact, to combine "together into a civic body politic … to enact, constitute and frame such just and equal laws … for the general good of the colony". The town that grew around the shallows, where the eastern tip of the Cape spirals in thin bars of sand, became a centre for fishing and whaling, then a summertime artists' colony. Lately it has been promoted as a haven for business and tourism catering to the gay community.

Cape Cod is a long wide sandbar, surrounded on three sides by water. The towns are small, and the land is flat, and sparsely green. At the west end (a few hour's drive from Provincetown), the village of Woods Hole is home to several scientific research organizations, and the launch point for vacationers bound for the big islands of Nantucket and Martha's Vineyard. Between marshy inlets, the sand dunes rise, providing shelter for small clusters of weathered, "saltbox" houses.

Gilman Ordway Building at the Woods Hole Research Center Falmouth, Massachusetts

Fig. 4.2.51 Southwest corner

Fig. 4.2.52 Orientation



Relevance
Climate: Coastal, north Atlantic

Site Context:
settled sand bar with dunes and marshes, scrub forest, small houses in the understory, salt air and ocean light, site is 4 km. from village port, along 2-lane road

Project Goals:
Consolidate offices and labs. Reflect the core ideals of occupants. Promote their health and that of the larger world. Adapt an historic house, to suit the local context.

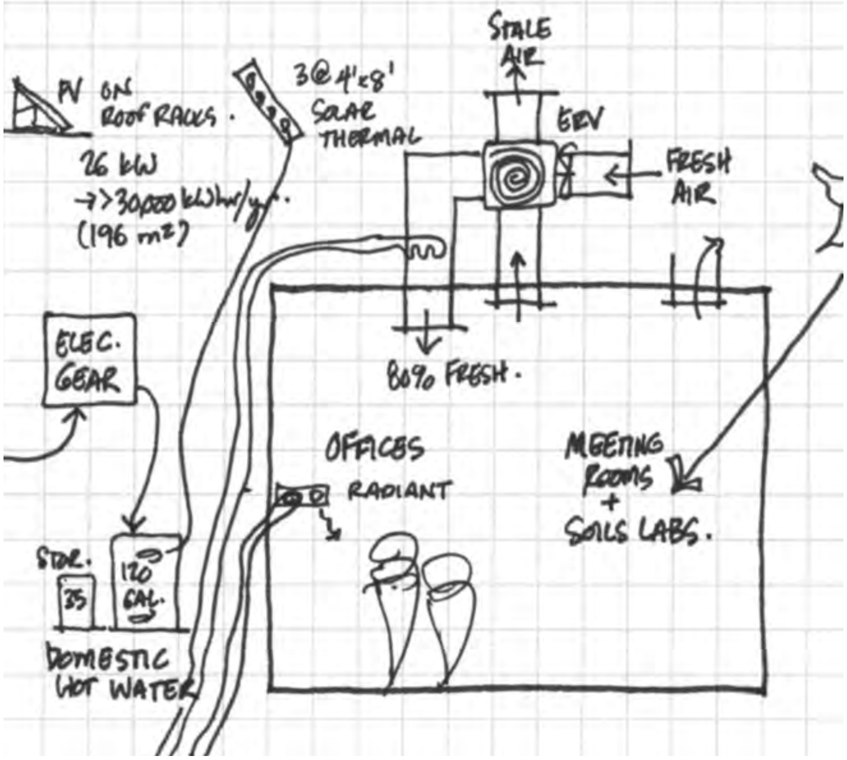
Density: **SUBURBAN**
FloorArea: 19,200 sf
Occupied: 2003
Capital Cost: $6,200,000 proj

Awards:
... AIA TopTenGreen 2004
... NESEA Green Buildings Awards, 2004
...Hon. Mention, EDC Mag., Institutional Category, '04

Image credits:
Fig. 4.2.54 Alan Orling
Fig. 4.2.57 Judy Watts Wilson
Fig. 4.2.56 & .58 brochures

Context, Form & Orientation
Height: 3 storeys
Plan Aspect: 1:2.96 *Facade:GFA* 1:1.70 *Surface (incl. roof):GFA* 1:0.96
Form driven by: topography, forest, respect for historic house

Enclosure (addition)
Walls: cement board, offset wood studs, spray foam
Windows: triple-glazed in wood frames in new; double-gl in reno
Roof: EPDM on 4" EPS
Window-wall ratios: o/a 25.9 ; *north* 27.8; *east* 14.8 ; *south* 31.2; *west* 29.7
Daylight:



Notes:

Figure 4.2.53 Climate control systems

Figure 4.2.54
North facade, from the ravine

FIT

What does this place allow us to do?

- marine climate allows passive use of breezes
- rolling terrain affords interesting options for locating the building
- available land may allow installation of wind turbine on the site

What does this place help us to do?

- circulating ocean "groundwater" helps low-load heating & cooling
- hilltop helps access to ocean views and strong winds (for power)
- low forest cover helps access to sunshine (for power)

What does this place require us to do?

- rest very lightly on a fragile ecosystem
- respect changing seasons - weather ranges from benign to hostile

BALANCE

Can a natural system gain, by satisfying a human desire, here?

- the design may support the philosophy of the institution, which monitors climate change by studying large forests
- visiting researchers may carry reports of the "low-load" success to other places in the world, where it may encourage more such work
- question whether heat rejection/assumption into ocean water would be possible at very wide scale (i.e. major city)

NATURAL SOLUTION

How durable, adaptable, replicable, and fecund is the design?

- structure, skin and interiors appear fairly durable
- solution is very specific to site and circumstance
- approach may be widely applicable, but the need to preserve an existing house presented unique challenges, here

SOCIAL BENEFIT

Is it good for the community?

- the presence of the institution benefits the local economy
- as a precedent for the re-use of historic buildings, questionable

INPUT PER OUTPUT

Are the inputs low, for a given unit of output?

- energy inputs are very low (see right)
- capital cost was somewhat higher than average, at the time

CONDITIONS OF SUSTAINABILITY

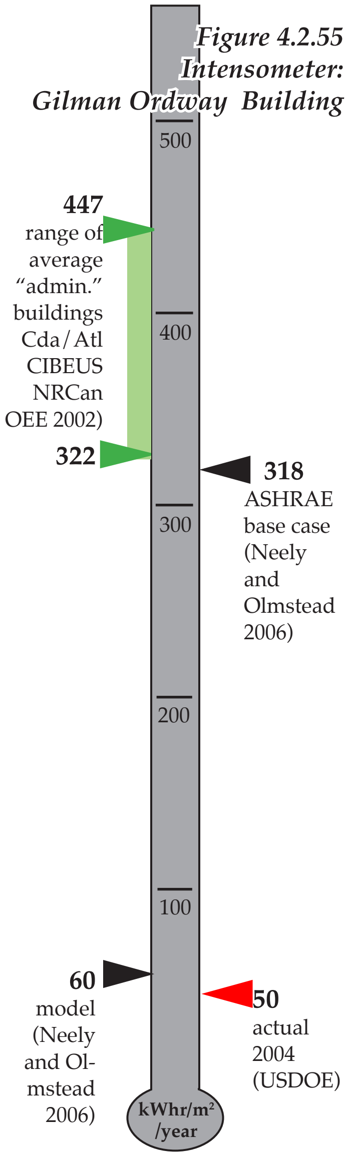


Figure 4.2.55
Intensometer:
Gilman Ordway Building

Gilman Ordway at Woods Hole Research Center

CONDITIONS OF EFFECTIVE DESIGN

Figure 4.2.56 MEANINGFUL

Figure 4.2.57 ENJOYABLE

MEANINGFUL

What is the strongest message of the design?
To employees, the design says "this is our meeting place", to neighbours and visitors it says "we are a professional institution".

Does the design express belonging to the local community?
Yes, to a degree. The adaptive re-use "Hilltop House" (ca. 1877 - the "golden age for summer mansions") sustains the pattern of settlement and distinctive character of the place. But the "restoration" is not entirely sensitive. A plan to install a wind turbine is under debate.

Does it imply renewed community vitality?
No, not really. The Village of Woods Hole is a centre of marine science, in which several institutions have thrived independently, since the first arrived in 1871. This building was a summer house, a guest house, and a restaurant. Its re-use as a workplace changes the type of vitality - one that appears neutral to the immediate neighbours (see Figure 4.2.56).

Does it say "welcome" and/or express stability and sound governance?
Mixed messages. The building is not open to the public, and the approach is not very welcoming. The stone walls, signage, and planting signal an infusion of investment, but the entry sequence is confusing. The real entry is not the front door of the house. It is at the rear - uphill, under a canopy and out of view (see Figure 4.2.51). Yet, the state of the grounds and building do speak of a well-run institution.

Is there a future vision - about humanity & nature - implied by this design?
Yes, to a degree. The technical elements all are chosen to minimize the building's contribution to global warming. However, this is not obvious from inside or near the building.

ENJOYABLE

Does the design suggest that the owners care for the health of occupants?
Yes, clearly. The overall impression is of "a clean, well-lighted place". Workstations and air quality seem to be better than average.

Is it comfortable? (thermally, acoustically, visually)
Yes, clearly. A survey by students from U. Oregon found that thermal comfort was acceptable, that glare was not troublesome, and that local controls were advantageous. During the tour, there was one anecdotal complaint about noise from the corridors entering private offices.

Does the space planning work superbly?
Yes, to a degree. The central hub provides orientation and cohesion. But the net-to-gross ratio is very high and the "gut" of the upper floor of the house results in poorly defined spaces that are under-utilized.

Does the design lift the spirit?
Yes, to a degree. The new addition, with its views into the woods connects the work indoors with its subject outdoors (the study of forests). But the treatment of the historic house, with its T-bar ceiling and oddly proportioned spaces is disappointing.

BEAUTIFUL

Does the design extensively employ daylight?
Yes, clearly (see Figure 4.2.57). Natural light enters the addition from all sides, giving a very pleasing variety. During the tour, occupants praised the architect saying “the daylight - he really got that right”.

Are materials, lighting and space arranged in a way that is interesting, appealing, and memorable?
Yes, to a degree. Odd choices include placing mechanical equipment in a room on the top level in a corner with a view of Vineyard Sound to the southeast (see “Not-so-Clever”, in Part 3). Also the location of the soils labs on the third floor is regretted by the building manager (it would have been better suited to the ground level).

Is the design a strong exemplar of the sensibilities prevailing at the place and time in which it was created?
No, not really. The abundance of wood in the interior lends the building a sense of “custom craft”. Otherwise, only one of the elements identified - the use of free-form - is present, but can be appreciated only by looking at the plan, not by experiencing the place (see Figure 4.2.58).

CLEVER

Is unusual technology - emerging or re-emerging - applied in this design?
Yes, clearly. High-performance windows, geothermal, PV, solar systems, and a public SCADA monitoring energy flow are all applied.

Do technical strategies drive the form?
Yes, to a degree. The roof shape of the historic house was changed to accommodate mechanical equipment (compare Figures 4.2.56 & 4.2.58).

Does the design attain a measurable superlative (e.g. biggest, most, first ...)?
Yes, clearly. It is the least energy-intense of any office building yet seen.

Are the key design strategies well integrated with one another?
Yes, clearly. Examples include: preserve the house and hide the equipment; provide daylight with views into the forest and reduce thermal loads.

SUMMATION

This project is very strong with respect to energy conservation. Weaknesses - slight and severe - are mainly associated with the adaptive re-use of the house, relating most significantly to meaningfulness and beauty. The orientation of the addition serves the preservation of the southeast corner of the historic house, but sacrifices legibility and incurred high costs (for retaining walls). Greater care with the original building fabric (e.g. respect for the original proportions of windows, inclusion of original shutters, preservation of demising walls) also would have led to increased satisfactoriness. In general, the design approach - a high-performance enclosure, ample daylight, and a blend of energy sources - would be applicable to a civic building.

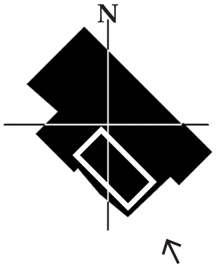
CONDITIONS
OF
EFFECTIVE DESIGN

Figure 4.2.58 BEAUTIFUL

Figure 4.2.59 CLEVER

Provincetown Art Association & Museum (PAAM) Provincetown, Massachusetts

Fig. 4.2.60 Southeast facade
Fig. 4.2.61 Orientation



Relevance
Climate: Coastal, North-Atlantic

Site Context:
across a densely populated, narrow, 2-lane road from a sandy beach; neighbours are houses, small private art galleries, restaurants and shops; frequented at all hours by pedestrians

Project Goals:
Upgrade gallery and storage to comply with requirements of American Association of Museums. Accommodate art classes. Help sustain and nurture an artistic culture in Cape Cod

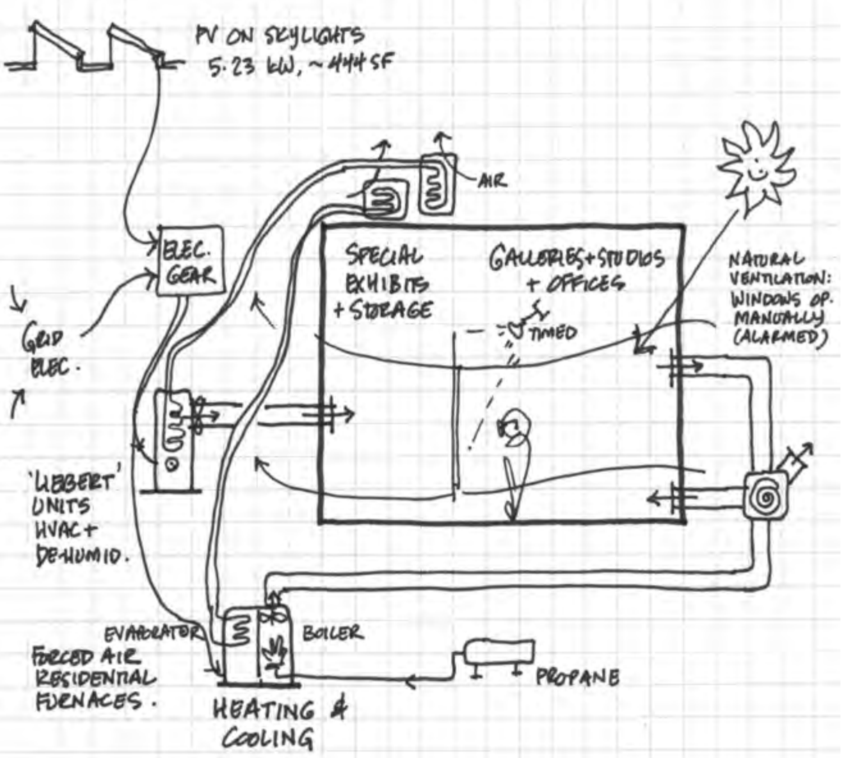
Density: URBAN
FloorArea: 19,500 sf
Occupied: 2006
Capital Cost: $5,000,000

Awards:
...AIA Top Ten Green , Honorable Mention, 2007
...Chicago Athenaeum American Architecture Award, 2007
...LEED Silver

Image credits:
Figures 4.2.60 & .63 Anton Grassi/Esto, from AIA COTE

Context, Form & Orientation
Height: 2 storeys + basement
Plan Aspect: 1: 1.75 *Facade:GFA* 1: 2.79 *Surface (incl. roof):GFA* 1: 1.35
Form driven by: maximum buildable footprint & the need to wrap around the existing historic building

Enclosure
Walls: cedar siding + insul +wood frame or insitu concrete
Windows: double-glazed in custom wood frames
Roof: tbd
Window-wall ratios: o/a 14% ; *north* 16%; *east* 4% ; *south* 30% ; *west* 10%
Daylight: controlled in galleries, ample in studios (on level 2)



Notes:

Figure 4.2.62 Climate control systems

Figure 4.2.63
Looking southwest from the main gallery

FIT

What does this place allow us to do?

- sand, which is easy to dig, would allow ground-source heat pump (not used in this design)
- low vegetation (sand dunes) allows exposure to sun

What does this place help us to do?

- sea breezes helps to use passive, natural ventilation sometimes
- sunlight helps to generate power at the building on
- sunlight and regular rain could help grow a garden and hardwood trees

What does this place require us to do?

- habitat for small animals and birds is able to continue only if buildings are kept small and low

BALANCE

Can a natural system gain, by satisfying a human desire, here?

- the potential to enjoy a rare combination - a beach, a harbour for small pleasure boats, and an urban scene (restaurants, art galleries, etc.) brings people repeatedly to this place for extended vacations; a sense of "ownership" may translate to preservation of the existing pattern of settlement, which has been reasonably stable for 400 years; yet there is a risk of overly intense development and sprawl

NATURAL SOLUTION

How durable, adaptable, replicable, and fecund is the design?

- very durable enclosure, interior somewhat adaptable/flexible for other assembly-type uses
- exterior elements replicable, if a similar context were the challenge, approach and result very fecund esp. for visiting designers

SOCIAL BENEFIT

Is it good for the community?

- yes, very - puts P-town on the national map of significant art institutions; and supports local art programs of all sorts

INPUT PER OUTPUT

Are the inputs low, for a given unit of output?

- energy inputs are low-mid range for the use (see diagram, right)
- capital cost inputs 15% higher than avg. for town hall at the time

CONDITIONS OF SUSTAINABILITY

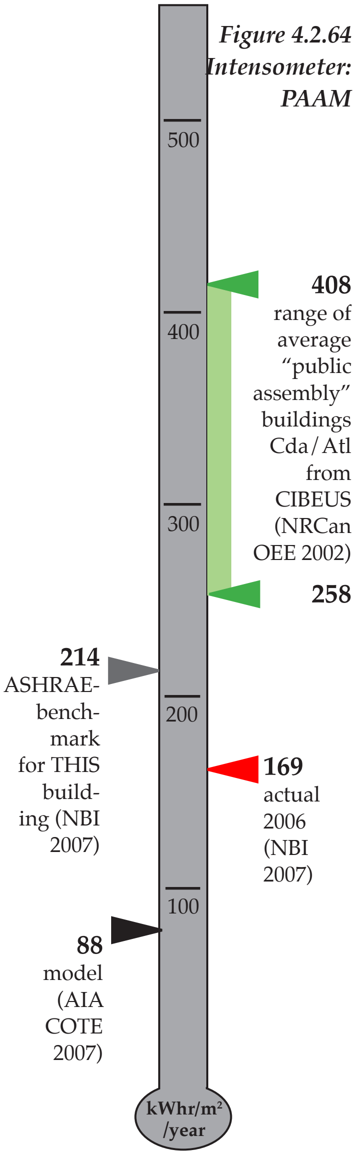


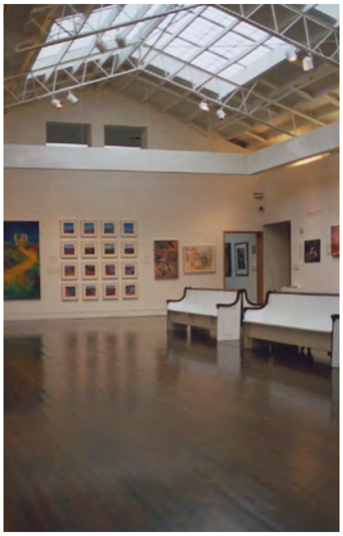
Figure 4.2.64
Intensometer:
PAAM

PAAM

CONDITIONS OF EFFECTIVE DESIGN

Figure 4.2.65 MEANINGFUL

Figure 4.2.66 ENJOYABLE



MEANINGFUL

What is the strongest message of the design?
To neighbours and visitors it says "this place belongs in the big leagues, with respect to contemporary art". To employees, the design says "there is a vibrant future, here".

Does the design express belonging to the local community?
Yes, clearly. Local motifs appear in a contemporary interpretation, e.g.: cedar shingle siding, board-form concrete wall, and glass "belvederes". This invokes the feel of the beach and of traditional building on Cape Cod - yet the form of the elements clearly is of the 21st century.

Does it imply renewed community vitality?
Yes, clearly. The site is in an anchor position, at the east end of the commercial/gallery district (further east is mainly residential). The design affirms a point of interest at this location.

Does it say "welcome" and/or express stability and sound governance?
Yes, clearly. The public spaces outside the galleries welcome passersby. They are conducive to casual occupancy, such as a pause, while walking the dog (see Figure 4.2.65). The design is not overly ostentatious, but it does display discerning care in every detail.

Is there a future vision - about humanity & nature - implied by this design?
Yes, clearly. The distinctly contemporary character of the design suggests a new era, for this long-established institution. Also, new climate control systems hopefully will allow PAAM to borrow significant art from other galleries.

ENJOYABLE

Does the design suggest that the owners care for the health of occupants?
Yes, to a degree. This building type offers limited opportunities for such an expression. Beyond meeting basic expectations (keeping the rain out, and providing fresh air), care for occupant health is not overt.

Is it comfortable? (thermally, acoustically, visually)
Yes, to a degree. Some staff complain that the building is too cold. In a commissioning report (Oct 2006) several ongoing challenges with temperature and humidity control are noted. The custodian has proposed to abandon automatic control of "natural ventilation" and to operate fans manually (suggests the systems interfaces or the controls are performing very poorly). Acoustic comfort is not a significant issue. The level and quality of light in all galleries is very good (see Figure 4.2.66), and daylight sensors are reported to be working as designed.

Does the space planning work superbly?
Yes, clearly. The new galleries, although small, afford a degree of flexibility in configuration, using relocatable partitions. During a special event (e.g. an exhibition opening), the glazed doors facing the street may be opened fully, making practical use of both indoor and outdoor space (see Figure 4.2.60). Circulation through exhibit spaces is simple, obvious, and free of dead-ends. And one potential conflict is well-re-

solved; students in art classes have access to the studios, via a dedicated entry so as to avoid disturbing patrons in the galleries.

Does the design lift the spirit?
Yes, clearly. Comments in the visitors' log include: "beautiful building ... bumps P-town up a notch!"; "the weather was hot, so we came into this cool space filled with fabulous art - great way to loose the day".

BEAUTIFUL
Does the design extensively employ daylight?
Yes, clearly. In the largest gallery insulated fibreglass panels in the roof provide ample, diffuse natural light (see Figure 4.2.66).

Are materials, lighting and space arranged in a way that is interesting, appealing, and memorable?
Yes, clearly. There are six galleries - of various size and proportion.

Is the design a strong exemplar of the sensibilities prevailing at the place and time in which it was created?
Yes, clearly. Treatment of public space is noted above. Contrast of surface textures is extensive - in the rough/smooth of the wood/large panes of glass. "Out-of-scale" elements include the belvederes and shingles (see Figure 4.2.67). Custom wood windows and cladding are handcrafted. Some have criticized the treatment of the historic house, suggesting that the its front "stoop" might have been better used.

CLEVER
Is unusual technology - emerging or re-emerging - applied in this design?
No, not really. There is heat-recovery, and sophisticated electronic controls. A nominal amount of PV is installed on the roof.

Do technical strategies drive the form?
No, not really.

Does the design attain a measurable superlative (e.g. biggest, most, first ...)?
Yes, clearly. This project is the first LEED-certified museum in the U.S.

Are the key design strategies well integrated with one another?
Yes, to a degree - e.g. vents, sunshades at front entry (see Figure 4.2.68).

SUMMATION
This project is very strong, particularly in meaning and beauty. It appeals to educated, affluent vacationers. Very slight weaknesses appear with respect to thermal comfort, operation of climate control systems (complex) and exposure of large glass elements to high winds.

The design approach - rather than the specific tactics - could be applied to a civic building in Great Lakes Basin. The re-interpretation of traditional local elements (in a contemporary idiom), the use of sound urban planning principles, and the integration of a better-than-average enclosure - could help realize comparable level of design excellence, in another place and time, using a different architectural vocabulary.

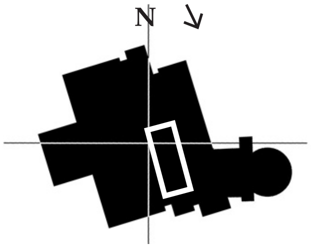
CONDITIONS OF EFFECTIVE DESIGN

Figure 4.2.67 BEAUTIFUL

Figure 4.2.68 CLEVER

GTA - Police Station (Administration)
#4 District, Vaughan

Fig. 4.2.69 Northeast facade
Fig. 4.2.70 Orientation



Relevance
Climate: Cool-humid Grt. Lakes

Site Context:
flanks an arterial road that serves a new residential suburb with little accommodation for pedestrians; all transport is high-speed automotive; neighbour is regional Works yard

Project Goals:
Accommodate police personnel serving local neighbourhood plus regional training centre; establish known presence in community; welcome visitors.

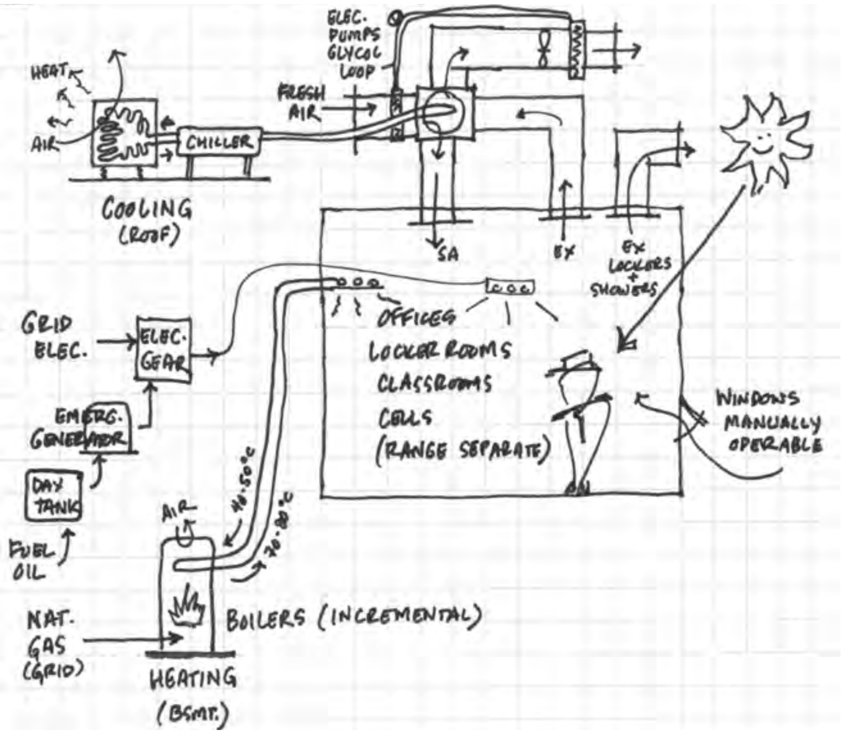
Density: SUBURBAN
FloorArea: 45,995 sf
Occupied: 1996
Capital Cost: $5,800,000

Awards:
... n/a

Image credits:
images B.M. Ross

Context, Form & Orientation
Height: 2 storeys + basement
Plan Aspect: 1: 1.31 *Facade:GFA* 1: 2.97 *Surface (incl. roof):GFA* 1: 1.30
Form driven by: functional program, arterial road access

Enclosure
Walls: brick on block cavity wall w/3" polyiso insul.
Windows: double-glazed in aluminum frames; Al curtainwall
Roof: BUR on 3" polyisocyanurate
Window-wall ratios: *o/a* 26%; *north* 37%; *east* 25%; *south* 31%; *west* 14%
Daylight: skylit atrium is main circulation space



Notes:

Figure 4.2.71 Climate control systems

Figure 4.2.72
Looking east, through the secure police atrium

MEANINGFUL
The strongest message of this design is that an essential public service is present and available. To a degree, the design expresses “belonging” to the community, though it must appeal to drivers moving along arterial roads at highway speed. Its “belonging” is to a regional, not a local, identity - and it succeeds in being recognizable as one of five similar buildings within an hour’s drive. The front facade is welcoming: open, easy to see and reach, and adorned with the symbols of local civic agencies (see Figure 4.2.69). The expression of a future vision about the environment was not among the many objectives of this project.

ENJOYABLE
The design suggests care and consideration for occupants, to several groups with diverse needs, including: victims approaching the front desk for help, community groups that use meeting rooms, staff who work in various specialized units, the press, as well as detainees. Detailing and very careful space planning, that works superbly and is somewhat flexible, are the primary means of achieving this. Acoustic separation was a priority during design, and its effectiveness has been proven during occupancy. The anecdotal reports of police officers are that “we love going to work in that building”.

BEAUTIFUL
The design employs daylight extensively - from windows at the end of every corridor to the skylit atrium (see Figure 4.2.72). Circulation from the atrium to the perimeter is simple, giving good sense of orientation at all times. Materials are chosen primarily for durability; detailing is not particularly “contemporary” but it is highly resolved. Overall, the design is a slightly-above-average exemplar of civic buildings in the GTA at the time.

CLEVER
Radiant heating was unusual in 1994 when this project was designed; otherwise technical strategies do not have a major influence on form.

NATURAL
That the design is durable and replicable is proven by its predecessors and successors; the “type” has been adapted 7 types by the architect, for 3 different clients. Effluents are controlled to prevailing standards, but otherwise Its relationship to the natural systems around it is scant.

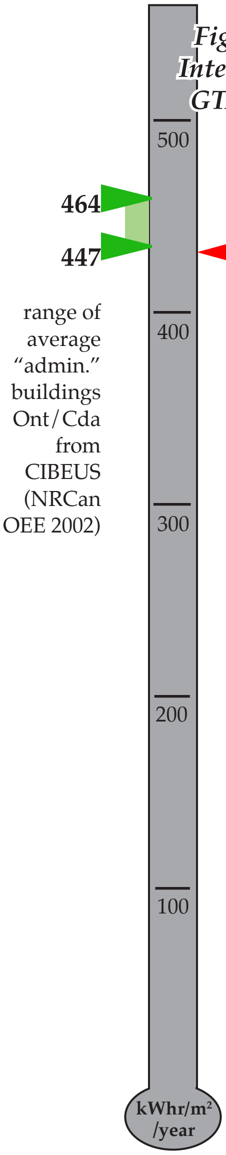
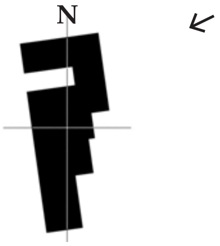


Figure 4.2.73
Intensometer:
GTA - Police

GTA - SAC (Public Assembly)
University of Waterloo
School of Architecture, Cambridge

Fig. 4.2.74 Northeast facade
Fig. 4.2.75 Orientation



Context, Form & Orientation
Height: 3 storeys
Plan Aspect: 1: 2.34 *Facade:GFA* 1: 1.76 *Surface (incl. roof):GFA* 1: 1.09
Form driven by: adaptive re-use of former silk mill

Enclosure
Walls: solid brick masonry approx. 20” thick
Windows: double-glazed in aluminum frames; some operable
Roof: white PVC replaced 2009 w/3 ply BUR on 3” styrofoam
Window-wall ratios: o/a 39% ; *north* 36%; *east* 45% ; *south* 36%; *west* 43%
Daylight: ample in studios, library, Loft; light shelves in offices

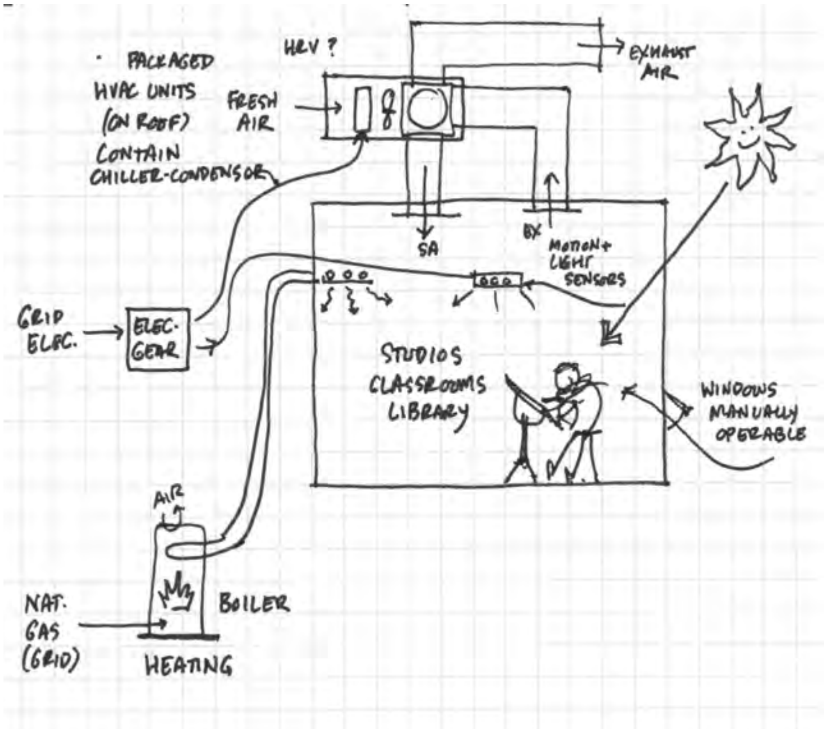
Relevance
Climate: Cool-humid Grt. Lakes

Site Context:
flanks the Grand River, at the centre of historic core of Galt; mixed use, mostly 3-storey buildings; 3 pre-1890 stone churches within one block;

Project Goals:
Accommodate the School of Architecture, revitilize the downtown core; provide stimulus to “town and gown” partnerships, e.g. Mayor’s Festival of the Arts, community garden, etc.
Density: URBAN
FloorArea: 72,946 sf
Occupied: 2005
Capital Cost: $8,500,000

Awards:
...OAA Award of Excell. 2008
...Canadian Urban Institute “Brownie”, 2005
... CWC “Woodworks”, 2005

Image credits:
Figures 4.2.75 & .77 Ben Rahn, A-frame



Notes:

Figure 4.2.76 Climate control systems

Figure 4.2.77
Looking west through the Loft

MEANINGFUL
The strongest message here is that "a solid historic structure now has a contemporary sizzle". The design could not make the building fit into its context more than it did, but it succeeds in making the historic centre of town more interesting, by accommodating new civic events, installations, and a public gallery and cafe. It is welcoming: the lights are on at all hours (see Figure 4.2.74), and there is a public path through main floor. If there is a future vision regarding ecology, however, it is mainly through the adaptive re-use essence of the project.

ENJOYABLE
Thermal comfort was erratic during years 1 and 2 and continues to be so during the summer. Acoustic exposure between adjacent spaces is somewhat challenging. Visual comfort is high, due to the even daylight in studios and teaching spaces. The space planning works superbly due to straightforward circulation, and views outward that sustain orientation. Many spaces are flexible (see Figure 4.2.77). Inside and out, the design lifts the spirit - every opportunity has been taken to provide ways to appreciate the river, as well as views to & from the town.

BEAUTIFUL
Daylight was available in the original building for the purpose of illuminating the mill processes; now it serves the design studios. Contemporary sensibility is introduced through the juxtaposition of hard clean new materials, such as black steel and glass, with rougher historic textures, such as wood and brick.

CLEVER
Other than radiant heating, motion detectors on lighting, and good quality windows, the technology is not particularly unusual.

NATURAL
This place needs the river to rise and fall; the ground floor might have been more clearly suited to this, albeit rare, possibility. Durability and adaptability is proven through the adaptive re-use. The design approach is replicable, and applicable to another former mill building. The project has been very good for the community - public spaces adjacent and inside are animated, and the growing sense of vitality is recorded in the local news. Figure 4.2.78 shows that inputs are low for an assembly building and near-average for an education building.

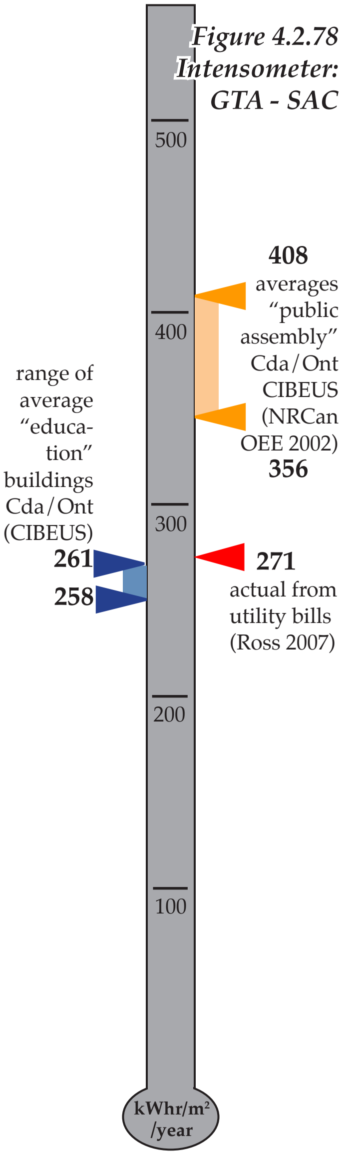
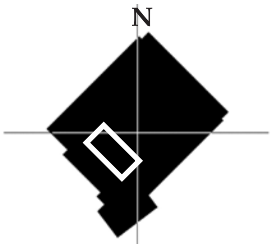


Figure 4.2.78
Intensometer:
GTA - SAC

"default" design

GTA - School
Claireville Elementary, Brampton

Fig. 4.2.79 Southeast facade
Fig. 4.2.80 Orientation



Relevance
Climate: Cool-humid Grt. Lakes

Site Context:
flat site at edge of new development, surrounded by new houses; 1 km. from conservation area and 3 km. from active farmland

Project Goals:
repeat a proven design in a quickly growing region and accommodate the functional program in accordance with the provincial funding formula

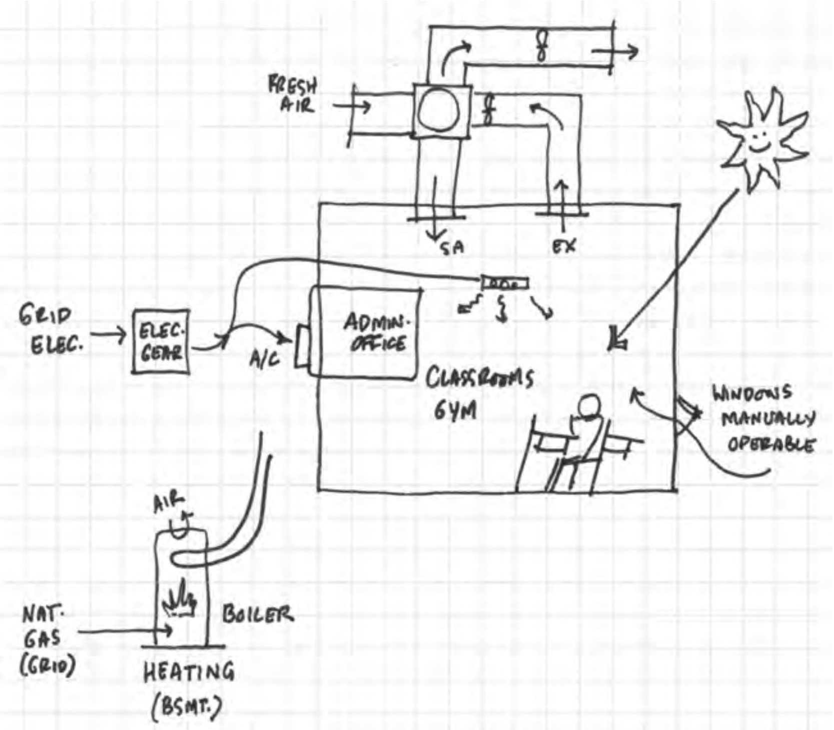
Density: SUBURBAN
FloorArea: 61,773 sf
Occupied: 2007
Capital Cost: $7,700,000

Awards:
...n/a

Image credits:
Figure 4.2.79 C. Echlin

Context, Form & Orientation
Height: 2 storeys + basement
Plan Aspect: 1: 1.21 *Facade:GFA* 1: 3.71 *Surface (incl. roof):GFA* 1: 1.30
Form driven by: functional program; optimized structure, most efficient net-to-gross floor area

Enclosure
Walls: brick on block cavity wall
Windows: double-glazed in aluminum frames
Roof: BUR on 2" polyisocyanurate insulation
Window-wall ratios: o/a 26% ; *north* 26%; *east* 9% ; *south* 28% ; *west* 42%
Daylight: skylight atrium near front entry



Notes:

Figure 4.2.81 Climate control systems

MEANINGFUL

As in GTA-Police, the strongest message of this design is that an essential public service is present. A sense of belonging the a particular community is not strongly conveyed; it is repeat design, situated in a new residential suburb with little character. However, a strong sense of “welcome” is achieved in the open front facade and prominent front door. There was no intent to embody a future vision regarding energy or ecology in the design.

ENJOYABLE

Care for occupants is evident in the detailing, which allows the building to be maintained as a “clean, well-lighted place”. Thermal, acoustic and visual comfort are good for the building type. Space planning is superb - there is a clear circulation path, around the gymnasium at the centre; visitors and children are well-oriented at all times. The design lifts the spirit, mainly by virtue of the skylit atrium.

BEAUTIFUL

Unlike many elementary schools, the design includes a skylit atrium, just inside the entry. Other than the very subtle free form in the plan at the entry corner, this is not a strong exemplar of contemporary sensibility - there is no contrast of surface textures, out-of-scale materials or handcraft - and no evidence of any attempt to relate spaces indoors to spaces outdoors.

CLEVER

The form of this building is driven by the program of spaces, which is a product of a tightly regulated formula. There is no unusual technology in the design; the integration of region-wide “standard systems” is the result of years of constructing and maintaining similar designs.

NATURAL

The durability and replicability of the design have been proven by the fact that it has been repeated so many times. Its clarity and simplicity make it quite adaptable - the enclosure and climate control systems easily could be upgraded to lower energy use with no sacrifice in the positive attributes noted above. As shown in Figure 4.2.83, the energy inputs are near the provincial and national averages for the output of usable floor area.

CONDITIONS OF SUSTAINABILITY

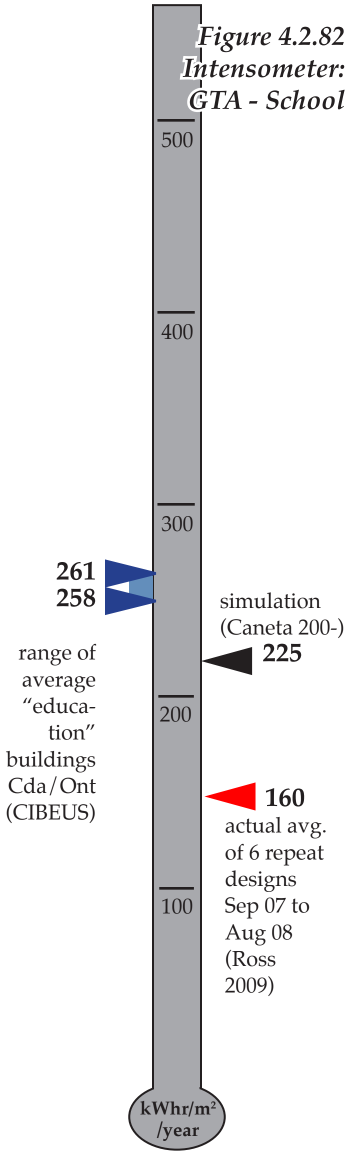


Figure 4.2.82 Intensometer: GTA - School

Quality in the "new normal" and "GTA default" designs

In the "new normal" buildings, the overall design quality is higher than in the "GTA defaults". At the same time, the energy-efficiency levels in the "new normal" buildings are exemplary, while levels in the GTA defaults are not far from national averages.

In general, the "GTA default" buildings are of more satisfying quality, in many respects, than are many other buildings of their type at the time of their design. Evidence of this is in anecdotal comments of building occupants to other architects, repeat work from the clients involved, the reflections noted here, in relation to the QDQ and, in one case, an Award of Excellence from a jury of architects.

The "new normal" designs compare very favourably to the "GTA defaults", communicating more focussed messages more emphatically, incorporating daylight and contemporary sensibility more thoroughly, integrating emerging technologies more often, and being more uniquely suited to their surroundings than the "GTA defaults". Only in relation to the questions in the "enjoyable" category do the two groups of buildings appear to be nearly equivalent. However, here, it is difficult to tell whether the "GTA defaults" perform more satisfactorily than the "new normal" designs, because there has been so little objective post occupancy evaluation of the buildings in either group.

Meaningfulness is present in the "GTA defaults". They are welcoming, and express community vitality, and sound governance. For instance, just by virtue of their function and position among other buildings, the GTA-School and GTA-Police station are recognizable as housing essential community services. The public entry, in all three cases, is emphasized, and public space is included inside the building. The GTA-SAC expresses community vitality even more emphatically by its design than the other two GTA defaults.

Meaningfulness is stronger in the "new normal" group than in the "GTA defaults", mainly in relation to the expression of belonging to the local community. The cedar shingles at PAAM, a contemporary twist on the Cape Cod vernacular, and the red siding at Wind NRG, a 21st-century version of the Vermont barn are examples of the devices used by the designers. At the same time, each of the seven "new normal" designs implies a future vision about energy or ecology - which the "GTA defaults" do not. From the PV panels on the roof at the AJLC at Oberlin College to the sightlines between the garden and the worship space at St. Gabriel's Church, these buildings are all situated on a trajectory towards different ways of living in the future - ways that are "in and of" the surrounding natural systems. The "new normal" designs also express renewed community vitality. For instance, SAS Institute Canada and Artists for Humanity, just by being situated where they are, breath life into forgotten corners of Toronto and Boston.

Enjoyability in all of the “GTA default” designs is strong with respect to obvious care for occupant needs, acoustic comfort, superb space planning. Students in the GTA-School and officers who work in the GTA-Police report that the architecture lifts their spirits, and that they to look forward to entering the buildings. The GTA-SAC goes further, by design, lifting the spirits of neighbours as well as occupants through its deft expression of new life in an old building.

Enjoyability is at least as strong in the “new normal” designs as it is in the “GTA defaults”, although the emphasis is somewhat different. The sense of calm at St. Gabriel’s, the fresh air at Wind NRG, and the local control of ventilation and ergonomic workstations at SAS all communicate care for the occupant. Thermal, acoustic and visual comfort are reported as generally satisfactory at the Gilman Ordway Building, Wind NRG, and SAS. Space planning at SAS, Wind NRG and PAAM may be described as not just satifactory but quite clever. The visitors who responded to the design at SAS by asking where to apply for a job, who commented enthusiastically in the logbook, about the design at PAAM, who went to Wind NRG for an hour and spent an entire, thoroughly enjoyable full day, and who found in Artists for Humanity a strong sense of “yes you can” have all testified to the power of these designs to lift the spirit.

However, some discomfort, flaws in space planning, and disappointing lack of spirit are reported, in relation to the “new normal” designs. Uneven temperatures are reported at the AJLC at Oberlin, a wide temperature gradient at Artists for Humanity, hot, humid and still conditions in summer at Wind NRG, and persistent problems with temperature and humidity control at PAAM. Space planning efforts failed to accommodate all user needs at the AJLC at Oberlin, where the soils lab is situated in an adapted house next-door. At the Gilman Ordway Building, space allocation in the renovated house is poorly defined, and some spaces in the addition, such as the lab and fan room, are situated contrary to the owner’s wishes. The architectural treatment of the historic portions of the Gilman Ordway Building and PAAM has left some quite disappointed, while the “against all odds” spirit at the AJLC at Oberlin lowers, rather than lifts, the spirit. In short, the “new normal” buildings are far from perfect.

Beauty is measured first, in the QDQ, by the amount and quality of natural light in a design. Here, the “GTA defaults” register well, with the GTA-Police and GTA-School both incorporating a skylit atrium, as well as light into, and view out of corridors. The design at GTA-SAC benefits from an existing building that was always intended to allow ample daylight deep into each floor area, and this attribute was respected in the renovation.

Daylight is celebrated and enhanced in the "new normal" designs with greater creative flair than in the "GTA defaults". The sense of the earth turning on its axis, brought into the worship space at St. Gabriel's is a unique experience. The atrium at SAS, in the upper floors and embellished with a terrace is a surprise. And the introduction of high-level light, and light from many directions is one thing that distinguishes the work of William McDonough + Partners Architects, at both the AJLC at Oberlin and the Gilman Ordway Building; occupants of both commented that the designers "really got that right".

Beauty is also gauged, in the QDQ, by the use of particular devices that characterize today's contemporary sensibility. The "GTA default" designs are somewhat weak in this regard. Small free-forms are evident at the front corners of the GTA-School and the GTA-Police Station. A more thorough exposition can be seen at GTA-SAC in the juxtaposition of new, machined materials with the rougher, original brick and wood.

The "new normal" designs invest more often in contrasting surface textures, free forms, and handcraft. All but the Gilman Ordway Building have an indoor space that relates to an outdoor space.

Cleverness is evident in the "GTA defaults", to some degree, and in the "new normal" cases to a greater degree, where the list of new technologies is longer, and integrative thinking is more strongly evident.

With respect to the "Naturalness" questions, the "GTA default" designs register reasonably well in relation to the latter three questions - durability and replicability, contribution to community, and inputs per unit of output. However, these designers do not seem to have asked the first two questions, regarding what the place needs, allows and helps them to do, or whether a natural system could potentially gain, as a result of a design decision. The "new normal" cases are also durable and adaptable, and good for the community. Their replicability is somewhat lower, because they are so uniquely fit to their locations. In contrast to the "GTA default" cases, the inputs (energy use) per output (usable floor area) are dramatically reduced in the "new normal" cases.

The designers of every one of the “new normal” buildings seemed to be asking the first two naturalness questions. When protecting the watershed from sudden run-off (at St. Gabriel’s and SAS), re-introducing or preserving the habitats of non-human species (at St. Gabriel’s, the AJLC at Oberlin, and PAAM), and reminding local cultures about nature (at St. Gabriel’s, the AJLC and Artists), the designers were asking “what does this place need us to do?” The places allowed the designers to harvest rain, at St. Gabriel’s and SAS. And the places helped the designers to set examples for others at four of the buildings, and even to grow edible produce (at the AJLC).

While the “GTA defaults” communicate meaning, accommodate people comfortably, and employ natural light, the “new normal” designs go further in all three areas. They also show evidence of an added facet of creative thinking, in relation to the “naturalness” questions. More post-occupancy review is needed to determine whether challenge in the new normal building with respect to comfort are truly more severe than in the “GTA default” buildings.

Avoiding numerical scores when discussing design quality

It may be tempting to rank the projects according to how many “Yes, clearly” and “No, not really” answers each earned, in relation to the QDQ. However, any declaration of one project as less successful than another, as if that could be measured on a uni-valent scale, is resisted, here. The “complexity and contradiction” that emerges while reflecting, in a qualitative way, on the twenty-one qualitative questions, is far more interesting, and should prove more useful in future design practice.

Each case presented a distinct set of challenges to its architect. Various hurdles that were present in some of the case studies – and not others – are reflected in Figure 4.2.84 (overleaf). If one were to “score” success in the most challenging context, as if it were equivalent to success in the least challenging context, the result would neither be accurate, nor particularly useful. At worst, it might even shift attention away from important achievements in the more challenging circumstances.

Diversity of purpose

Looking at the facts page of each appraisal and the first “meaningfulness” question (“what is the strongest message of the design?”), one can see a wide gamut of goals and priorities, among the cases. While St. Gabriel’s Church says “behold the mystery and wonder of cre-

Figure 4.2.83
The relative difficulty of the design challenges

(for image credits, see Figures 4.2.1 through 4.2.83)

	St. Gabriel's	SAS	AJLC	Wind NRG	Artists	Gil. Ordway	PAAM	Police	SAC	Elem'y
owner flexibility as to materials and systems	◐	◐	◐	◐	○	◐	○	◐	◐	◐
complexity of functional program	●	◐	◐	●	○	◐	○	●	◐	◐
need to consult with many stakeholder groups	◐	○	●	◐	○	●	◐	◐	○	○
intention to satisfy LEED as the "green" standard	●	●	○	●	●	○	●	○	○	○
location is time-consuming to reach for a/e team	○	○	◐	○	○	●	●	○	○	○
physical constraints/fewer options on site	◐	●	◐	○	●	◐	●	○	●	○
historic building to be preserved	○	○	○	○	○	●	●	○	●	○
difficulty 1 (least) to 7 (most):	**5**	**2**	**3**	**4**	**1**	**7**	**6**	**GTA**	**GTA**	**GTA**

Legend:

● most challenging

◐ moderately challenging

○ less challenging

ation", PAAM says "this place is in the big leagues of contemporary art". The message about the "importance of employee comfort and wellness", so evident in the designs of SAS and Wind NRG, is widely applicable, and is growing in popularity, especially within the electronic-technology sector. On and off the "green building" rosters, many of today's high-tech businesses aim to have their buildings signal such a concern. In contrast, the message that "a new relationship between humankind and nature is in order", expressed at the AJLC at Oberlin, is not so readily applied to a diverse clientele.

Not every message is equally applicable in all circumstances. To treat the main message in any project as if it were equivalent to the message in all of the others, or to try to weigh one message against another, would neither be fair nor accurate. With respect to the AJLC at Oberlin case, it is possible, even if the probability is debatable, to imagine every Faculty of Environmental Studies in North America wanting to communicate the message that "a new relationship between humankind and nature is in order". Further, it is possible, though even less likely, that every one might choose to use its building as the vehicle for conveying such a message to its community. However, not all building committees in all Colleges will be sympathetic to the didactic program established at the AJLC. A School of Philosophy might be quite reluctant to adopt such a statement as its primary message. And a School of Agricultural Sciences, even if it adopted the message, might take issue with the way it is conveyed at Oberlin. In a similar way, the message of St. Gabriel's – that worship must include the contemplation of natural systems – may not be adopted widely by all religious orders, let alone more secular agencies.

Nevertheless, each of these messages was chosen by the project participants as the thing they wished to work towards. This discussion is about whether the message is conveyed successfully, not about the relative merit of choosing to convey it. If an analysis of design quality were to conclude that a building such as the AJLC at Oberlin is more (or less) successful than one such as Wind NRG – because the message is more provocative, urgent, spiritual or fundamental – then the analysis would be tainted by an extraneous value judgment. It is difficult to imagine the utility of such a judgment, toward answering the research question, or in future design practice.

Therefore, a steadfast resistance to the temptation to "tally a score" has, in this instance, proven to be an appropriate approach. This realization also reinforces the discussion of the issues that arise with green building rating systems, some of which use numbers to try to "score" design quality (see Section 3.4). The rich detail that has emerged from this qualitative analysis has proven far more interesting.

The importance of location in the "new normal" cases

Various design approaches define the seven cases; this is evident in the array of building forms, facade materials, window types, climate-control systems, and other elements.

Yet certain tendencies commonly appear. In all of the projects, there is an emphasis on the thermal resistance of the enclosure (keeping the heat in), a restriction on the overall window-to-wall ratio, and a recurring intense interest in the qualities of natural light.

A clear link is evident - between understanding climate and place and the conditions of sustainability. The researcher's understanding of each place is recorded in the descriptive essays, written in reflection of each road trip. None of the five "Naturalness" questions could have been answered without having that experience.

This link also is evident when it comes to the cold, hard facts about annual energy use. These cases show that links between energy-efficiency and design quality may be made in urban settings, as well as "back on the land". In some of the designs, there is an obvious concern for the restoration of animal habitats - particularly for birds and small animals (e.g. St. Gabriel's garden, and the AJLC's mini-wetland). In others, there is a corresponding concern for the restoration of human habitats (e.g. the re-invigoration of post-industrial urban neighbourhoods at SAS and Artists for Humanity) - or for the restoration of historic building fabric (at both of the buildings on Cape Cod).

An urban ecology affords a different mix of opportunities and restrictions that a rural ecology. In some cases, the shade offered by neighbouring buildings is beneficial, as at SAS. However, noise and airborne pollution in a downtown core may prevent the designers from even considering strategies such as natural ventilation. The harvest of rainfall, and the management of the heat-island effect are particularly prevalent in the urban projects.

The architects used their understanding of climate and place to convey various messages, create comfort, feed human aesthetic sensibilities, and demonstrate their cleverness.

Applicability

All of the buildings here were designed to be in occupied service for at least 20-30 years. Only the AJLC at Oberlin was intended to be a "living lab", where change-outs of equipment might have a didactic purpose. In very general terms, the design approaches in the "new normal" cases do not depart from those commonly seen in civic buildings in North America. For instance, sound urban planning principles are at work at PAAM, the AJLC at Oberlin, SAS, and Artists for Humanity. Also, careful functional planning is at the essence of the AJLC, PAAM, and St. Gabriel's Church. No great provocative formal shocks are made in the "new normal" designs; there are no blobs, crystals, treehouses or arks. Therefore, it may be said that the attitudes of the architects working in the new normal cases is close enough to that of the architects of the "GTA default" cases that applying "low-load + high-satisfaction" strategies to GTA projects in the future is an entirely plausible scenario.

Contrary to expectations raised by previous case studies, the new normal cases rely on enclosure performance, architectural arrangement and efficient climate control systems - more than they do on a "kit of green parts". In the "new normal" designs, there is not much evidence of green roofs, recycled cladding, or average windows. What is evident are: abundant daylight, locally meaningful cladding, carefully detailed, thermally resistive enclosures (including very high-quality windows), atria, and landscapes that link interior spaces and exterior spaces while supporting the climate control systems.

Rather than simply specifying components marketed as "green", an architect wishing to move toward the "new normal" could start from this short list of strategies. While may be "less flashy", these things will result in a building that is both lower-load and higher-satisfaction. A discussion of the capital cost implications in contained in Section 4.7. Synergies and risks when strategies to lower load and design approaches to heighten satisfaction are discussed in Section 4.6.

Reflections on the Questions of Design Quality (QDQ)

The newly-framed statement of expectations worked well, when applied to the case study buildings. However, three interesting challenges arose. First, the questions in the "Natural" category (testing Fit, Balance, Natural Solution, Social Benefit, and Input per Output) are rather more difficult to answer than the questions under the categories "Meaningful, Enjoyable, Beautiful and Clever". In particular, the question "what does this place need us to do?" might well be answered "nothing!" Yet, one must assume that a building will be constructed, whether or not it is beneficial to natural systems. Also, any answer to the question “how durable is the design?” will be highly speculative. Only time will tell. Setting these challenges aside, the answers to the questions in the “Natural” category flowed most easily for St. Gabriel’s and the AJLC at Oberlin. Perhaps this is because these are the works of client-architect teams that have adopted a philosophical attitude of trying to view human work from a natural-systems vantage point.

Also, there is a problem with the question “does the design attain a measurable superlative?” Given the richly varied successes of these case studies, the question, in application, seemed a little silly. Perhaps, in future, it should be shifted to a simple “point of information”, rather than a part of the “gauge” of design quality.

A question to add to the QDQ would be something like “is the design free of superfluous (or gratuitous) elements?” The question occurred on visiting the MIT Chapel by Eero Saarinen, immediately after seeing Artists for Humanity. Both are successful designs, but Saarinen imbues every material choice and every detail in the MIT Chapel with meaning - there is nothing left to take out. Artists for Humanity, for all of the simplicity of its design, seemed messy in comparison. Some elements (such as the windshield guardrails, and the curtainwall detailing) seemed over-worked and underwhelming; they could be deleted without great loss to the overall design. Similarly, some of the detailing at the AJLC at Oberlin (such as the exposed steel frame) had a certain tortured quality, relative to more cleanly detailed structures. Among the case studies, St. Gabriel’s Church stands out as the design that is “cleanest” in this regard. The designs of SAS and PAAM would share the position of a close second.

Otherwise, the twenty-one questions in the QDQ provided a useful framework for recording the responses of the researcher, and the building occupants, to each design. The consistent application of the questions established a strong foundation on which to build the comparative analysis, contained in these pages. A similar result may result from continuing to apply the questions to new cases.

4.3 USING THE INTENSOMETER TO GAUGE WHETHER A DESIGN IS "LOW-LOAD"

As explained in Chapters 2 and 3, registering the energy-intensity of a design on the Intensometer shows its performance relative to others, and to relevant averages. Only a low energy-intensity design leads to a building that is a low-level emitter of GHGs.

In Figures 4.3.2 through 4.3.4, the nineteen case study buildings are shown according to type of occupancy. As far as possible, actual data is used. Every "actual" entry includes all energy used in the building, regardless of source or destination - including any energy generated on site, as well as plug loads incurred by users' equipment. Any usage that is omitted in a "predicted" entry is not known, and likely varies with each case. *

On the Intensometer, average energy intensities for buildings of similar use are used as the primary reference. The data in the Canadian survey (CIBEUS) is drawn from a total of 137,039 buildings, with a total floor area of 3.2 billion square feet, constructed between 1920 and 1999. The averages from CIBEUS are relevant to this study because 40% of buildings and 50% of all floor area in that survey is between 10,000 and 99,999 sf. Also, 60% of the buildings and 58% of the floor area was constructed between 1960 and 1999. In the CIBEUS data set, 72% of the buildings and 82% of the floor area has double-glazed windows. The size of the data set, for the building types and geographic areas of interest here, is shown in Figure 4.3.1.

	Canada	**Ontario**	**Atlantic**	
Office	15,077	6,834	997	bldgs.
	620,696,308	347,519,970	12,635,860	sf
Admin	4,837	1,290	354	bldgs.
	222,982,482	(not pub'd)	8,775,609	sf
Public	9,570	3,198	645	bldgs.
	124,653,460	37,126,199	5,096,216	sf
Edu	11,508	4,764	831	bldgs.
	607,820,389	126,605,641	36,321,816	sf

Figure 4.3.1
Size of data set in CIBEUS

(NRCan OEE 2002)

In order to maintain fidelity with reports from actual end-use records (i.e. fuel bills) and because all entries are within a single climatic zone, the entries are not adjusted to a single location. †

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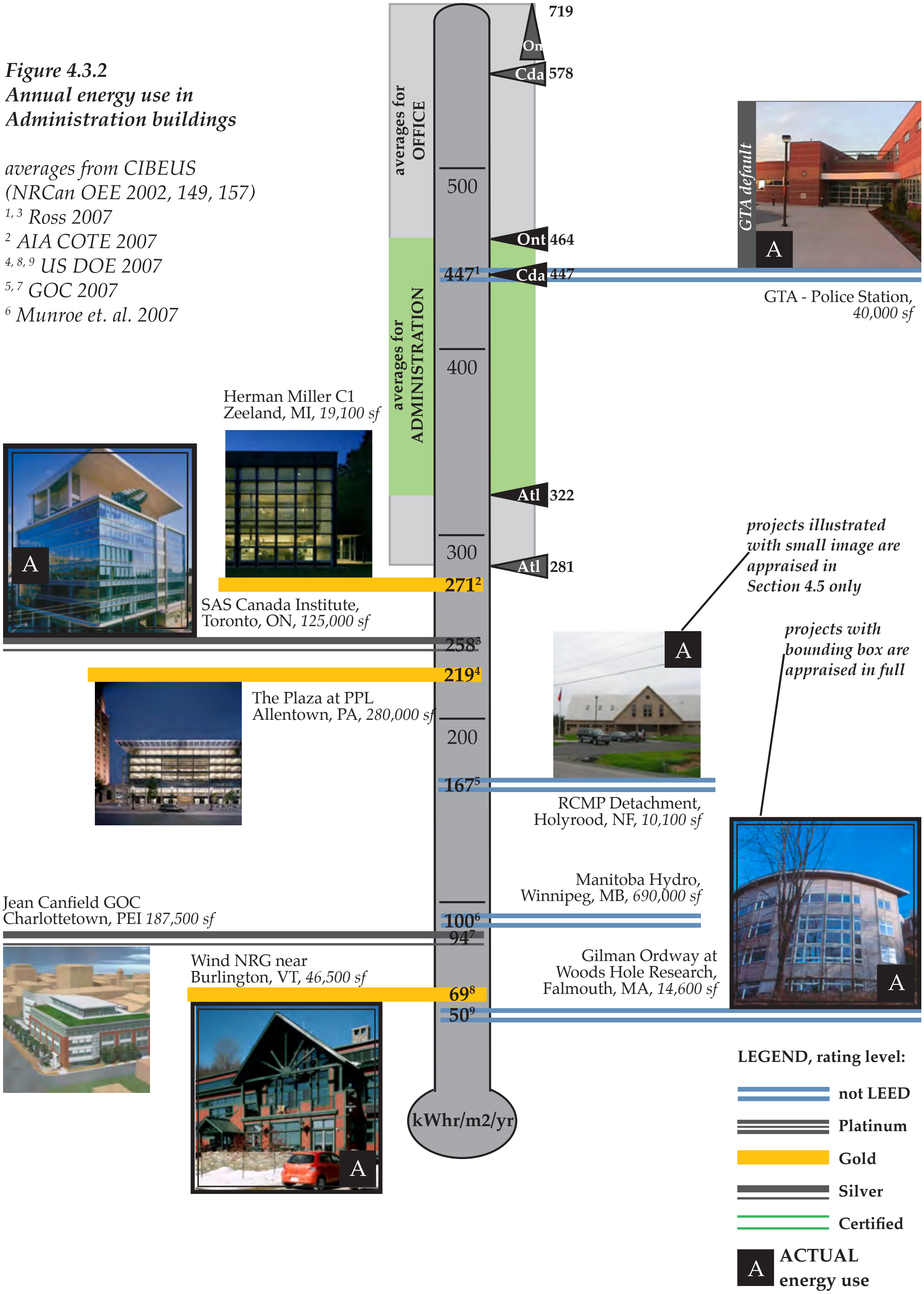
*In the detailed appraisals in Section 4.2, all of the cases showed a gap between the predicted and actual levels of energy use. In the course of this research, it was rare for the actual rate to be less than the prediction. In most cases, the actual ranged from 10% to 30% more than the prediction. One over-run of 90% was observed. This gap may have resulted from variable weather, longer operating hours, or unexpected inefficiency in the control systems, or some combination of all three factors. It is due in part to inaccuracies in the energy simulation models, as well.

† The most extreme example would be to adjust the building in Saskatoon to Toronto conditions, modifying heating and cooling energy only to reflect the difference in HDD and CDD. The resulting hypothetical energy use would be 220 kWhr/m^2/yr.

Figure 4.3.2
Annual energy use in
Administration buildings

averages from CIBEUS
(NRCan OEE 2002, 149, 157)
[1, 3] *Ross 2007*
[2] *AIA COTE 2007*
[4, 8, 9] *US DOE 2007*
[5, 7] *GOC 2007*
[6] *Munroe et. al. 2007*



Administration buildings

Figure 4.3.2 shows the cases designed for either public or private agencies whose primary activity is administrative work. The range of Canadian averages for "Administration" buildings (shown in green) sits highest on the intensity scale - well above "Public Assembly" and "Education" types. In an "Administration" building, a consistently medium-to-high level of occupancy is accommodated for long hours, during a typical week, and these buildings are used every week throughout the year.

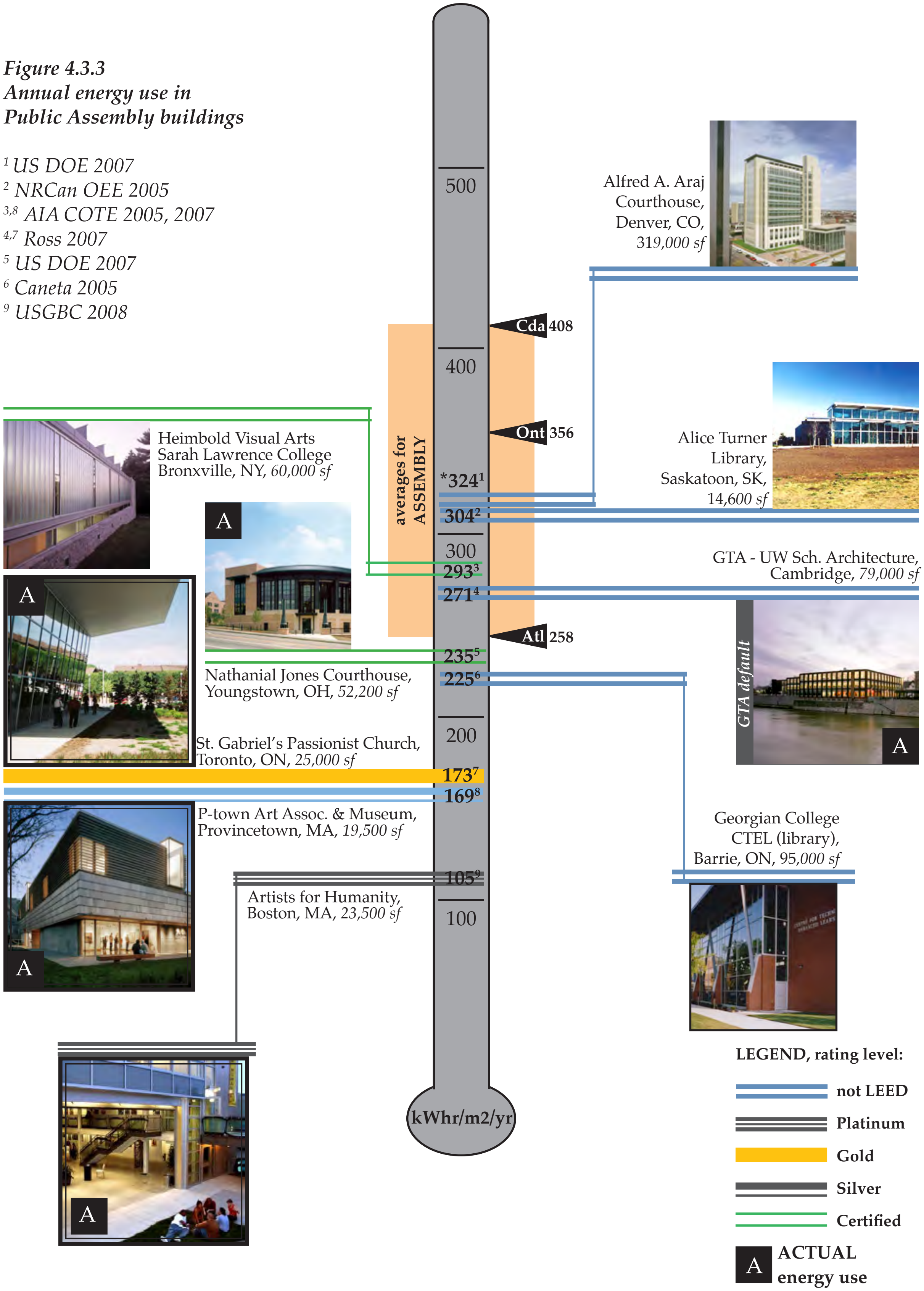
The CIBEUS data for "Administration" buildings is used in preference to the data for "Office" buildings, because the definition of the "Administration" category in CIBEUS is more relevant to the cases chosen here, and because the range is tighter (the range for "Office" buildings is shown in pale gray in Figure 4.3.2). According to the categories defined in CIBEUS, an "Administration" building accommodates: Crown corporations including public utilities, federal and provincial courthouses, police buildings, town halls, and the offices of religious organizations, trade unions and First Nations Bands. In contrast, the CIBEUS data for "Office" buildings includes: professional service offices, except medical offices, headquarters of banks and brokerage firms, corporate head offices and branch offices.

The first observation to make in each Intensometer is the gap between the least energy-intense case (here, Gilman Ordway) and the most relevant Canadian average (for Ordway, the Atlantic average, at 322 kWhr/m^2/yr). Another type of comparison is between two buildings of very similar use, such as RCMP Holyrood and GTA Police. In these two comparisons, the "new normal" building operates at 16% (Ordway) and 37% (RCMP Holyrood) of its comparator.

On this Intensometer, there are both LEED and non-LEED buildings registered at exceptionally low levels of energy-intensity. The LEED Gold buildings here operate at a broad range of energy-intensities; the lowest of the four LEED Gold buildings (Wind NRG) registering at 25% of the energy-intensity of the highest (Herman Miller C1). Both of these observations support the contention that LEED level does not correlate well with energy use.

Figure 4.3.3
Annual energy use in
Public Assembly buildings

[1] *US DOE 2007*
[2] *NRCan OEE 2005*
[3,8] *AIA COTE 2005, 2007*
[4,7] *Ross 2007*
[5] *US DOE 2007*
[6] *Caneta 2005*
[9] *USGBC 2008*



Public Assembly buildings

The CIBEUS data for "Public Assembly" buildings draws on: community and convention centres, auditoria and concert halls, libraries, museums and art galleries, places of public worship, train and bus stations and airline terminals. All of the sub-types within this category are subject to bursts of high occupancy, interspersed with periods of low occupancy. For example, in a church it is common, on a Saturday, for several weddings to be scheduled; in the art galleries, periodically, there is an evening of show openings; and, in the courthouses, there is the morning and noon-time rush to several courtrooms.

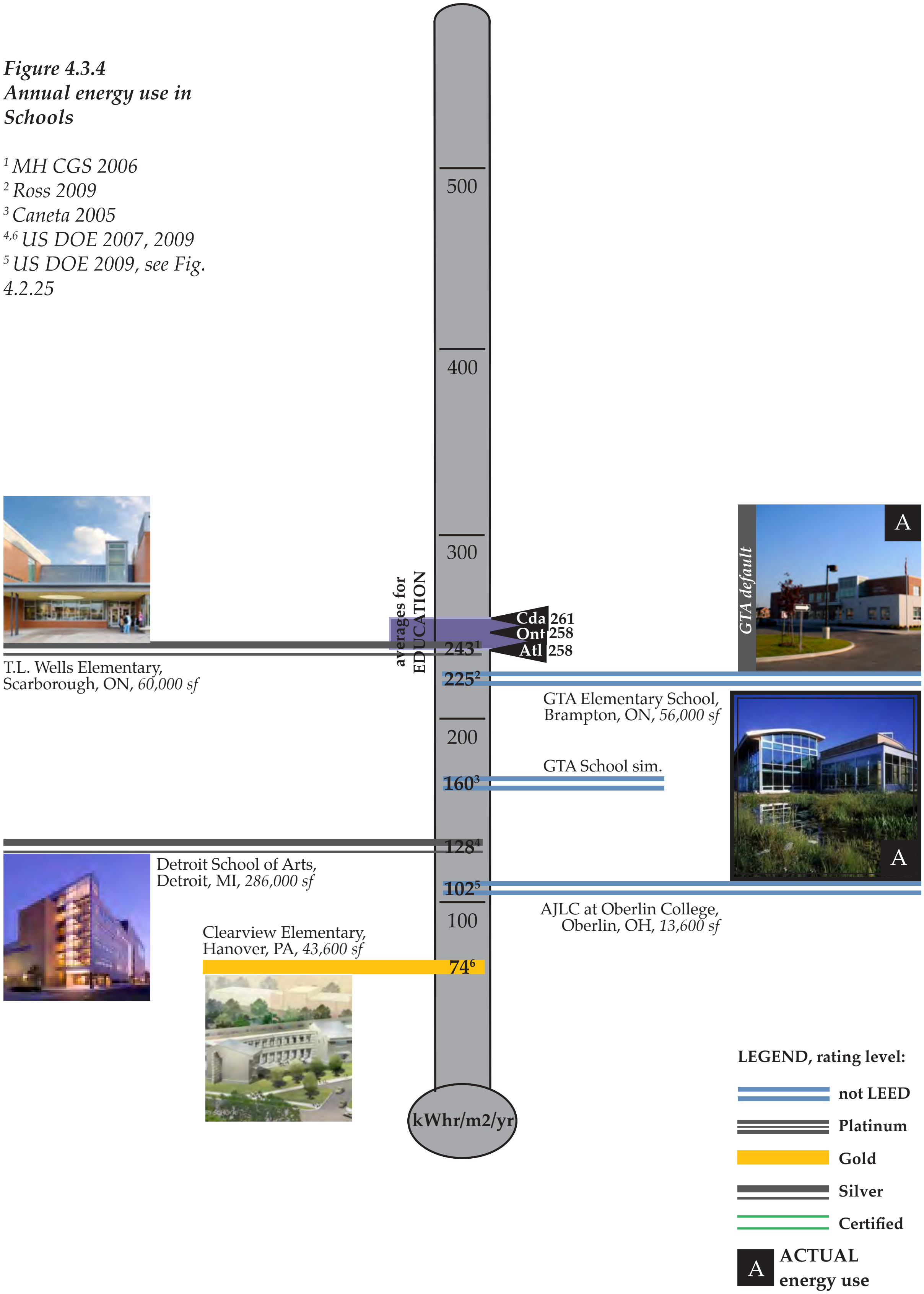
Figure 4.3.3 shows that the actual energy use at St. Gabriel's Church is 49% of the Ontario average for "Public Assembly" buildings. The least energy-intense building of this type (Artists for Humanity) operates at 41% of the Atlantic average.

The four LEED buildings on this Intensometer are arrayed in an order that seems nearly logical. The LEED Certified buildings (Heimbold and N. Jones Courthouse) are high on the scale, the LEED Platinum building (Artists for Humanity in Boston) is lowest on the scale, and the LEED Silver and Gold buildings are in between. If LEED level corresponded well to actual energy-intensity, then the positions of St. Gabriel's Church and PAAM would be reversed, and there would be more distance between the two. This is another example of the blurring of distinction between Gold and Silver levels, one of the weaknesses in LEED, that is discussed in Section 3.4.

Two non-LEED buildings in south-central Ontario show energy-intensities well below the average for the region. The Georgian College CTEL already noted; and the GTA SAC, for which an actual figure is given, taken in its second year of operation. Although not studied here, the Alfred A. Araj Courthouse and the Georgian College CTEL are registered to show a few more non-LEED projects that are, nonetheless, predicting levels of energy-intensity lower than the relevant averages for existing buildings, independently of any goal to attain a label as a "green building".

Figure 4.3.4 Annual energy use in Schools

[1] MH CGS 2006
[2] Ross 2009
[3] Caneta 2005
[4,6] US DOE 2007, 2009
[5] US DOE 2009, see Fig. 4.2.25



Schools

Figure 4.3.4 shows three LEED-labelled and two non-LEED education buildings. This category shows the tightest range of averages, across all regions in Canada. The schools surveyed probably are more closely comparable than the buildings in the other categories, with more consistent functional programs, and intensity of occupancy. Also, school construction in Ontario has been tightly regulated as to floor area, since the 1960s; and "industry standard" practice in specifying enclosure elements and mechanical systems has been quite consistent, since the 1980s. The performance of the GTA Elementary School (one of a large family of "repeat" designs), so close to the Ontario average, is testament to this point.

The CIBEUS data does draw on elementary and high schools as well as college and university buildings, pre-schools and daycares, and schools of art, dance, drama and music. Among university buildings, all types are included: academic buildings, gymnasia and stadia, libraries, student unions and administrative buildings.

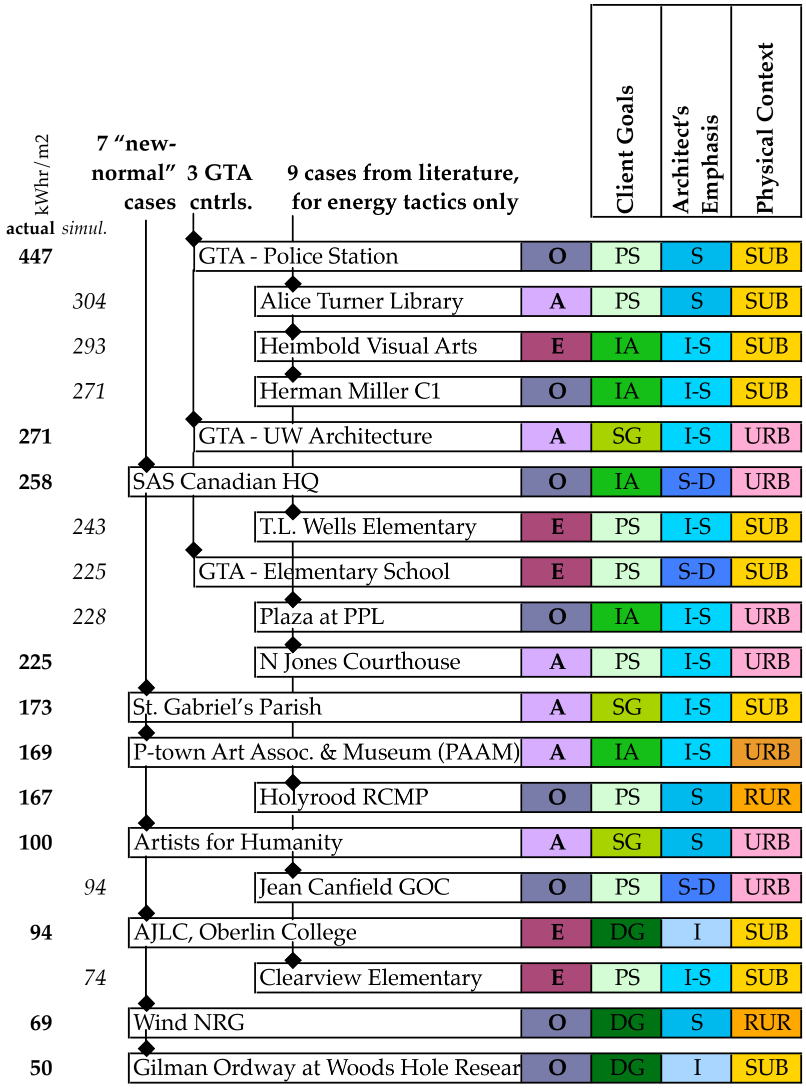
Figure 4.3.4 shows the degree to which the North American averages may be bettered by a "low load" designs. The three least energy-intense buildings use between 28% and 49% of the average. Two of these (DSA and the AJLC at Oberlin) are located in the heart of the Great Lakes Basin, just south of the Canada-U.S. border.

How much reduction is possible?

The three Intensometers show that it is possible to realize designs that use as little as 20% of the current average amount of energy. (That is, reductions of up to 80% are feasible.) A designer who wishes to realize a "low-load + high-satisfaction" architecture may be encouraged to know that this has really been accomplished in the designs so-far appraised as meaningful, enjoyable, beautiful and clever.

The Intensometers also show that deep reduction is feasible, with or without participation in the LEED program. They distinguish actual success from predictions, and they show that the level of certification of a LEED-labelled building is not a reliable indicator of its energy use, or of its greenhouse gas emissions.

Figure 4.4.1
Client disposition, architect’s emphasis, and physical context, in the case study buildings



kWhr/m2 actual	simul.	7 “new-normal” cases	3 GTA cntrls.	9 cases from literature, for energy tactics only			Client Goals	Architect’s Emphasis	Physical Context
447			◆		GTA - Police Station	**O**	PS	S	SUB
	304			◆	Alice Turner Library	**A**	PS	S	SUB
	293			◆	Heimbold Visual Arts	**E**	IA	I-S	SUB
	271			◆	Herman Miller C1	**O**	IA	I-S	SUB
271			◆		GTA - UW Architecture	**A**	SG	I-S	URB
258		◆			SAS Canadian HQ	**O**	IA	S-D	URB
	243			◆	T.L. Wells Elementary	**E**	PS	I-S	SUB
	225		◆		GTA - Elementary School	**E**	PS	S-D	SUB
	228			◆	Plaza at PPL	**O**	IA	I-S	URB
225				◆	N Jones Courthouse	**A**	PS	I-S	URB
173		◆			St. Gabriel’s Parish	**A**	SG	I-S	SUB
169		◆			P-town Art Assoc. & Museum (PAAM)	**A**	IA	I-S	URB
167				◆	Holyrood RCMP	**O**	PS	S	RUR
100		◆			Artists for Humanity	**A**	SG	S	URB
	94			◆	Jean Canfield GOC	**O**	PS	S-D	URB
94		◆			AJLC, Oberlin College	**E**	DG	I	SUB
	74			◆	Clearview Elementary	**E**	PS	I-S	SUB
69		◆			Wind NRG	**O**	DG	S	RUR
50		◆			Gilman Ordway at Woods Hole Resear	**O**	DG	I	SUB

Legend

Function:

O Admin. Office
A Public Assembly
E Education

Physical context:

URB Urban
SUB Sub-urban
RUR Rural

Client’s design driver:

DG Deep green
PS Public-service
SG Social agenda
IA Iconic architecture

Emphasis of Architect’s Practice:

I Idea
I-S Idea-Service
S Service
S-D Service-Delivery
D Delivery

4.4 CLIENT + ARCHITECT + CONTEXT - IS THERE AN "IDEAL"?

Before delving further into how success was achieved, note is taken here about who achieved it, and where.

The ambitions in these projects are high. In roughly half of the projects, energy-efficiency was an explicit goal. In all of the projects, other desirable design attributes - such as meaningfulness, superb functionality and visual appeal – were desired as well. The primary driver, from the client's perspective, the emphasis of the architectural practice, and the physical context of each project are categorized in Figure 4.4.1.

The Clients: from "deep green" to iconic architecture

According to the primary emphasis of its business, and how that has driven its approach to the design of its building, four categories of client are evident:

- "deep greens", whose raison d'etre involves an environmental concern,
- public agencies for whom green building is an "emerging policy",
- institutions whose "social priority" is most dominant, and
- clients for whom "iconic architecture" was the primary goal.

A"deep green" client is committed, in its essence, to an environmental concern. Woods Hole Research Center is the base of operations for scientists who study climate change. The AJLC Oberlin College was built for the Faculty of Environmental Studies. Wind NRG designs and assembles technology for the wind industry. All of these clients possess more than a desire to express a vague idea about "sustainability" in their projects. Their core values demand that, when they make a building, they "walk the walk", making real achievements, and that their customers and neighbours are made aware of their doing so.

The public-service institutions – such as school boards, agencies of the Crown, municipal police services and libraries - tend to have a broader mandate than the deep greens. This type of client may be experimenting with an emerging policy about green design. More importantly, the lowering of environmental loads is not fully integrated into the core business of this client type. The level of commitment of this group of institutions is important to study, because its members tend to hold large portfolios of buildings. Their experiments with "green" prototypes may lead to a roll-out in many additional projects. The key challenge for each of these public institutions is to learn how to lighten the load it imposes on natural systems, without lightening the support it provides to essential public services.

Another type of client puts its social priority first, but sees a synergy between that agenda, and a "green" agenda. One example is Artists for Humanity in Boston, which is a philanthropic agency that engages inner-city youth in art projects that are sold or displayed to corporate supporters. Another is St. Gabriel's Passionist Church, which is home to a Catholic parish that ascribes to the cosmology of the 20th century environmentalist Thomas Berry. This type may be as committed as the deep green, but has a mandate to guard its spending, favouring programs over bricks and mortar.

The fourth type of client puts a very high priority on iconic architecture. For instance, SAS Institute Canada wanted to be visible to its clientele, which is situated in the nearby financial core of Toronto. In a very different context, using a very different architectural language, the Provincetown Art Association & Museum also wanted its building to communicate its character to a defined clientele - at both the local and national level.

This typology of clients is a matter of primary emphasis; no client possesses only one of these attributes. However, the intentions of each type may help understand why each project attained the level of energy-efficiency that it did, and the relative importance of other goals.

The architect's primary emphasis: Idea, Service or Delivery

Research has found that several factors combine to characterize professional service firms, including architecture and engineering practices. The choices the firm emphasizes most often – such as services offered, type of client, ways of working, and staffing patterns - place a firm along a spectrum marked by three types (Maister 1986).

An idea firm offers its clients, who see themselves as patrons, new, perhaps contentious, ideas. In engineering, such firm may be Ph.D.-owned, and often works under research grants. In architecture, it may be either a “star-chitect” or a specialist - in subjects such as heritage preservation or sustainability. To keep its edge, this type of firm must remain flexible in scale, hiring the best and brightest graduates, but not necessarily assuming long-term loyalty. In an idea firm, all significant decisions remain in the hands of a select few “at the top”.

At the other end of the spectrum, is the efficiency expert, or delivery firm, which rarely innovates. Its clients value fast, reliable, cost-controlled services. In engineering, these firms are very large; in architecture, they may be large or small. Such a firm emphasizes routine production of known designs, and makes extensive use of standard details and procedures, as well as advanced computing technology. The staff includes a relatively high percentage of para-professionals, who are encouraged to remain, long-term, often through advantageous salary and benefits packages.

Between the extremes of idea and delivery, lies the service firm. This type of firm is structured to offer its clients reliable service on complex assignments. The architects in this type of firm share goals and values with their clients, developing very long-term relationships; they often have deep roots in their communities. The clients often expect to be involved, day-to-day, in the project. The buildings designed by a service firm rarely are on the cutting edge, but clients receive sage advice, gleaned through experience with many other clients in comparable situations.

The physical context: urban, suburban or rural

A variety of contexts is represented - within the seven case studies that were visited, and within the overall list. There are as many urban projects as suburban, and only two rural projects (see Figure 4.4.1).

In an urban setting, where there are the greatest physical constraints, the challenge of balancing “low-load + high-satisfaction” is expected to be most extreme. Lessons learned through the urban case studies may help address the research questions about the importance of building orientation, and whether limited options impede the potential for energy-efficiency on urban sites.

The combination that achieves the “new normal” most often

Figure 4.4.1 was examined to see whether any obvious correlations exist to help clients and architects to form effective collaborations, or to suggest what level of success is most probable in a given scenario.

The nineteen projects were initiated by a balance of client types: three deep greens, eight public service, three social agenda, and five iconic architecture types. The seven "new normal" cases that were fully appraised were created by three deep greens, two social agenda clients, two iconic architecture clients; public service clients were not represented in this group. As might be expected, the deep green clients achieved the lowest energy-intensity levels. The lowest six projects on the energy-intensity scale, all at under 100kWhr/m^2/yr, were driven mainly by deep greens (three), followed by public service (two) and social agenda (one) clients. The iconic architecture clients realized projects that are spread through the rest of the range of energy intensity. It looks as though public service clients, so far, are not demanding exemplary energy performance at the same rate as other types of clients, and that a client whose primary interest is iconic architecture is not so likely, as yet, to realize an extremely "low-load" building.

As far as the architectural firms are concerned, there seems to be little that distinguishes the "green" projects from the "GTA defaults". The majority (17/19) of the case study projects were designed by: pure service, idea-service, or service-delivery architectural firms. Firms emphasizing pure delivery are not represented. (Delivery firms are very reliable at producing contract documents for projects in which all factors are easily predicted. To date, attainment of "low-load + high satisfaction" architecture requires more innovation than typically is the norm in a Delivery firm.) Also, firms that are known for their very strong emphasis on ideas are in the minority. Designing the GTA default projects, were one Idea-Service firm, one Service firm, and one Service-Delivery firm. Designing the seven "new normal" cases, there was one Service-Delivery firm, and two each of Service, Idea-Service, and Idea firms. The "new normal" cases seem to demand an architect that leans toward the Idea-Service end of the spectrum more often than do the GTA default cases.

The most frequent match is between a client wanting iconic architecture and an idea-service firm. So, the sum of Context + Client + Architect that achieves "low load and high satisfaction" seems to be a client wanting both "green" design and iconic architecture working with an idea-service architect. The case studies show that this combination can be successful in rural, suburban, or urban settings.

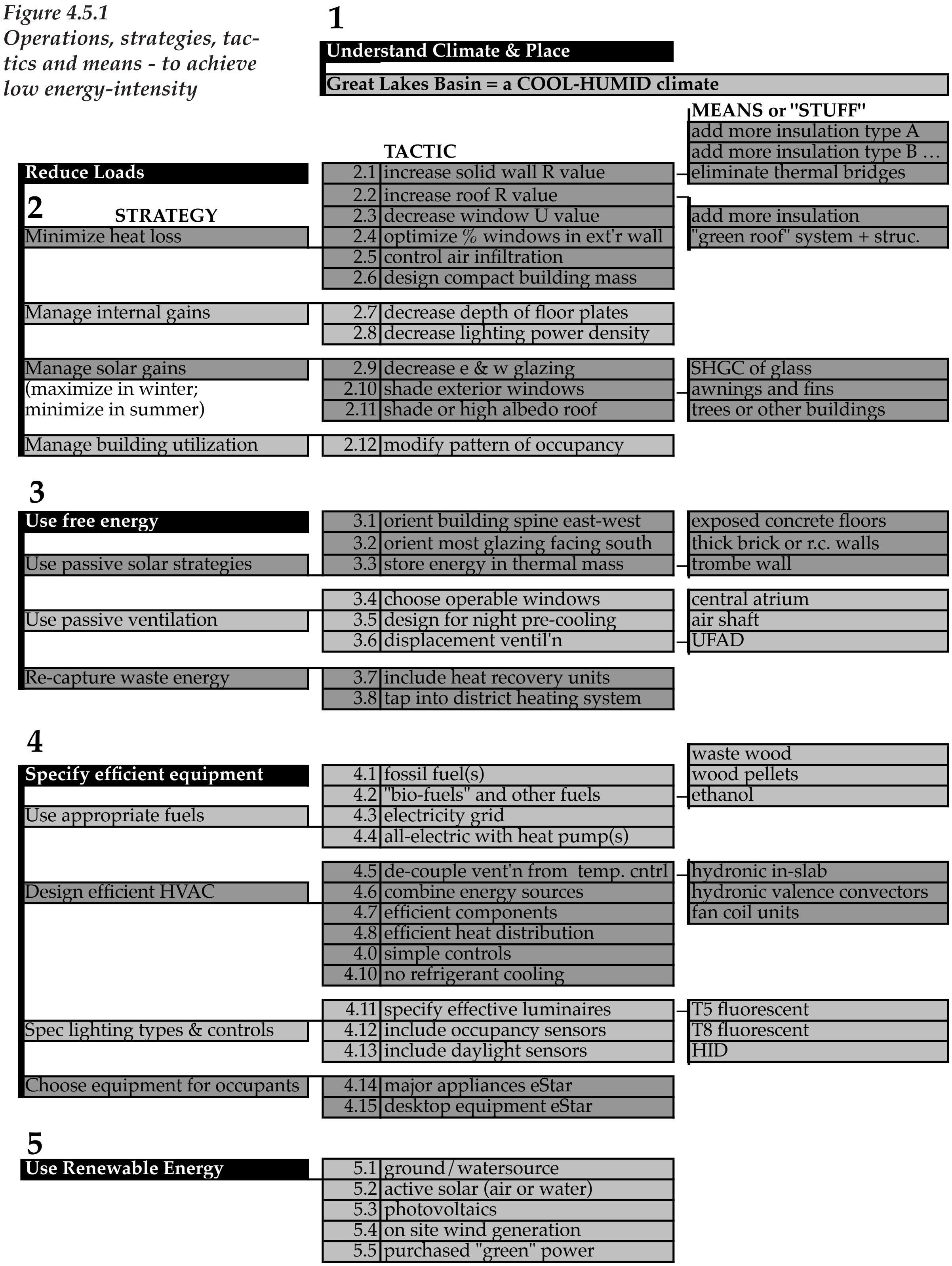
Context and type of client do not correlate to a significant degree. Of the two rural projects, one is for a private, deep green company (Wind NRG), and the other is for a public agency with an "emerging policy" (Holyrood RCMP). Among the suburban projects, there are deep greens (such as the AJLC at Oberlin and Gilman Ordway at Woods Hole), plenty of public-service institutions (such as Alice Turner Library and T.L. Wells Elementary), and clients seeking iconic architecture (such as Heimbold Visual Arts). Among the urban projects there are four types of clients.

Context and type of architect correlate, to some degree. Idea and Idea-Service architects are found working in the suburbs and in urban contexts with roughly equivalent frequency. However, rural projects seem to be associated with Service firms – the long-term practices with deep roots and close friendships in their local communities. Also, the two projects done by Service-Delivery firms are large urban buildings – drawing on the production capabilities of these larger practices. But the correlation that is evident – between context and type of architect – does not seem to be different in these "low-load + high-satisfaction" buildings than it might be in any other group of buildings.

A larger sample set might reveal different patterns - respecting the correlation between context and client, context and architect, or client and architect. Still, from this set of projects, admittedly limited in number, it appears that:

- a project with very low energy intensity is most likely to involve a deep-green client, and least likely to involve a public service client,
- a project with moderately low energy-intensity may involve any of the four types of client,
- a low-load + high-satisfaction project is unlikely to involve an architect whose practice emphasizes either pure delivery or pure idea; a combination of idea + service is the most in demand by clients, of all type, in this group,
- within the mid-spectrum of architectural firm types, there is little correlation between the level of energy-intensity and the emphasis of the architectural practice,
- context and type of client do not correlate, and
- context and type of architect correlate to some degree, but no more in new-normal projects than in the GTA defaults.

Figure 4.5.1
Operations, strategies, tactics and means - to achieve low energy-intensity



4.5 BEST PRACTICE DESIGN APPROACHES FROM THE STRATEGY GRID

The idea that design strategies ought to be chosen from a climate-centred list is expressed in numerous sources in the literature. McLennan argues that success stems not only from the choice of design strategy, but also from the order in which the strategies are applied (Olgyay 1963, Lloyd-Jones 1998, Yeang 2006, McLennan 2004).

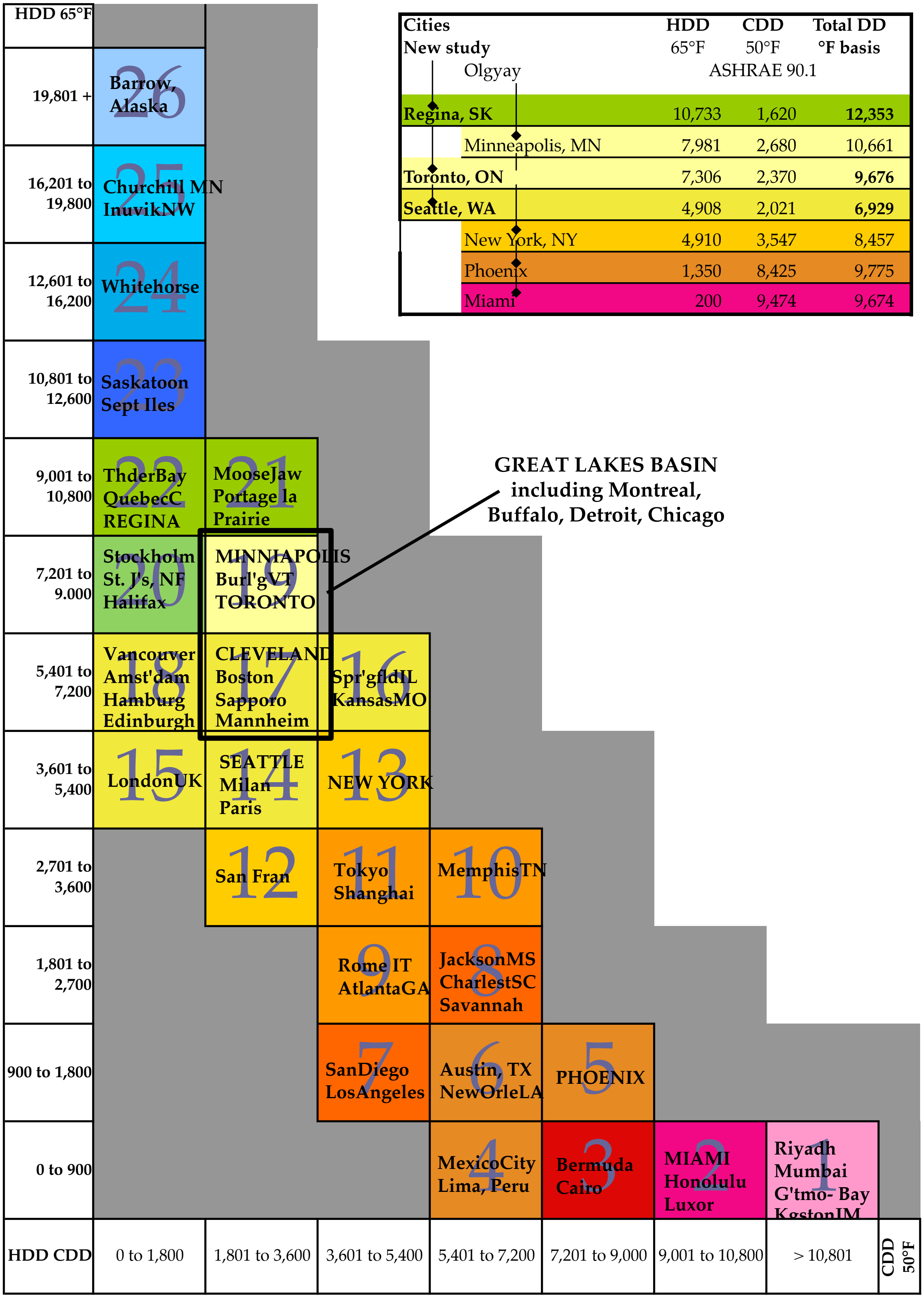
In this section, all relevant aspects reported in the literature about all of the case study buildings are viewed through the lens of the Cool-humid Strategy Grid, shown in Figure 4.5.1. Then, a closer look is taken at the seven “full-appraisal” buildings, comparing them to the three “default” buildings in the GTA.

As described in Section 2.6, in composing this Strategy Grid, McLennan’s four-part order is expanded; the use of renewable energy sources is added as a fifth step, to distinguish this from the (third-step) use of “free” energy sources. Also, the realities of the climate in the Great Lakes Basin are acknowledged (operation #1) and several climate-centred design strategies are listed, in relation to each of the five operative steps. For each strategy, there are several alternative tactics that will advance performance of the building. As the cases studied here will show, most designs employ several tactics in combination. Furthermore, for each tactic, there are several alternative “means” - the physical “stuff” that is constructed - a few examples of which are listed to the right side of Figure 4.5.1.

The goals of this exercise are to:

- understand how great is the gap between “standard practice” in the design of civic buildings in the GTA and “best practice” among the lowest-load case studies,
- develop and hone questions, about “how much” a particular design strategy matters, that can be explored in the Study of Design Parameters, in Chapter 5, and
- detect patterns that support or disprove McLennan’s argument that the order of operations matters.

Cities New study Olgyay	HDD 65°F	CDD 50°F ASHRAE 90.1	Total DD °F basis
Regina, SK	10,733	1,620	**12,353**
Minneapolis, MN	7,981	2,680	10,661
Toronto, ON	7,306	2,370	**9,676**
Seattle, WA	4,908	2,021	**6,929**
New York, NY	4,910	3,547	8,457
Phoenix	1,350	8,425	9,775
Miami	200	9,474	9,674



HDD 65°F								
19,801 +	26 Barrow, Alaska							
16,201 to 19,800	25 Churchill MN InuvikNW							
12,601 to 16,200	24 Whitehorse							
10,801 to 12,600	23 Saskatoon Sept Iles							
9,001 to 10,800	22 ThderBay QuebecC REGINA	21 MooseJaw Portage la Prairie						
7,201 to 9.000	20 Stockholm St. J's, NF Halifax	19 MINNIAPOLIS Burl'gVT TORONTO						
5,401 to 7,200	18 Vancouver Amst'dam Hamburg Edinburgh	17 CLEVELAND Boston Sapporo Mannheim	16 Spr'gfldIL KansasMO					
3,601 to 5,400	15 LondonUK	14 SEATTLE Milan Paris	13 NEW YORK					
2,701 to 3,600		12 San Fran	11 Tokyo Shanghai	10 MemphisTN				
1,801 to 2,700			9 Rome IT AtlantaGA	8 JacksonMS CharlestSC Savannah				
900 to 1,800			7 SanDiego LosAngeles	6 Austin, TX NewOrleLA	5 PHOENIX			
0 to 900				4 MexicoCity Lima, Peru	3 Bermuda Cairo	2 MIAMI Honolulu Luxor	1 Riyadh Mumbai G'tmo- Bay KgstonJM	
HDD CDD	0 to 1,800	1,801 to 3,600	3,601 to 5,400	5,401 to 7,200	7,201 to 9,000	9,001 to 10,800	> 10,801	CDD 50°F

Operation #1, Understand climate and place

Figure 4.5.2 (opposite)
a - Climate conditions in world cities

b (inset) - Climate conditions in North American cities

(data drawn from "Climates for building environmental requirements" and Climate Data Tables D-1 to D-3, in ASHRAE Standard 90.1-1999, 90, 126-152 and OBC 2006)

In the outline of the "Order of Operations", in reference to "Understand Climate and Place", McLennan suggests:

> *"Designers should first understand the place in which they are designing. What effect does the climate have? Temperature, humidity, diurnal temperature swings, precipitation amounts and distribution, snowfall, wind speed and direction, air quality, landscape features, vegetation, surrounding obstructions, etc. must all be understood." (2004)*

McLennan hints, but does not make explicit that the architect's "understanding" ought to expand to include quantitative measures of climatic effects. To this end, the numbers that engineers use as design guides may be made more meaningful by looking at them in context.

Quantitative understanding

Figure 4.5.2 puts the North American climates that are of interest here into a worldwide context. This diagram, which is an embellishment of one in the ASHRAE Standard, illustrates only the thermal aspects of climate, because designers of mechanical systems are concerned primarily with the total yearly need for heating and cooling.

In Figure 4.5.2a, cold regions are coded in "cool" shades of blue, while hot regions are coded in "hot" shades of orange and red. A comparison of the cities in the Great Lakes Basin to coastal cities in either Canada or the U.S. illustrates the perception that the Great Lakes Basin is "the worst of both worlds", presenting a very challenging climate to the would-be low-energy designer. San Francisco stands as an exemplar of a benign climate, with the least need for heating or cooling. Other coastal or near-coastal cities at mid-latitudes - on the Pacific Rim (Shanghai and Tokyo), and surrounding the Atlantic (London, Paris, and New York) appear, on the chart, to have similar climates to San Francisco. In contrast, Toronto, Minneapolis and Burlington, Vermont have at least twice the heating degree days (HDD) as San Francisco, yet they are no cooler in the summer. In fact, their mid-continent position means they do not always benefit from cooling breezes on hot summer days, in the way that coastal regions do.

In Figure 4.5.2b (inset), conditions in the four cities studied in Olgyay (1963), as representative of distinct North American climate zones, are compared to conditions in three cities in which building types are simulated in Chapter 5 of this study. Heating and cooling needs are similar across a "cool-humid" zone that encompasses

Figure 4.5.3
Order of Operation #1
relative to the case study
buildings

1

Understand Climate

	kWhr/m2			1.1 HDD (18 °C basis)	1.2 CDD	1.3 TOTAL DD	1.4 WINTER LOW (°C)	1.5 SUMMER HIGH (°C)	1.6 precipitation (mm/year)	1.7 general zone	1.8 insolation (kWhr/m2/day)
OFFICE	**447**		GTA Police (Toronto ON)	4,066	252	4,318	-17	29	793	Ge	3.45
		271	Zeeland MI (Chicago IL)	3,613	461	4,074	-6	32	922	Gs	3.55
	258		SAS (Toronto ON)	4,066	252	4,318	-17	29	793	Ge	3.45
		219	Allentown (Pittsburgh PA)	3,241	404	3,645	-2	30	963	A	3.64
	167		Holyrood NF (Halifax NS)	4,367	104	4,471	-6	26	1,452	A	3.03
		94	Charlottetown PEI (Halifax NS)	4,367	104	4,471	-6	26	1,452	A	3.48
	69		Wind NRG (Burlington VT)	4,262	272	4,534	-21	29	917	Ge	3.33
	50		Falmouth MA (Provid. RI)	3,199	397	3,596	-12	30	1,181	A	3.89
PUB. ASSEMBLY		*304*	A Turner (Saskatoon SK)	5,852	117	5,969	-17	29	350	P	3.29
		293	Bronxvlle (Hartford CT)	3,394	422	3,816	-3	31	1,173	A	3.67
	271		GTA SAC (Toronto ON)	4,066	252	4,318	-17	29	793	Ge	3.45
	225		Youngst'n (Cleveland OH)	3,403	390	3,793	-14	30	983	Gs	3.49
	173		St. Gabriel's (Toronto ON)	4,066	252	4,318	-17	29	793	Ge	3.45
	169		Ptown MA (Providence, RI)	3,199	397	3,596	-12	30	1,181	A	3.89
	100		Artists (Boston MA)	3,130	432	3,562	-11	31	1,080	A	3.89
EDU		*243*	T.L. Wells (Toronto ON)	4,066	252	4,318	-17	29	793	Ge	3.45
	160		GTA School (Toronto ON)	4,066	252	4,318	-17	29	793	Ge	3.45
	102		Oberlin (Cleveland, OH)	3,403	390	3,793	-14	30	983	Gs	3.53
		74	Hanover (Pittsbgh PA)	3,241	404	3,645	-2	30	963	Gs	3.64
			averages:	3,846	306	4,151	-12	29	966		3.53

Legend

258 **ACTUAL energy intensity**

243 *predicted energy intensity*

Comprehensive case study

- Canadian Prairie
- Canadian Maritimes (Atlantic Coast)
- Great Lakes Basin (east) & Laurentian-Adirondack
- Great Lakes Basin (south)
- US Northeast Atlantic Coastal

both Toronto and Minneapolis, which is colour-coded in pale yellow throughout this section. Both Seattle and New York may be said to fall within a separate, “temperate” zone, which is coded in gold throughout this section.

Figure 4.5.3 shows detailed data, with respect to a broader range of aspects of climate, for each of the locations where a case study building is situated. Here, the impact of temperature swings and humidity can be seen. In the “cool” and “cold” climates in central and north-eastern regions of North America, seasonal and diurnal swings of temperature in the central regions are among the most extreme in the world. And, while colder places (such as Saskatoon) tend to be relatively dry, the Great Lakes Basin and New England states also experience precipitation and humidity levels that are common in places such as Florida and Louisiana. (Compare the 350 mm. in Saskatoon to 793 mm. in Toronto, and 1200-1400 along the Atlantic coast, from Hartford, CT to Halifax, NS).

So far, this data has been discussed in terms of the question, “how much of a challenge does this climate present?”. Yet, a designer also may ask, “how significant are the opportunities that this climate offers?” By asking the latter question, one may consider strategies for indoor passive climate control. If natural energies are available, then they may be harvested. For instance, some cold climates offer enough solar energy to power equipment, such as hot-water heaters, albeit for a limited time. In other cold climates, available sunlight is too minimal – of too short duration, too intermittent (due to cloudiness), or too poorly timed (relative to season) – to be reliable. Understanding the climate and the place clearly is a prerequisite to the application of design ingenuity related to passive systems. Figure 4.5.4 presents a practical interpretation of insolation data.

1 kW (approx. 10m2 in area) of south-facing PV, with latitude tilt has the potential to produce:

	kWhr/year
Cairo	1,635
Los Angeles	1,485
Regina, SK	1,361
Rome, Italy	1,283
Toronto, ON	1,161
Washington, DC	1,133
Vancouver, BC	1,009
St. John’s, NF	933
Moscow	803
London, UK	728

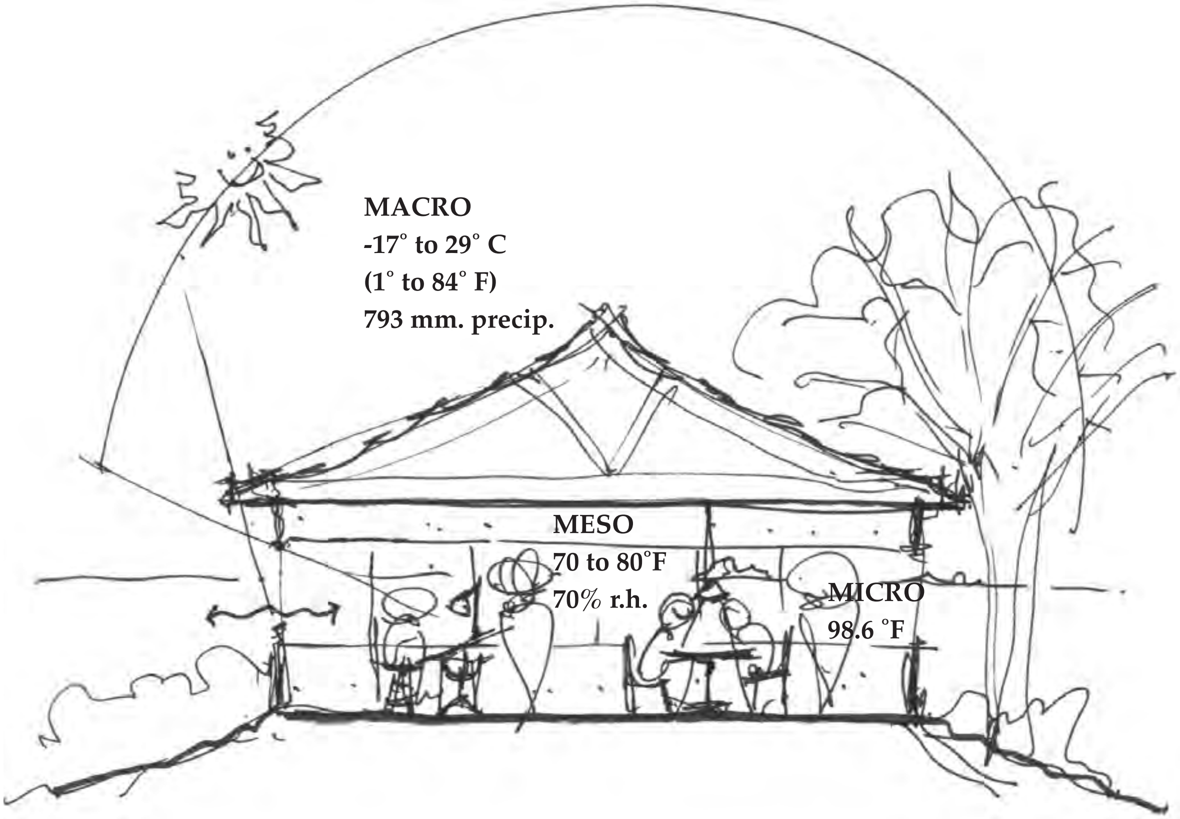
A south-facing vertical installation has approx. 65% potential of an optimal slope

Figure 4.5.4
Yearly PV potential in world cities

(NRCan 2007b)

Understanding the climate context is an essential first step, towards establishing goals for the design. Only after the goals are known, can the most effective “green design” strategies be selected.

Figure 4.5.5
"Reduce loads": architecture as mitigator of climate (after Fitch 1999)



Operation #2 Reduce Loads

Arguing that the "Order of Operations" is critical to realizing an effective design at a reasonable cost, McLennan states:

> *"Designers should then analyze what loads or system requirements there are in the design and seek to systematically reduce them or accurately define them rather than inflate them." (2004)*

In other words, a "low-environmental-load" architecture is one that demands no more energy than is strictly necessary to mitigate uncomfortable conditions outside, on the way to creating comfortable conditions inside. Fitch expressed this idea, and went on to describe three distinct scales of environmental control (1999). First, in his view, the human body is a "micro" environment, maintained in equilibrium at 98.6 °F, by complex biological processes. At the opposite extreme, the natural climate is a "macro" environment, in which conditions may vary considerably. In between the "micro" and the "macro" environments, a building creates a "meso" environment, in which conditions are moderated so that humans can thrive. Fitch declares:

> *"...the ultimate task of architecture is to act in favor of human beings - to interpose itself between people and the natural environment in which they find themselves in such a way as to remove the gross environmental load from their shoulders. ... Its purpose is to maximize our capacities ..." (1999)*

Victor Olgyay credited Fitch's perspective as a prime inspiration for the research behind *Design with Climate*. When Fitch, Olgyay and McLennan look at a building, they describe it as a "second skin", through which energy flows, as illustrated in Figure 4.5.5 . Viewed this way, if the aim in a design is to realize the most comfort, utility and delight at the least expenditure of energy, then their arguments is that an architect ought to start by understanding both the "macro" and "micro" levels, and tailoring the "meso" level accordingly. In the Great Lakes Basin, the principal objective at the "meso" level is to "keep the heat in". Providing appropriate lighting for work also is a significant goal, particularly in winter. Raising the thermal performance of all enclosure elements, being judicious with the amount of glazed openings, controlling air infiltration, and, perhaps, preferring an overall shape that is "conserving" are strategies that an architect can use to reduce loads. Solar gain may be useful, during the winter - however, it is highly undesirable during the hot and humid days of summer, when curbing excess solar gain would reduce the need for artificial cooling.

Figure 4.5.6
Order of Operation #2 in the case study buildings

2

Reduce loads

	kWhr/m2/yr		2.1 solid wall ≥ R-20	2.2 roof ≥ R-30	2.3 window ≤ U_{imp} 0.26 [1]	2.4 op'gs ≤ 40% of o/a façade area	2.5 air infiltration "controlled"	2.6 compact mass(SA:GFA≥1:1.05)	2.7 floor plates ≤ 60' one direction	2.8 ltg power density ≤0.9 W/sf	2.9 glass e&w ≤ 15% façade area	2.10 exterior shading of windows[2]	2.11 roof white or shaded	2.13 OTHER - see note
		to manage …	**heat loss**						**int gains**		**solar gain**			
	464^{on}													
OFFICE	**447**	GTA - Police Station	◇	○	◇	◆	◆	◆	○	○	○	○	○	
	271	Herman Miller C1	○	?	◇	◇	○	◆	○	◇?	◆	◆	○	
	258	SAS Canadian HQ	○	○	◇?	◆	?	◆	○	?	○	○	◆	
	219	Plaza at PPL	?	?	◇	○	?	◆	○	?	○	◆	◆	
	167	Holyrood RCMP	◆?	?	◇	◆	◆	?	◆	?	?	○	○	
	94	Jean Canfield GOC	◆	◆	◆	?	◆	?	◆	?	?	◆	?	
	69	Wind NRG	◆	◆	◆	◆	◆	○	◇	◇	◇	◆	◆	a,bg
	50	Gilman Ordway	◇	◆	◆	◆	◆	○	◆	◆	○	◇	◆	bg
	356^{on}													
PUB. ASSEMBLY	*304*	Alice Turner Library	◇	◇	◇	◆	◆	◆	◆	○	?	○	?	
	293	Heimbold Visual Arts	?	?	?	?	?	◇	◆	?	○	◆	○	a
	271	GTA - SAC Cambridge	○	○	◇	◆	?	◇	◇	?	○	○	◆	
	225	N Jones Courthouse	?	?	◇	?	?	?	○	?	?	◇	◆	
	173	St. Gabriel's Parish	◆	○	◆	◆	◆	○	○	?	○	◆	?	
	169	PAAM	○	?	◆	◆	?	◆	◆	◇[3]	◆	◆	◇	
	100	Artists for Humanity	◇	◇	◆	◆	◆	◆	◆	◆	◆	○	◆	bg
	$261^{on,us}$													
EDU	*243*	T.L. Wells Elementary	◇	?	?	?	◆	○	◆	◆	?	◇	?	
	160	GTA - Elementary School	◇	○	◇	◆	◆	◆	○	?	○	○	?	
	102	AJLC, Oberlin College	◇	◇	◆	◆	◆	○	◆	◆	○	◇	◆	a
	74	Clearview Elementary	◆	◆	◆	?	◆	○	◆	◆	◆	◆	◆	

Notes

[1] double-glazed 1" unit with LowE coating and argon fill (AFG)
this is 25% better than OBC 1997 best threshold of 1.87 for Toronto area bldg. 20-40% glzd.

[2] exterior shading devices includes trees

[3] at PAAM, LPD is 1.2 W/sf

a a substantial part of the building is below grade

bg perimeter of slab-on-grade and/or foundations also insulated

356^{on} Ontario average
251^{us} U.S. average

Legend

258 actual energy intensity
243 predicted energy intensity

7 "new normal"
9 "green"
3 "GTA default"

◆	exceeds criterion
◇	at or near criterion
○	does NOT meet criterion
🟧	re climate see Figure 4.5.3

Strategies used to "reduce loads" in the case study designs are discussed, in the following pages. The approaches preferred most often by the architects are revealed, and alternative tactics to realize each approach are illustrated. Questions as to *how much* each strategy influences real performance are refined through this process.

In Figure 4.5.6, the cases are arranged in order of energy-intensity, descending from the highest rate, at the top of the list, to the lowest, and the bottom. This chart aims to reveal what distinguishes the projects near the top of the list from those near the bottom. In this chart, strategies that were stated earlier as directions are now stated in more measurable terms. For instance, "increase solid wall R value" has become "solid wall ≥ R-20".

"Managing" heat loss means, in this cool-humid climate, minimizing it. As the energy-intensity of the designs decreases (towards the bottom of the chart), there is a clear tendency to use more strategies to minimize heat loss in a design.

"Managing" internal gains may mean either curbing them, or making use of them. In large, "internal load dominated" buildings, the accumulation of internal heat gains may be significant. Some office buildings build up so much internal heat that cooling is required, in the core, throughout the year. In Figure 4.5.6, it looks as though more of the designs at lower energy-intensity employ more internal-load-reducing strategies more often than those higher on the list.

"Managing" solar gain means avoiding the admittance of unwanted heat. According to Figure 4.5.6, the most energy-efficient buildings in this climate employ strategies to manage solar gains somewhat more often than the less energy-efficient buildings. If there is a difference between the least energy-intense designs and the more energy-intense designs, it is weakest with respect to this category.

In the following pages, each of the "reduce loads" strategies is examined to see the how it was used in the seven "new normal" designs that were fully appraised - as compared to its use in the three "GTA default" designs.

Design the exterior wall assembly to ≥ R-20

This benchmark is well in excess of the current Ontario Building Code minimums, which range from R-7.7 to R-13.9 (RSI 1.36 to 2.44). * Information is available for 12 of the 16 "new normal" and "green" cases. Of these, 5 meet and 4 exceed the benchmark, while 3 fall below it (see Figures 4.5.6). The cases that exceed the benchmark is exceeded, do so only slightly - to R-25 and R-30. The cases that falls farthest below is an adaptive re-use of an historic load-bearing brick structure (GTA - SAC).

In specifying exterior walls that perform well in a cool-humid climate, the designers showed a considerable range of expression. Exposed masonry – usually brick - is the primary cladding material in eight cases. Metal siding, cement board, cast-in-place concrete and natural stone are used, with rich architectural effect, in three.

Wood siding - a traditional material in the north-eastern regions of North America - is used in five cases. Detailing is traditional at RCMP Holyrood, or more contemporary, as at PAAM. Variations include cedar shingles, flat horizontal tongue-and-groove boards, board and batten siding, and horizontal slats. A few examples of the range are shown in Figure 4.5.7, and a comparison of the thermal resistance of the wall assemblies is shown in Figure 4.5.8.

Since the highest-performance houses are designed with walls up to R-60, the lower values seen here may seem surprising. The predominance, in these non-residential cases, of good – but not exceptional – insulation levels in exterior walls raises the question whether the R-value of the exterior wall plays a less important role in the overall energy-efficiency of mid- to large-sized buildings than it does in a single-family house. That is, do other load reduction strategies – such as those that relate to internal loads – perhaps have greater power?

Figure 4.5.7
Alternatives used as exterior cladding materials

a (top): brick at T.L. Wells
b (middle): wood siding at Holyrood RCMP
c (bottom): metal siding at Wind NRG

(image a Tom Arban, b Peter Adams)

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* OBC 2006, Supplementary Standard SB-10, Table 5A (Location 333, Toronto)

			Wall		Roof		Foundation	
	kWhr/m2/yr		R_{imp}	system	R_{imp}	system	R_{imp}	element
OFFICE	**447**	GTA Police	19	brick, 3" polyiso., block	15	BUR on 3" polyiso.	0	2' vertical
	258	SAS	14	4" insul. panel, st. stud	15	approx., 4 systems	6	2" spray?
	69	Wind NRG	20	2" insul. panel, st. stud, 2" rigid	40	whiteTPO on 6"isocyan	16	full u/s
	50	Gilman Ordway	20	cem. bd., offset wd. stud, foam	45	EPDM on 4" EPS	?	
PUBLIC	**271**	GTA - SAC	4	20" solid masonry	18	white PVC, 3.3", wd.	0	none
	173	St. Gabriel's	25	stone/EIFS, 4" rigid/spray, r.c.	30	5" polyiso. on mod.bit.	14	4" spray
	169	PAAM	12	wd. side & frame/r.c., 4" batts	24	?	0	none
	100	Artists	19	st. siding, 2" XPS, st. stud, batts	30	grey PVC on 6" XPS	6	2" u/s
EDU	**160**	GTA School	16	brick, 2" polyiso., block	14	BUR on 2" polyiso.	0	?
	102	AJLC, Oberlin	19	brick, insul. type?, block	27	?	12	4" u/s
		Average 3 GTA:	*13.0*	*0" to 3" insul.*	*15.7*	*2" to 3" insul.*	*0.0*	*none*
		Average 7 "new normal":	***18.4***	*two layers insul./some spray foam*	***20.0***	*4" to 6" insul.*	***5.4***	*full u/s*

Figure 4.5.8 (above)
Thermal resistance of solid enclosure assemblies

Minimize heat loss 2.2

Design the roof assembly to ≥ R-30

Figure 4.5.6 shows that the most energy-efficient buildings in each category of use exceed this benchmark. Figure 4.5.8 shows that much higher values (up to R-45) were chosen in two of the four the most energy-efficient cases. The current minimum in Toronto is R-20.4. * Curiously, none of the three "default" GTA cases, or SAS, meet this standard.

Figure 4.5.8 also shows the average thermal resistance for walls and roofs in the "full-appraisal" and "GTA default" cases. The four least energy-intense cases also incorporated full under-slab insulation (2" or 4"), while the "GTA default" cases had either vertical perimeter insulation, or no insulation, below grade.

Although "green roof" products have been extensively promoted in recent years, they appear in only three cases here. The vegetated area occupies only a small section of the overall roof, and is visible from inside the building. This suggests that the green roof has a greater aesthetic or "message" function, than a technical one. Figure 4.5.9 shows two alternate approaches to roofing.

Figure 4.5.9
Alternatives used to realize a thermally resistive roof:
a (middle) "green roof" at Plaza at PPL (image Peter Aaron/Esto)
b (bottom) white TPO membrane at Wind NRG.

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*OBC 2006, Supplementary Standard SB-10, Table 5A-2S

			Glass							Frame System	R
	kWhr/m2/yr		#	gas	tint	*BTU/hr-ft²-F*	**U**	**SC**	**VLT**		o/ / a
OFFICE	**447**	GTA Police	2	Ar	blue	est.	0.45			Kawneer 1600	
	258	SAS	2	?	blue	PPG Sungate100	0.31			?	
	69	Wind NRG	3	Ar	?	phase 2 label	0.17	0.276	0.41	Accurate Dorwin	
	50	Gilman Ordway	3	Ar	?	Heat Smart Plus	0.19			Loewen wood	5.4
PUBLIC	**271**	GTA - SAC	2	?	clear	AFGD	0.23	0.42	0.69	Kawneer Isolock	
	173	St. Gabriel's	3	K	?	"heat mirror"	0.14			Kawneer 7500	7.0
	169	PAAM	2	?	?	est.	0.35			custom wood	
	100	Artists	2	Ar	?	Viracon VE-185	0.33	0.61	0.76		
EDU	**160**	GTA School	2	?	?	est.	0.45				
	102	AJLC, Oberlin	3	Ar	tint	est.	0.18			atrium>punched	
						Average 'U' 3 GTA:	0.38		0.23	*Average VLT, 3 GTA*	
						Average 'U' 7 "new normal":	0.251		0.109	***Avge VLT, 7 "new-norm"***	

Figure 4.5.10
Window performance specifications in the case study buildings (approximate values)

W/ (m²-K)	*m²-K/ W*	*hr-ft²-F/ BTU*	*BTU/ hr-ft²-F*
-	-	R-1	-
U_{met} 2.86	RSI 0.35	R-2	U_{imp} 0.50
U_{met} 1.89	RSI 0.53	R-3	U_{imp} 0.33
U_{met} 1.50	**RSI 0.67**	**R-3.78**	**U_{imp} 0.26**
U_{met} 1.42	RSI 0.70	R-4	U_{imp} 0.25
U_{met} 1.14	RSI 0.88	R-5	U_{imp} 0.20
U_{met} 0.94	RSI 1.06	R-6	U_{imp} 0.17
U_{met} 0.81	RSI 1.23	R-7	U_{imp} 0.14

Figure 4.5.11
Conversion scale showing values for thermal resistance (R- and RSI) and conductance (U_{imp} and U_{met})

Minimize heat loss 2.3

Specify "high performance" windows
≤ U_{imp} 0.26 BTU/hr-ft²-F (≤ U_{met} 1.5 W/m² K)

This "benchmark" can be achieved in double-glazed, thermally broken, LowE-coated, argon-filled units in aluminum frames. It is slightly higher than the range currently required by the OBC. * It is in common use in civic buildings, as 2 of the 3 "GTA defaults" and 6 of the 16 other cases show (marked with white diamond in Figure 4.5.6). These buildings are good, but not exceptional energy-performers.

Figure 4.5.6 shows a clear correlation between energy-intensity and window specification; windows in the 3 least energy-intense cases in each category of use exceed the benchmark. Exceeding the window benchmark is one thing that distinguishes the very high-performance designs from the "GTA default" designs. Higher performance units used in the "new normal" cases incorporate triple glazing, LowE coatings, and either argon or krypton gas, in a variety of framing systems - such as aluminum, fibreglass, or wood (see Figure 4.5.10). Figure 4.5.11 provides a quick reference, relating metric and imperial values for solid wall resistance and window conductance.

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*OBC 2006, Supplementary Standard SB-10, Table 5A-2S, median value for 21-40% WWR, heated and cooled building

	kWhr/m2/yr		3D detailing	on-site mock-up	infra-red scan	pressure test	other
OFFICE	447	GTA - Police Station	◇	◆	◆	○	?
	258	SAS Institute (Canada) HQ	○	◆	?	?	?
	69	Wind NRG	◇	◆	◆	◆	?
	50	Gilman Ordway	◇	◆	?	◆	?
PUBLIC	271	GTA - SAC Cambridge	○	○	○	○	?
	173	St. Gabriel's	○	◆	○	○	?
	169	PAAM	○	?	?	?	?
	100	Artists	◇	◆	?	?	?
EDU	160	GTA - Elementary Sch.	○	◇	○	○	?
	102	AJLC, Oberlin	○	◆	?	◆	?

4.5.12
Measures used to control air infiltration in the case study buildings

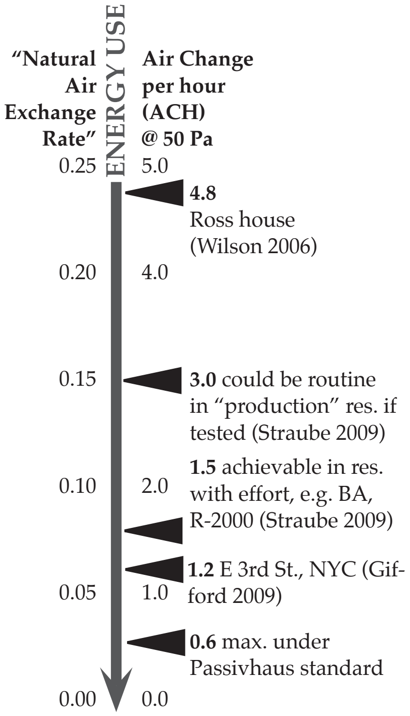
Minimize heat loss *2.4*

Control air infiltration

Careful detailing, to reduce the unintended infiltration of cold air and leakage of warm air, has been the subject of increasing attention in recent years - the intent usually being to prevent mold growth and premature deterioration of building components, not to minimize energy use. Figure 4.5.12 shows the measures used in the case study buildings to control air infiltration.

Figure 4.5.13 shows the air infiltration rates achieved in the author's single-family house (1 storey with basement, constructed ca. 1952, with some subsequent renovations), and a multi-unit residence in Manhattan (East 3rd Street), and makes reference to recent experience in the Building America Program and elsewhere (Straube 2009). Corresponding information regarding non-residential buildings is scant.

The current OBC requirements related to permeability govern air barrier materials only. * Whole-building enclosure standards in the U.K. set the maximum rate at just under 2.0 l/s-m^2, or 0.303 ft^3/min-ft^2 (Lstiburek 2006). (For the author's 100m^2 house, this would be approximately 1.94 ACH @ 50Pa.)



4.5.13
Frame of reference for air infiltration rates

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*OBC 2006, Section 5.4.1.2 requires air barrier material to have a maximum permeability of 0.02 L/(s*m^2) @75 Pa

Figure 4.5.14
The 40% WWR at the School of Architecture in Cambridge

a (top): west facade, 42.6% WWR

b (bottom): daylight entering the Library, through the same facade

(images Ben Rahn, A-frame)

Minimize heat loss 2.5

Limit glazed openings to less than 40% of the exterior wall area

All of the cases for which the window-to-wall ratio (WWR) can be calculated meet the criterion, while realizing an impressive range of architectural expression.

Figure 4.5.14 illustrates how generously a 40% WWR admits daylight into the interior of a building. The School of Architecture, originally designed as a silk mill, stands out as an example of ample daylight for fine detail work.

Figure 4.5.15 illustrates the range of WWRs observed in this study. Specific figures for overall WWR and each facade are shown in Figure 4.5.20. For further discussion of the orientation of glazing, see item 2.9, below.

Figure 4.5.15
The range of WWRs in the case study buildings

a (top): 9.8% on the west facade of PAAM.

b (bottom): 79.8% on the south facade of SAS.

(image a-Anton Grassi/Esto, b-NORR Architects, from SAS 2006)

			Plan		Floor Areas		Enclosure Areas		Ratios		
	actual kWhr/m2/yr		Dimensions EW x NS (ft)	Aspect Ratio 1:	Foot-print (sf)	Gross (GFA) (sf)	Facades (sf)	Surface incl. roof (sf)	**Facade: GFA** 1:	**Surface: GFA** 1:	
OFFICE	**447**	GTA - Police Station [1]	109 x 142	1.31	19,806	45,995	15,504	35,310	2.97	1.30	d
	258	SAS HQ	139 x 109	1.28	15,151	120,000	49,256	64,407	2.44	1.86	d
	69	Wind NRG	245 x 120	2.04	29,400	46,500	16,239	45,639	2.86	1.02	d
	50	Gilman Ordway	160 x 54	2.96	8,640	19,200	11,282	19,922	1.70	0.96	w
PUBLIC	**271**	GTA - SAC [2,3]	131 x 307	1.06	25,162	72,946	41,486	66,648	1.76	1.09	d
	173	St. Gabriel's	119 x 155	1.30	18,445	25,000	11,334	29,779	2.21	0.84	d
	169	PAAM	65 x 114	1.75	7,410	19,500	6,994	14,404	2.79	1.35	w
	100	Artists	63 x 113	1.79	7,119	23,500	12,095	19,214	1.94	1.22	w
EDU	**160**	GTA - School	193 x 160	1.21	30,887	61,773	16,671	47,558	3.71	1.30	d
	102	AJLC Oberlin	144 x 44	3.27	6,336	13,600	11,634	17,970	1.17	0.76	r
			Average:	*1.80*	*16,836*	*44,801*			*2.94*	*1.49*	
			Median:	*1.53*	*16,798*	*35,497*			*2.32*	*1.54*	

sources for calcs: d dwgs w web r report

Notes

[1] plan dimensions of main block at ground level

[2] plan dimensions at largest extent

[3] aspect ratio as if EW dimension were averaged

Figure 4.5.16
Proportions of the case study buildings

(sources noted in right-hand column: d, architectural drawings; w, web documents; r, reports)

Minimize heat loss **2.6**

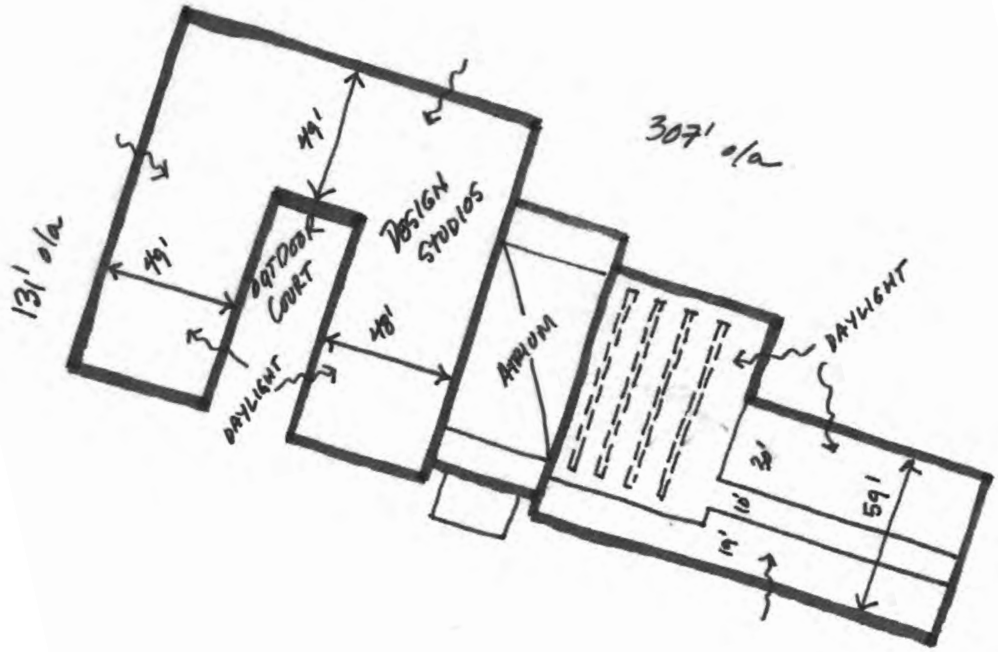
Design a compact mass (SA:GFA ≥ 1:1.05)

Traditional buildings in cold climates were cubic or spherical, as in the Ontario farmhouse and the igloo. This fact has contributed to the expectation that a building with a high ratio of usable floor area per unit of surface area must be more energy-efficient than a "spread out" building that has more surface area. *

Figure 4.5.16 shows that the case study buildings negate this expectation. Three of the four least energy-intense designs provide little floor area per surface area (less than the average for the group), while three of the four most energy-intense buildings provide more floor area per surface area. This begs the question whether designing a compact mass may be less influential than expected, and less significant than other design parameters, when it comes to lowering energy use.

---

* A 22' x 45' free-standing residence with no basement has a SA:GFA ratio of 1: 0.52, while an office tower, such as Toronto's 72-storey First Canadian Place, has a SA:GFA ratio of 1: 3.67. The latter is more likely a result of optimizing the investment pro-forma, during the design stage (maximizing leasable area in relation to structure and building skin), rather than optimizing energy use.



Manage internal heat gains 2.7

Design "skinny" floor plates (≤ 60' in one direction)

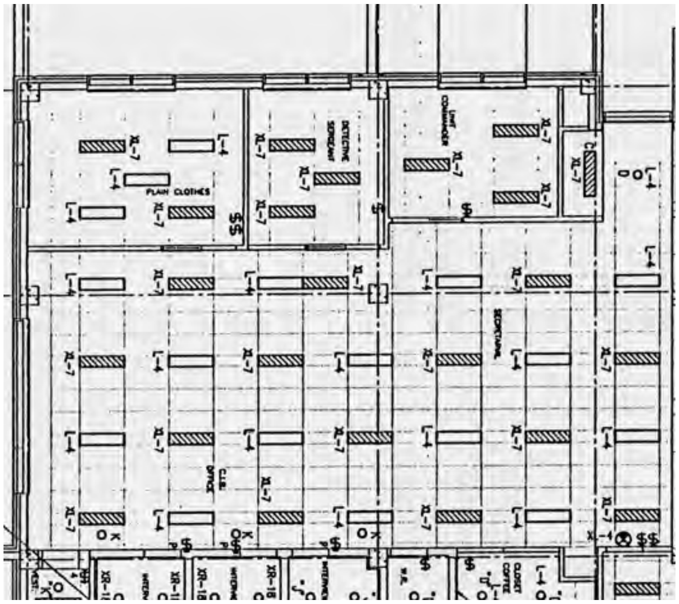
If "design a compact mass" is less important than expected, perhaps the more powerful parameter is the replacement of artificial light with natural daylight. To admit daylight deep into a building, either top-lighting (skylights and clerestories) or the careful design of sidelighting, or both, are required. Lechner depicts office buildings as "internal load dominated", in contrast to single-family houses, which are "envelope dominated" (2001, 216). Some claim the energy needed to run lights as 37% of the total energy use in a "typical" North American office building. If this is so, then "daylight harvesting" may have a powerful effect on the energy-intensity of a large building.

As Figure 4.5.16 shows, the most energy-efficient cases in each category of use are designed with "skinny" floor plates. The fifth (Wind NRG) employs a clerestory and skylights to "slenderize" its plan (see Figure 4.6.9b). All five of the less energy-efficient case studies also employ skylights. As shown in Figure 4.4.17, the GTA-SAC is subdivided into slender "wings".

Figure 4.5.17
Skinny wings at GTA - SAC

a (top): plan shows typical maximum dimension ≤ 50'.
b (bottom): daylight penetrates in the design studios (head of window is at approx. 12' above the floor).

(photo Ben Rahn, A-frame)



4.5.18
Plan of open office at north-west corner of GTA Police,
showing conventional distribution of recessed downlights

4.5.19
Lighting power densitiy in an open office area

e.g. approx. 9W/m^2 using direct/indirect fixtures with T8 lamps, at Wind NRG Phase 1 (image Carolyn L. Bates)

Manage internal heat gains 2.8

Limit lighting power density to ≤ 0.9 W/sf (10 W/m^2 *)

In the least energy-intense cases, lighting power density (LPD) was kept low, by using high-efficiency lamps in a variety of fixture types. In these cases, ceilings were sufficiently high to permit a lighting design using pendant fixtures, casting direct-indirect light. At the AJLC at Oberlin College the following values for installed LPD are reported (Pless and Torcellini 2004):

	W/m2	W/sf
Classrooms	13.6	1.26
Offices	9.5	0.88
Whole building †	8.5	0.79
Whole site	10.0	0.94

These values stand in dramatic contrast to those in the older default designs, such as the corner office in GTA Police (Fig. 4.5.18) where lighting consumes 18.0 W/m^2 (1.67 W/sf).

For more information about the efficiency of lamps, see Strategy 4.11 “Specify efficient luminaires”.

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* The OBC 2006 standard for offices is 11 W/m^2, (Table 12.3.4.8).
† including building-mounted exterior fixtures; excluding parking lot and walkway lighting

	kWhr/m2/yr		**all walls**	**south**	**west**	**north**	**east**
OFFICE	**447**	GTA - Police Station	26.2%	30.7%	13.8%	36.9%	24.5%
	258	SAS Institute (Canada) HQ	40.4%	79.8%	70.6%	4.3%	5.6%
	69	Wind NRG	28.7%	35.7%	16.4%	42.9%	17.2%
	50	Gilman Ordway	25.9%	31.2%	29.7%	27.8%	14.8%
PUBLIC	**271**	GTA - SAC Cambridge	39.3%	33.0%	42.6%	35.8%	45.4%
	173	St. Gabriel's	29.5%	55.9%	9.4%	15.3%	38.4%
	169	PAAM	14.0%	30.0%	9.8%	15.6%	4.3%
	100	Artists	21.7%	58.7%	0.0%	58.7%	1.9%
EDU	**160**	GTA - Elementary Sch.	26.3%	27.6%	42.3%	26.3%	8.6%
	102	AJLC, Oberlin	43.0%	57.0%	14.0%	38.0%	46.0%
		Average 3 GTA:	*30.6%*	*30.4%*	*32.9%*	*33.0%*	*26.2%*
		Average 7 "new normal":	***25.0%***	***44.2%***	***20.9%***	***22.6%***	***15.0%***

Figure 4.5.20 (above) Window-to-wall ratios in the case study buildings

Manage solar gains 2.9

Limit the WWR on the east & west facades to ≤ 15%

East- or west-facing glass may be highly desirable, either to make an outward statement (as at the Nathaniel Jones Courthouse) or to admit light to or provide a view from an internal perspective. However, there is an impact on heat gain – and on occupant comfort – from piercing sunlight, particularly in the winter.

Figure 4.5.20 shows the window to wall ratios (WWR) for the ten cases. On average, glass is more evenly distributed to all four facades in the GTA defaults than it is in the "green" cases. In 3 of the 5 least energy-intense designs, the WWR on the east and west is significantly lower than on the north and south. Yet PAAM and Artists for Humanity are the only cases in which the WWR on both the east and west facades is less than 15%; in both cases, this is a function of site constraints. Skilful handling of east light is illustrated by two of the best energy-performers, such as Wind NRG, depicted in Figure 4.5.21. This suggests that wholly eliminating east & west-facing glass is not essential to achieving exceptional energy performance.

Further analysis is needed to determine how much east and west glass affects energy use at these latitudes.

Figure 4.5.21 West wall at Wind NRG, Phase 2

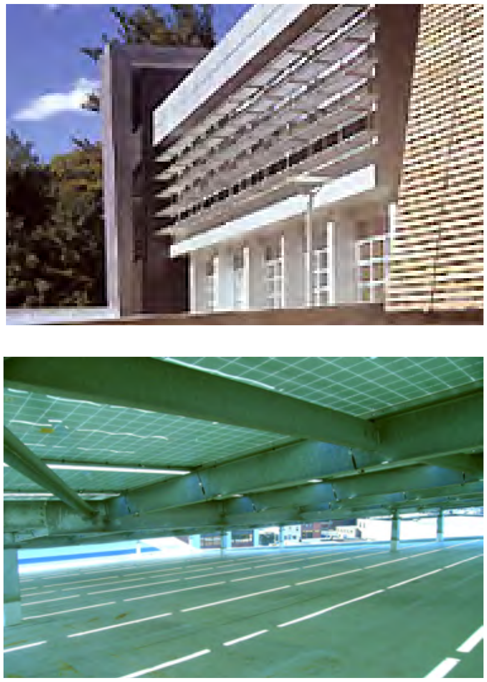
Openings are similar to Phase 1 which the WWR, west, is 16.4%
(image Maclay Architects 2008)

Manage solar gains 2.10

Employ exterior sunshades

This may include louvres hung on the exterior of the building (e.g. Figure 4.5.22a), nearby buildings or trees. SAS and the Plaza at PPL, are shaded by taller buildings, to the west in both cases. Deciduous trees reduce solar gains in summer, and permit them in winter.

In Figure 4.5.6, the use of sunshades does not appear to correlate to energy-intensity. None of the "GTA defaults" include sunshades. In 8 of the other 16 cases, there are exterior shades on the majority of windows (black diamond). In an additional 4 cases, some windows are partly shaded (grey diamond). However, the distribution of shaded and not-shaded windows throughout the range of energy-intensities, suggests that this device does not have powerful impact. Furthermore, the 2 cases at which shades were planned but not constructed (the AJLC and Artists for Humanity) still register toward the low end of the energy-intensity scale. Sunshades are touted in the "green building" literature as valuable; these observations beg the question whether they are less so in the Great Lakes Basin than elsewhere.



4.5.22
Exterior shading devices

a (top): awnings shade the glass wall at the Heimbold Center at Sarah Lawrence College.

b (bottom): PV panels shade the roof at Artists for Humanity

(image a-Polshek Partnership Architects, from AIA COTE 2005)

Manage solar gains 2.11

Shade the roof, or choose a white membrane

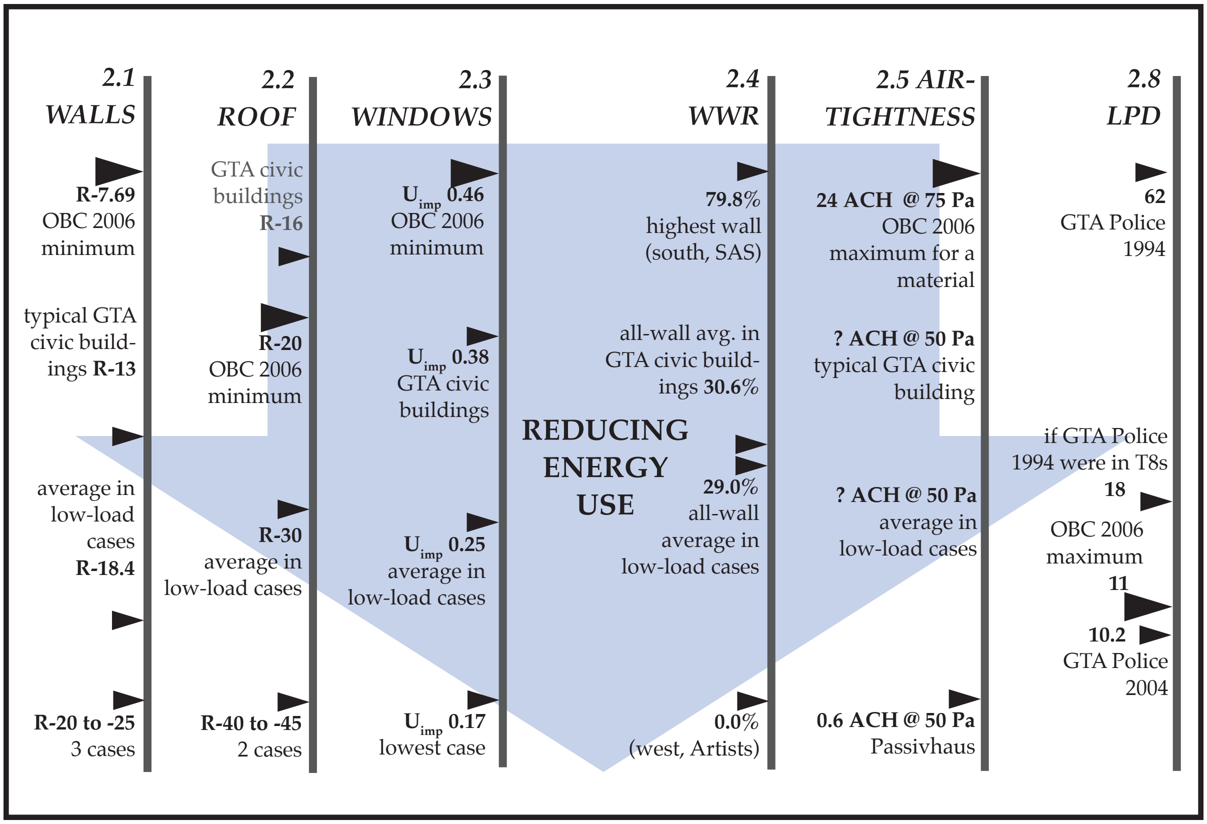
Roofs may be shaded by adjacent buildings, by clerestories, or by PV racks. For instance, both roof and PV rack are cooled in the arrangement at Artists for Humanity, shown in Figure 4.5.22b. In each category of use, there seems to be some correlation between roof treatment and energy-intensity (see Figure 4.5.6).

Manage building utilization 2.12

Modify the pattern of occupancy

The gap between simulated and actual energy intensity might be due to a building used more, or less, than planned. However here, many of the buildings are used by more people for more hours than planned. For instance, during the site visit, Wind NRG was occupied by twice as many staff as anticipated in the design.

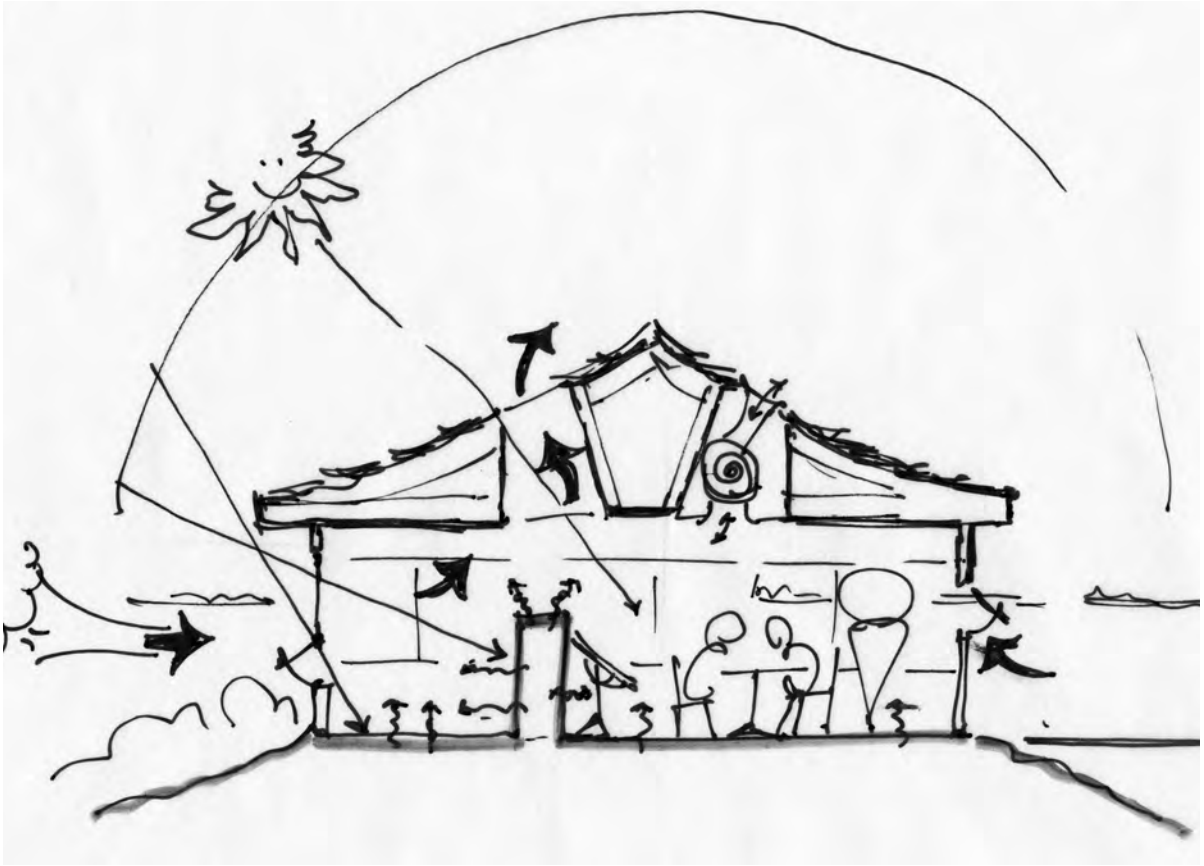
Summary



4.5.23
Measures in the “Reduce Loads” category, relative to current regulations in Ontario

Figure 4.5.23 summarizes the key findings with respect to Order of Operation #2, “Reduce Loads”. It shows that the least energy-intense designs far exceed current OBC minimums with respect to roof R-value, window U-value, and lighting power density. Window-to-wall ratio an air-tightness in are not regulated in Ontario, but both seem to play a significant role in the low-load cases. A list of questions for further study is found in the summary of Chapter 4 (Figure 4.8.8).

Figure 4.5.24
Use "Free" energy



Operation #3, Use free energy

In the outline of the "Order of Operations", McLennan suggests that, after understanding the climate and reducing loads:

> *"Designers should then look to use free sources of energy to further minimize loads and dependence on mechanical systems such as using the sun for heat and natural ventilation to cool where appropriate." (2004)*

"Free sources of energy", by implication, are those that remain untapped, in the typical "default" designs of North American non-residential buildings. Though untapped, this energy is available "on the doorstep" and it may, or may not, be abundant. Figure 4.5.24 illustrates the general concept.

Taking advantage of it involves "passive" strategies, such as the arrangement of windows and vertical shafts through a building - rather than "active" strategies, such as the generation of electricity using equipment. Figure 4.5.25 (overleaf) shows the "passive" strategies that are used in the case study designs, under three sub-categories: passive solar, passive ventilation, and heat recovery. The more active strategies are included in Step #5, "Use renewable energy sources" (starting on page 326).

Wasted energy, including heat lost up the exhaust stack of a building, or heat shed by a neighbouring industrial process, is another type of "free energy". While most of the strategies in this category rely on the arrangement of parts, rather than the parts themselves, the use of equipment for heat recovery (e.g. enthalpy wheels) is included here, as a near-passive strategy.

Figure 4.5.25
Order of Operation #3
in the case study buildings

3

Use free energy

	kWhr/m2			3.1 oreint bldg. spine east-west	3.2 south façade WWR ≥ 40%	3.3 store engy. in thermal mass	3.4 include operable windows	3.5 night pre-cooling	3.6 displacement ventilation	3.7 district heating	3.8 heat/energy recovery units	3.9 OTHER - see notes
				solar			vent'n				recovery	
OFFICE	**447**		GTA - Police Station	○	○	○	◇[6]	○	◇[8]	○	◇[3]	-
		271	Herman Miller C1	○	◆	○	◇[6]	○	○	◆	○	-
	258		SAS Canadian HQ	○	◆	○	?	○	◆[7,8]	○	?	?[4]
		219	Plaza at PPL	◇	◆	○	○	○	◇[8]	○	◆	-
	167		Holyrood RCMP	○	○	◆	◇[6]	○	?	○	◆	-
		94	Jean Canfield GOC	○	◆	?	?	?	◇[8]	◆	◆	-
	69		Wind NRG	◆	◇	◇	◆[5]	○	◇[8]	○	◆	
	50		Gilman Ordway	◇	○	○	◆[5]	○	◇[8]	○	◆	-
PUB. ASSEMBLY		*304*	Alice Turner Library	○	◆	○	○	○	○	○	◆	-
		293	Heimbold Visual Arts	○	◆	◇	◇[6]	○	◇[8]	○	?	-
	271		GTA - SAC Cambridge	○	○	◇	◇[6]	○	◇[8]	○	?	-
	225		N Jones Courthouse	○	◆	?	○	○	○	◆	?	◆[1,4]
	173		St. Gabriel's Parish	○	◆	◆	◇[2,6]	○	◆[7]	○	◆	◆[4]
	169		PAAM	○	○	○	◇[6]	◇	○	○	◆	-
	100		Artists for Humanity	○	◆	○	◇	◆	◇[8]	○	◆	-
EDU		*243*	T.L. Wells Elementary	◆	◆	○	◇[6]	○	◆[7]	○	?	-
	160		GTA - Elementary School	○	○	○	?	○	◇[8]	○	?	-
	102		AJLC, Oberlin College	◆	◆	○	◆[5]	○	◆[7,8]	○	?	-
		74	Clearview Elementary	◆	○	○	◇[6]	○	?	○	◆	-

Notes

◆[1]	recirc loop on utility supplied steam
◆[2]	admin. wing only
◆[3]	glycol run-around loop
◆[4]	dump waste heat into parking garage
◆[5]	windows on auto operators
◇[6]	windows open manually
◆[7]	UFAD
◇[8]	stack effect vent'n via atrium

Legend

258 **actual energy intensity**

243 *predicted energy intensity*

7 "new normal"
9 "green"
3 "GTA default"

◆	exceeds criterion
◇	at or near criterion
○	does NOT meet criterion
🟧	re climate see Figure 4.5.3

Use passive solar strategies **3.1**

Orient the building spine east - west

This is declared an important strategy in the literature - particularly in the study of single-family houses (see Sections 2.3 & 3.5). To test this, the footprints of all cases are arrayed, at a consistent scale and orientation, and grouped according to energy-intensity in Figure 4.5.26. The contention is supported by the 4 of 6 least energy-intense cases that lie with their spine along an east-west axis. On the other hand, there is an east-west case that uses more than 251 kWhr/m^2/yr, and 5 of the 6 cases that run at a fairly low level of energy-intensity (from 103 to 250 kWhr/m^2/yr) are not oriented east-west.

In Figure 4.5.25, there seems to be some correlation between building orientation and energy-intensity among the office buildings - but no such correlation among the public assembly or school buildings. This suggests that building orientation may help, but that it is no guarantee of low-energy use. A question for research in the Study of Design Parameters is - how much does building orientation matter in the Great Lakes Basin compared to other latitudes?

Use passive solar strategies **3.2**

Give the south facade a WWR ≥ 40%

Because east-west orientation exposes the long flank of a building to the sun, it is assumed that it produces an opportunity to open the south facade, admitting solar energy passively. Yet even if the building spine cannot be oriented east-west, as is the case with many urban projects, the area of south-facing windows still can be augmented.

Figure 4.5.25 shows that none of the default designs has a south wall with a WWR ≥ 40%. In contrast, 11 of the 16 other cases, including 4 of the 7 “new-normal” cases, do. Since all 16 cases operate at a lower-than-average level, it may be that south-facing windows are very helpful. However, 1 of the 2 least energy-intense designs does not use the strategy, and the cases that use it occur across the full range of energy-intensity, (see also Figure 4.5.20). It may be window orientation - not building orientation - that exerts the more powerful leverage on overall energy-intensity. However, realizing very low levels of energy-intensity still depends on many other design parameters. Just how much benefit a south facade that is opened to the sun provides to a non-residential building in a cool-humid climate is yet to be determined.

Figure 4.5.26 Orientation of the case study buildings

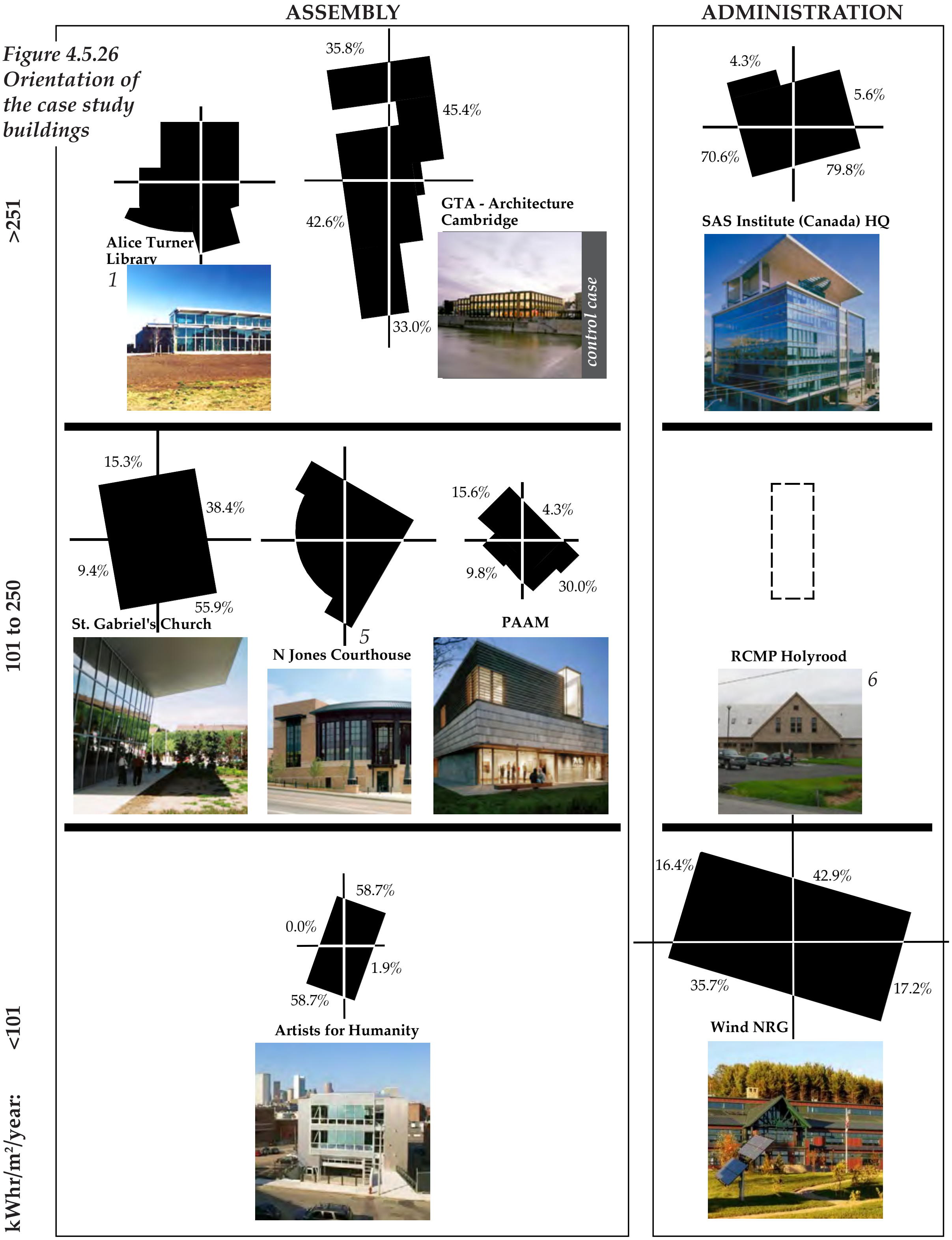


image credits: 1 GOC 2007b; 2 Mariusz Mizera in AIA COTE 2004; 3 Richard Barnes in AIA COTE 2005; 4 Tom Arban in Chodikoff 2005; 5 Peter Aaron/Esto in USDOE 2009f; 6 Peter Adams; 7 Peter Aaron/Esto in US DOE 2007b; 8 GOC 2007a; 9 Robb Williamson Courtesy of NREL in US DOE 2002; 10 L Robert Kimball & Assoc. in US DOE 2009d; all others see Figs. 4.2.1 through 4.2.83

ADMINISTRATION   SCHOOLS

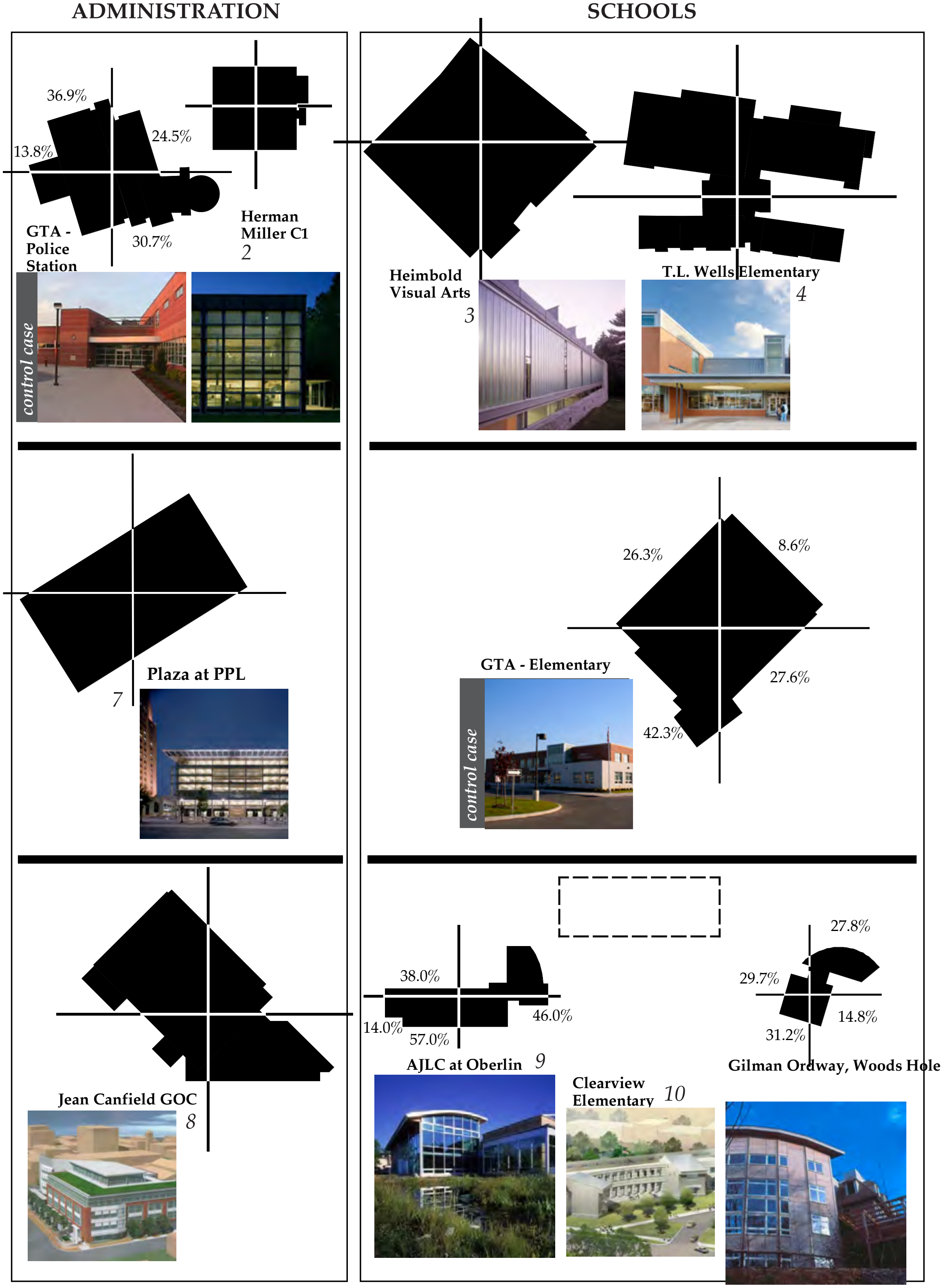


Figure 4.5.27
A Trombe wall at RCMP Holyrood

sits behind the south-facing windows and radiates stored heat into the main office (image Peter Adams)

Use passive solar strategies 3.3

Store energy in thermal mass

Figure 4.5.25 shows that in 5 of the 17 cases (for which information is known), energy is stored in thermal mass of some kind. The 3 marked “at or near criterion” collect heat gains from sunlight and human occupancy in an exposed concrete floor, while the other 2 use of other parts of the building. At Holyrood RCMP, in which the primary office space is designed around a 1.5-storey Trombe wall, made of cast-in-place concrete (see Figure 4.5.27).

At St. Gabriel’s Church, three walls of the nave are constructed of cast-in-place concrete, exposed to daylight from skylights over each wall, and from the fully-glazed south wall. This strategy may even out extreme temperature swings arising from short bursts of intense occupancy in the worship hall. It also gives the space an appropriate feeling of weight, reminiscent of a stone church in Europe.

Figure 4.5.28
Automatic operators on windows at Wind NRG Phase 2

Use passive ventilation 3.4

Include operable windows

In 13 of 16 cases (for which information is known), the design includes windows that can be opened manually. This includes 2 of the 3 “GTA defaults”, in which the opening of windows is controlled by operating policies.

As Figure 4.5.25 shows, 3 of the 6 least energy-intense cases, have windows that are equipped with automatic operators (shown in Figure 4.5.28). These are controlled by paired sensors that detect when cooling and ventilation are needed inside and conditions outside are favourable. The office spaces at Wind NRG also are equipped with a manual over-ride. This equipment, by all reports, works reliably. However, such an arrangement demands careful and sustained attention from both the design team and the multiple trades that are involved in the installation.

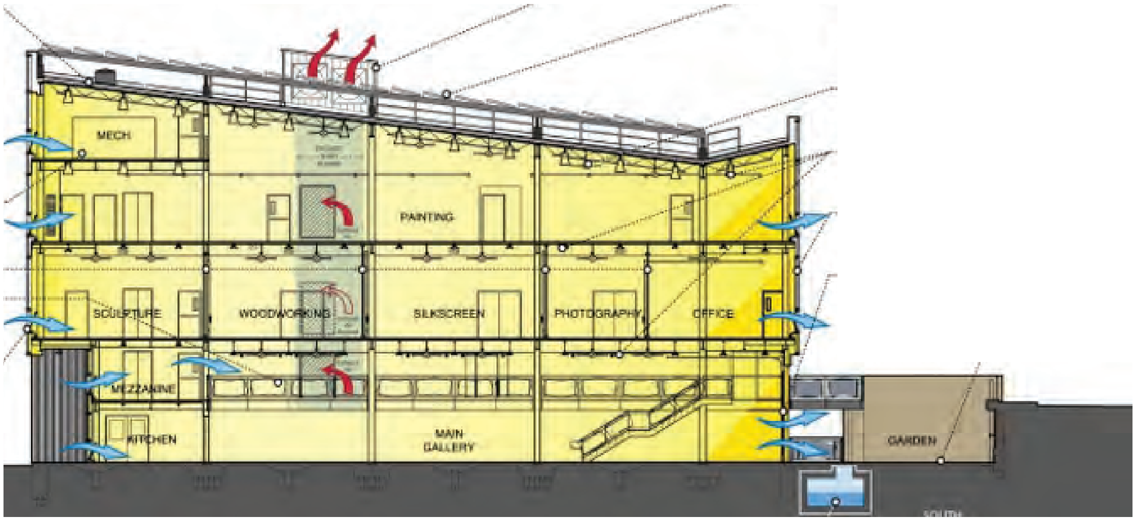


Figure 4.5.29
Night pre-cooling at Artists for Humanity

(image Pat Cornelison, from USGBC 2008)

Use passive ventilation 3.5

Design a system for night pre-cooling

Only 1 of the 19 projects studied here uses night pre-cooling (see Figure 4.5.29). In this case, no refrigerant-based means of mechanical cooling is incorporated in the design. In hot weather, staff open vents at the end of the work day, by hand. Cool air is drawn, in the early morning hours, through the building by roof-mounts fans, sitting atop a vertical shaft at the core (indicated by red arrows).

The system at Artists for Humanity relies on cool air from over the North Atlantic Ocean, which is just a few blocks away from the building site. Such a system might not work as well further from the shore, or in a more inland location. Unusually high temperatures, and large temperature variations, are tolerated by occupants of this building, without much complaint. The conditions in the building are better than those expected in an artist's loft. During the first 2 years of occupancy, the building was closed twice when very high heat prevented reasonable conduct of work.

The experience at Artists suggests that night pre-cooling would be insufficient, if applied to an office building, to counteract the bursts of hot-humid weather that are characteristic of the climate in the Great Lakes Basin - and that it ought only to be used where the expectations of the users are quite flexible.

Use passive ventilation 3.6

Figure 4.5.30
Underfloor air distribution at St. Gabriel's

distracts very little from the appreciation of other elements in the space

Design displacement ventilation, including Underfloor Air Distribution (UFAD).

The natural tendency of warm air to rise through a multi-storey atrium or ventilation shaft is part of the design in 5 of 7 "new normal" cases, and in all 3 of the 3 "GTA default" cases. In 3 of the "new normal" cases, this movement is assisted by fans located in the ceiling of major spaces and the atrium (see Figure 4.5.25).

Ventilation air in every case is delivered overhead to each occupied space, unless noted otherwise. Ventilation air is delivered from under a raised floor (UFAD) in 3 of the 7 "new normal" cases (indicated in Figure 4.5.25). Not true "stack effect" ventilation, the UFAD systems are propelled by fans, but take advantage of rising warm air to reduce air velocity. St. Gabriel's nave is an example - a large space that benefits by being freed of the clutter of overhead ductwork (see Figure 4.5.30). Since these 3 cases are distributed throughout the energy-intensity spectrum, it does not appear as though UFAD is a powerful driver of energy savings.

Figure 4.5.31
Heat-recovery using an enthalpy wheel at Artists for Humanity

Re-capture waste energy 3.7

Tap into district heating systems

Heat is supplied by municipal utility steam at the N. Jones Courthouse in Youngstown Ohio, and the Jean Canfield building in Charlottetown PEI. A central plant, fuelled by wood scraps from the manufacture of furniture, serves the Herman Miller C1 building, and others on the factory campus in Zeeland, Michigan. Of the total energy used by the C1 building 69% is generated on the campus, taking care of 100% of the heating and cooling loads. In all of these cases, access to waste energy reduces the overall capital costs that would otherwise be incurred for major equipment in the building. However, the total energy used is not reduced - rather, the "waste energy" is a supplementary source contributing part of the need.

Re-capture waste energy 3.8

Include heat-recovery units

A substantial approach to energy recovery may be taken through the inclusion of a Heat Recovery Ventilator (HRV) or Energy Recovery Ventilator (ERV) in the air-handling equipment (shown Figure 4.5.31).

In the "GTA default" designs, a small amount of heat recovery is made, via a "glycol run-around loop" that captured some waste energy from the exhaust airstream, and routed it back into the main air handler. In 10 of the other 11 cases (for which information is certain), an HRV or ERV is used. The prevalence of this device in buildings that are relatively low energy-users suggests that it is helpful. However, its effectiveness may depend upon other design decisions.

When the building enclosure keeps the heat in, and ventilation is de-coupled from space cooling, HRV equipment can be compact. The housing containing the enthalpy wheel and motor, pictured in Figure 4.5.31, is no more 4' wide x 4' tall x 3' deep - to serve a 23,500 sf public assembly building.

Summary

Observing these cases permits the formulation of qualitative, if not quantitative conclusions related to the use of "free energy" to lower the overall energy use of a non-residential building in a cool-humid climate.

It appears to be helpful to orient the building spine east-west, although these cases prove that it is not critical, and is certainly no guarantee of profound energy-savings. Other parameters may have the power to over-ride the effect of this approach. Strategies that may be helpful, but also may introduce contingent challenges, include storing energy in thermal mass, distributing ventilation air from the underfloor (UFAD), and eliminating refrigerant-based cooling.

The design strategies that seem to offer the most powerful potential are:

- giving the south facade a WWR ≥ 40%,
- putting windows on auto-operators, and
- using heat/energy recovery ventilation equipment.

The first two of these may also increase comfort and delight for building occupants.

Figure 4.5.32
Order of Operation #4
in the case study buildings

4

Efficient equipment

kWhr/m2

				4.1 Fossil fuel(s)	4.2 "Bio-fuels" & other fuels	4.3 Electricity grid	4.4 All-electric w/heat pumps	4.5 de-couple vent'n/temp	4.6 efficient components	4.7 efficient heat distribution	4.8 simple controls	4.9 use equip. to best effect	4.10 no refrigerant cooling	4.11 e-efficient lamps & fixtures	4.12 occupancy sensors	4.13 daylight sensors	4.14 Estar appliances (eg. copiers)	4.15 lowE user equip (eg. laptops)
				fuel				**HVAC**						**lighting**			**users**	
OFFICE	**447**		GTA - Police Station	◆	○	◆	○	◈	◈	◈	?	○	○	◈	○	○	○	○
		271	Herman Miller C1	?	◆	◆	○	○	?	◆c	?	◈	○	◆	◆	?	◆	?
	258		SAS Canadian HQ	◆	○	◆	○	○	?	?	?	○	○	?	?	?	?	◈
		219	Plaza at PPL	◆	○	◆	○	○	◆i	?	?	◈	○	?	◆	◆	○	○
	167		Holyrood RCMP	○	?	◆	◆	◆	?	◆	?	◈	○	◆	◆	◆	◆	◆
		94	Jean Canfield GOC	◆	○	◆	○	◆	?	?	?	?	○	◆	◆	◆	?	?
	69		Wind NRG	◆	◆	❖	○	◆	?	?	?	◆	◈	◆	◆	◆	◆	◆
	50		Gilman Ordway	○	○	❖	◆p	◆	?	?	?	◆	○	◆	◆	?	◆	◆
PUB. ASSEMBLY		*304*	Alice Turner Library	◆	○	◆	○	◆	◆	◆	?	○	○	◆	◆	◆	?	○
		293	Heimbold Vis. Arts	○	○	◆	◆	?	?	?	?	○	○	?	◆	?	?	?
	271		GTA - SAC	◆	○	◆	○	◈	?	◆	?	○	○	◆	◆	◆	◆	◈
	225		N Jones Courthouse	?	○	◆	○	◆	○	?	?	◈	○	◆	○	◆	○	○
	173		St. Gabriel's Parish	◆	○	◆	○	○	◆	○	?	○	○	?	?	○	?	?
	169		PAAM	◆	○	❖	○	○	?	?	?	◈	○	?	◆	◆	?	?
	100		Artists for Humanity	◆	○	❖	○	◆	◆	◆c	?	◆	◆	◆	◆	◆	?	◈
EDU		*243*	T.L. Wells Elem'ry	◆	○	◆	○	◆	?	?	?	◈	◈	?	?	?	?	?
	160		GTA - School	◆	○	◆	○	?	?	?	?	○	◈	?	?	?	?	?
	102		AJLC, Oberlin	○	○	❖	◆	◆	?	?	?	◆	○	◆	◆	◆	○	?
		74	Clearview Elem'ry	◆	○	◆	○	◆	?	◆c	?	?	○	?	◆	◆	?	?

Notes

◆i	ice storage system increases efficiency of chillers
◆c	extensive commissioning to verify equipment operating as designed
◆p	water-to-water heat pump replaced elec boiler

Legend

258	**actual energy intensity**
243	*predicted energy intensity*

7 "new normal"
9 "green"
3 "GTA default"

❖	grid-tied + generating onsite-see Figs. 4.5.33 & .41
◆	exceeds criterion
◈	at or near criterion
○	does NOT meet criterion
🟧	re climate see Figure 4.5.3

Operation #4: Specify efficient equipment

To the architect who has understood the local climate, reduced the loads in the design, and used any "free" energy that is available, McLennan then suggests:

> *"Only after each of the other steps has been done should the designer look to mechanical or technological solutions to design problems. At this point the designer should specify the most efficient and elegant solution possible." (2004)*

Figure 4.5.32 shows the equipment strategies used in the case study designs, under three categories: fuel source, heating ventilation and air conditioning systems (HVAC), lighting and users' equipment.

Here, the understanding of the researcher - a result of the tours and subsequent re-examination of information published by others - is presented, without the kind of in-depth analysis that a mechanical engineer might make. This comparison involves matters that are within an architect's purview, in her role as co-ordinator of the design team - including the general nature of the systems chosen, and the impact of the systems upon building occupants. While overall research remains focussed on parameters other than equipment, a comparison of the engineers' designs highlights several important matters, about which an architect ought to remain aware.

Use appropriate fuels **4.1**

Shift the fuel mix away from fossil fuels

As Figure 4.5.32 shows, 13 of the 17 projects, for which information is certain, rely on a fossil fuel as one of their energy sources. In most cases, the fuel is natural gas; none use conventional heating oil. One (Wind NRG) uses liquid propane gas (LPG), due to its rural location. There are 4 all-electric designs.

Use appropriate fuels **4.2**

Use "bio-fuels" & other fuels where locally available

Only two of the projects utilize so-called "current sunlight", in lieu of a fossil fuel. These are the cases already noted under Strategy 3.7, in which the "bio-fuel" is a waste product of a nearby industrial process (wood from the manufacture of furniture at Herman Miller C1, and wood pellets from local lumber mills at Wind NRG). No other instances of the use of "bio-fuels" were observed among the cases studied here.

Use appropriate fuels **4.3**

Share with electricity grid as much as is practical

All of the projects are tied to the electricity grid. In the GTA Police and GTA Elementary School, roughly half of the annual energy needs are supplied via the electricity grid, and half from burning fossil fuels.

The potential of site-generated electricity, to meet the energy needs within an individual building, is shown in Figure 4.5.33. In the five projects here, energy is collected using at least two sources - PV, solar thermal, or wind turbine equipment - in combination. To date, only the AJLC at Oberlin has shown a surplus - and this on an annual, not an instantaneous basis.

	ACTUAL Energy use: kWhr/m^2/yr		Quoted use ref. kWhr/m^2/yr	Purchased (all fuels) kWhr/m^2/yr	Generated on site kWhr/m^2/yr	of 'E'	On-site source type
OFFICE	69	Wind NRG	68 act.	48	21	30%	18 PV roof+trackers=74 kW peak 1 wind, 2 sol. therm preheats DHW
	50	Gilman Ordway	50 act.	33	17	34%	2,000 sf PV, rated 26.4 kW 96 sf solar thermal preheats DHW
PUBLIC	169	PAAM	88 **sim.**	84	4	4%	444 sf PV, rated 5.23 kW peak
	100	Artists	81 **sim.**	53	28	34%	7,000 sf PV, rated 45 kW peak
EDU	102	AJLC, Oberlin	102 act.	-13	115	113%	4,000 sf PV (bldg), rated 60 kW 7,000 sf PV (pkg), rated 100 kW
					average of 5 cases:	43%	

Figure 4.5.33
Energy generated on site as a percentage of overall usage

Use appropriate fuels 4.4

To avoid fossil fuels entirely, use all-electric systems

The 4 all-electric designs use heat pumps (ground-source or water-source) and hydronic distribution of heating and cooling. The Gilman Ordway Building on Cape Cod and Holyrood RCMP in Newfoundland run on a combination of grid-supplied power and energy generated on site. They can do so, only because the energy-intensity, by design, is so exceptionally low. This would also have been true of Clearview Elementary and PAAM, where ground source systems were planned, but not constructed (in the former case, for reasons of cost; in the latter, due to the failure of a similar system in a nearby village). As Figure 4.5.33 shows, at the AJLC at Oberlin, enough power was generated (in one of six years) to run the heat pumps, and feed electricity back into the grid. At the Gilman Ordway Building, heat pumps rely (for the present) more on the electricity grid than any other source. Nevertheless, the grid electricity used in this building is roughly 25% of that used in the GTA Police case.

The AJLC at Oberlin had, as one of its core design goals, to see whether it is possible to run a non-residential building at this latitude without fossil fuels. The logic of this in Ohio, where electricity is provided mainly by aging coal-fired generating plants, has been questioned (Scofield 2009).

The case of Heimbold raises the question of what is the upper limit of energy intensity at which all all-electric heating systems becomes impractical?

Figure 4.5.34
Boiler, HVAC & domestic hot water systems in the case study buildings

			≥90 % efficient	modular	central air handler (s)	ventil. air heats + cools the space	ventil. air ventilates only	radiant hydronic distribution		central heat pump (s)	in-room ht. pmp. or fancoil	gas or grid elec	site gen'd renew
	actual kWhr/m2/yr		**BOILER**		**HVAC**			heat	cool			**DHW**	
OFFICE	**447**	GTA - Police	○	✔	✔	cools	✖	✔	✖	○	○	✔	○
	258	SAS	?	?	✔[1]	✔	○	○	○	○	?	✔	○
	69	Wind NRG	n/a	✔	✔	○	✔	✔	✔	✔[8]	○	✔	✔[9]
	50	Gilman Ordway	n/a	n/a	✔	○	✔	✔	✔	✔	?	✔	✔[9]
PUBLIC	**271**	GTA - SAC	?	?	✔	cools	✖	✔	✖	○	○	✔	○
	173	St. Gabriel's	✔	?	✔	✔	○	○	○	○	✔[3]	✔	○
	169	PAAM	?	✔	✖	✔	○	○	○	○	○	✔	○
	100	Artists	✔	?	✔	○	✔	✔	✖	○	?	✔	✔[7]
EDU	**160**	GTA - School	?	✔	✔	?	?	?	?	○	✔[2]	✔	○
	102	AJLC Oberlin	n/a[4]	n/a	✔	cools	○	✔[5]	✖	✔	✔[6]	✔	✔[7]

Notes

[1] at SAS, two units; dehumidification added in 2009
[2] at GTA School - in-room fan coil?
[3] at St. Gabriel's fan coil units in narthex & nave provide local boost to air temp. in floor plenum
[4] at AJLC, original electic boiler was replaced with water-to-water heat pump in year ##
[5] at AJLC, radiant hydronic in floor, heated by electricity, supplements heat in atrium
[6] at AJLC, console heat pump units in each room condition space via floor plenum
[7] at AJLC & Artists, domestic hot water heated electically, from system largely powered by PV
[8] at Wind NRG, source is pond in Phase 1, spring water in Phase 2
[9] at Wind NRG & G. Ordway, DHW is htd by solar thermal if available; by another fuel when needed

Legend

✔ system exists as described
✖ part of system differs
n/a no equipment of this type
○ does NOT meet criterion

De-couple ventilation and temperature control

All buildings surveyed here have mechanical ventilation, delivered to each space from centralized fan equipment. Figure 4.5.34 shows that, in the three least energy intense buildings, and in others, ventilation is decoupled from temperature control. This decreases excess ventilation, and associated use of energy to drive central fans - as compared to other types of systems which deliver large amounts of air when temperatures fall outside an acceptable range.

At Wind NRG, and Gilman Ordway, both heating and cooling are delivered hydronically - either through radiant ceiling panels (valance convectors), in-slab tubing, fin-tube radiators, or fan-coil units (as shown in Figure 4.5.35). (At Artists for Humanity, there is no mechanical cooling, for which see item 4.9.) At GTA-Police and GTA-SAC, heating is delivered hydronically, while cooling is delivered by air that is conditioned within centralized equipment. (The systems are described graphically in Figures 4.2.71 and 4.2.76.) Equipment costs may be higher for the “hybrid” solutions. Also, some air is recirculated in the “GTA defaults”. In contrast, the fully decoupled designs in the “new normal” cases, accompanied by heat recovery in the ventilation stream (see tactic 3.8) allow 100% fresh air to be delivered at all times.

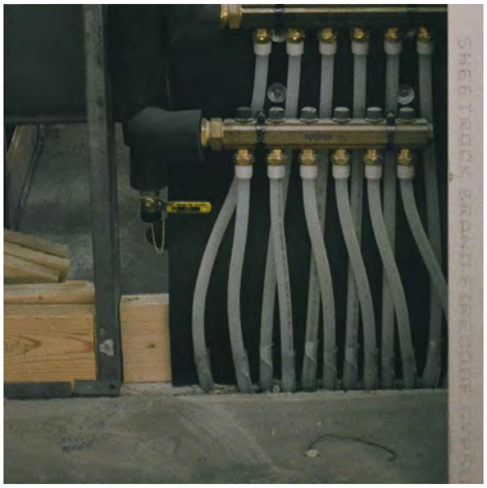


Figure 4.5.35
Hydronic distribution of heat through the floor slab at Wind NRG Phase 2

			Gross floor area sf	Total cooling capacity Tons	Floor area per Ton sf/Ton	Benchmarks sf/Ton
OFFICE	**447**	GTA - Police	45,995			
	258	SAS Canadian HQ	120,000			400 sf/Ton - "typical" office building
	219	Plaza at PPL	280,000	519	539	500 sf/Ton - "energy-efficient" building
	69	Wind NRG	27,500 [1]	30	917	
	50	Gilman Ordway	14,600	15	973	1,100 sf/Ton - "Green on the Grand" case
PUBLIC	*293*	Heimbold	60000	293	205	
	271	GTA - SAC	72,946			cooling in Admin. office only
	225	N Jones Courthouse	52,200	200	261	
	173	St. Gabriel's Parish	25,000			
	169	PAAM	19,500	52.4	372	
	100	Artists for Humanity	23,500	0	0	no mechanical cooling

Notes

[1] at Wind NRG, only 27,500 sf office area, of the total 46,500 sf Phase 1, is cooled

Figure 4.5.36
Total cooling capacity per floor area in selected cases

Design efficient HVAC 4.6

Choose efficient components

The efficiency rating of boilers, packaged HVAC units, and domestic water heaters is a subject for the mechanical engineers. A related issue is the size of units, particularly cooling equipment; a unit sized to handle peak cooling loads may be over-sized for the more regular loads, and may therefore waste energy by cycling on and off. Figure 4.5.36 shows the wide variation in the size of cooling equipment in the cases for which information is published, alongside typical benchmarks for office buildings (Stein 1986). Later research (beyond the scope of this study) may explain the reasons for this variation. Meanwhile, an architect ought to examine, and ask questions about, the overall size of central units.

Design efficient HVAC 4.7

Distribute heat efficiently & effectively

Air is the least efficient medium through which to deliver heat to a space, but it does disperse warmth through a space well. For heat delivery, electric convectors are more efficient; however fans, which use considerable energy, are still required to create comfort in a room. To combine efficient delivery with effective dispersion, many designers prefer an in-slab radiant hydronic system (see Figure 4.5.35, previous page). This type of system also is much quieter than forced-air systems, in which the frequent on-and-off cycling of the air stream can be an irritant in spaces intended for concentrated work.

Design efficient HVAC 4.8

Choose controls that are as simple as possible

Controls were a subject of frequent discussion during the site visits. Sophisticated electronic controls can save energy - particularly light sensors. However, complaints about HVAC controls showed ow complex, real-life conditions arise that are not anticipated well enough when control systems are designed. For instance, at Wind NRG Phase 2, controls on the in-slab radiant system were greatly simplified, in comparison to Phase 1. At PAAM, manual overrides were preferred by operators, when outdoor conditions were mild and humid (i.e. often). The interaction between users and automatic controls is an issue that demains close attention in the future (see Figure 4.5.37).

Design efficient HVAC 4.9

Use equipment to its best effect

This principle can best be observed in the least energy-intense designs, although it also is present in some of the others. It means using alternate sources of energy, and unusual equipment to the greatest extent possible, while also accepting that climate conditions demand the use of "conventional" (i.e. since the 1950s) measures, in order to maintain acceptable conditions for comfortable work. The ice system at the Plaza at PPL is one example of this principle at work.

VENTILATION AND CLIMATE CONTROLS

THIS STUDIO IS CLIMATE CONTROLLED

Studio doors should remain closed.

Generally, windows should remain closed.

To clear the air of unwanted fumes: use the ventilation fan. This will disengage the climate-controlled system (see black dial).

To open the windows: please turn on the exhaust fan first. This will disengage the system so energy is not wasted.

Only when the GREEN LIGHT is illuminated (next to the ventilation dial) can the windows be opened without activating the fan.

If you have any questions,
please talk to a staff member in the office.

WINDOW USAGE

THESE STUDIOS ARE CLIMATE CONTROLLED.

PLEASE READ VENTILATION GUIDELINES BEFORE OPENING WINDOWS

THANK YOU!

Figure 4.5.37
Control of ventilation systems at PAAM

At some of the projects, energy sources are combined differently in different seasons. For instance, in the project where solar thermal collectors heat domestic hot water, they do so when sunshine is available; power from the grid is used on cloudy - and most winter - days. The same principle applies to the whole building, in those cases where a substantial amount of electricity is generated using PV panels. The "best effect" principal was at work when the roof that supports the PV panels at Wind NRG was pitched at a suitable angle for the collection of solar energy during the summer, when it is available - rather than winter, when more energy overall is needed.

Also, as a result of the 2003 blackout (which affected most of Ontario and the U.S. Northeast for up to 3 days), value is perceived in "energy security" - that is, having an energy source close at hand, rather than being totally reliant on a multi-region electricity grid.

	kWhr/m²/yr		Heat	**Cool**	Light	Fa/Pu	Plug	Vert	DHW	Other	
OFFICE	*416*	GTA Police 2004	57%	*5%*	16%	12%	0%	0%	8%	3%	*sim.*
	271	H Miller C1	27%	*39%*	11%	7%	17%	0%	0%	0%	*sim.*
	219	Plaza at PPL	18%	*15%*	12%	23%	32%	0%	0%	0%	*sim.*
	68	Wind NRG	46%	**6%**	14%	7%	25%	0%	3%	0%	**actual**
PA	**79**	Artists	43%	**2%**	16%	2%	17%	0%	21%	-2%	**actual**
EDU	**160**	GTA School	55%	*0.7%*	28%	23%	0%	0%	28%	5%	*sim.*
	97	AJLC, Oberlin	47%	**7%**	13%	4%	17%	0%	1%	10%	**actual**
	73	Clearview Elem.	22%	*6%*	16%	32%	9%	0%	3%	13%	*sim.*
		average ALL:	39%	10%	16%	14%	15%	0%	8%	4%	
		average 2 GTA "defaults":	56%	3%	22%	17%	0%	0%	18%	4%	
		average 6 "new normal":	34%	13%	14%	12%	19%	0%	5%	4%	

Figure 4.5.38
Energy mix in the case study buildings

Design efficient HVAC **4.10**

Eliminate refrigerant-based cooling systems

In a cool-humid climate, cooling demands only a small fraction of the overall annual energy use. Figure 4.5.38 shows the apportioning of 6 of the 19 cases, for which information has been published - either through a report of actual energy use (bold figure) or in an energy model (figure in italics).

A few buildings have sections that are not cooled mechanically. One example is the warehouse at Wind NRG - dug into the hill, it benefits from constant cool temperature of the soil on three sides. The GTA - School (elementary level) is not cooled, with the exception of the administrative office, which occupies roughly 10% of the total floor area. The only other design that does not incorporate cooling is Artists for Humanity (see tactic 3.5).

	actual kWhr/m2/yr		T5	T8	T10	T12	HID		recessed light	pendant indirect	mainly indirect (
			LAMP						**LUMINAIRE**		
OFFICE	**447**	GTA - Police				✔			✔		
	258	SAS	✔							✔	✔
	69	Wind NRG		✔						✔	
	50	Gilman Ordway		✔							
PUBLIC	**271**	GTA - SAC		?						✔	
	173	St. Gabriel's					✔			✔	
	169	PAAM						✔			
	100	Artists		✔							
EDU	**160**	GTA - School		?							
	102	AJLC Oberlin		?						?	

Figure 4.5.39
Lamps & lighting fixtures in the case study designs

a (top) - lamps & fixtures used in selected cases

b (bottom) - energy draw of typical fluorescent lamps

T5

5/8″	21″ long	13 W
7.4 W/lin. ft.		

T8

1″ dia.	12″ long	13 W
	48″	28 W
7 W/lin. ft.		

T10

1.25″	48″ long	110 W
27.5 W/lin. ft.		

Choose lighting & controls *4.11, 4.12 & 4.13*

Lamp & fixture types

In 10 of the 11 cases for which information is known, the use of "energy efficient lighting" is reported. Figure 4.5.39a shows the lamp and fixture types used in selected cases. Figure 4.5.39b presents information about the power draw from lamps currently available. *

Occupancy sensors

As shown in Figure 4.5.32, occupancy sensors are used in 13 of the 15 cases for which information is known, and they are used in 5 out of 6 "new normal" cases. Only 1 of 3 "GTA default" cases includes occupancy sensors (GTA-SAC). The prevalence of this strategy is probably due to its low cost, and lack of impact on the architecture.

Daylight sensors

Figure 4.5.32 also shows that most, but not all, designs that incorporate occupancy sensors also include daylight sensors. In 10 out of 12 cases for which information is known, daylight sensors are used.

It is difficult to deduce how much effect these devices have by observing that they are present at a range of energy intensities. Daylight sensors may exert a powerful influence - particularly if combined with Strategy 2.7, "floor plates min. 60′ one way".

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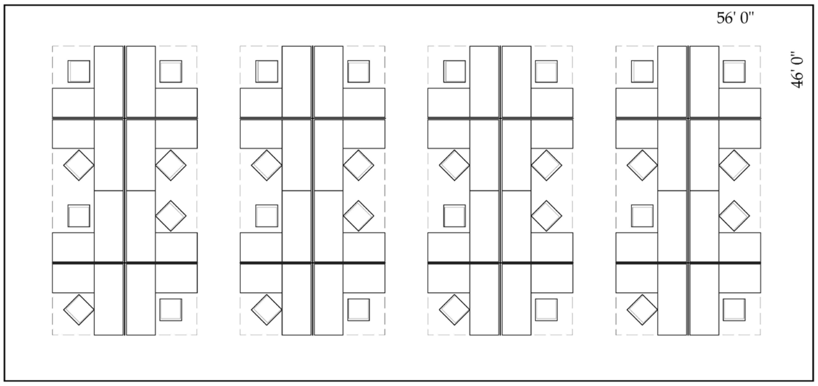
* from http://www.gelighting.com, accessed 29 September 2009

Figure 4.5.40
Study of plug loads in a selected portion of GTA - Police

a (top) - plan of open office

b (bottom) - plug loads using alternative desktop equipment



1,456 sf office pool
135 m2

Desktop equipment	**qty.**	**Watts**	**hrs/yr**		**kWhr/yr**	
CPU active/on screensave	32	250	4,400	=	35,200	
CPU in sleep mode	32	6	4,360		837	
CRT monitor	32	80	2,400		6,144	**312.5** kWhr/m2/yr
CPU active/on screensave	32	250	4,400		35,200	
CPU in sleep mode	32	6	4,360		837	
LCD flat screen	32	35	2,400		2,688	**154.9** kWhr/m2/yr
laptop	32	30	2,400		2,304	
flat screen	32	35	2,400		2,688	**20.0** kWhr/m2/yr

Choose occupant equipment **4.14 & 4.15**

Choose low-energy appliances & desktop equipment

The potential impact of "unregulated plug loads" on whole-building energy-intensity is significant. A small study, illustrated in Figure 4.5.40, estimates the energy use of the portion of the GTA - Police office (the same that is depicted in Figure 4.5.18 in relation to lighting power density). As the furniture plan shows, the open office can accommodate up to 32 desks (Figure 4.5.40a). In Figure 4.5.50b, a consistent set of assumptions is made about the number of hours the equipment is used (this office is occupied for two shifts, 5 days per week, every week of the year). The resulting energy intensity spans more than a ten-fold range. *

In 5 of the 9 case study designs, for which information about this issue is known, "energy Star" appliances and energy-saving desktop equipment were preferred over "conventional" alternatives.

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*power use of computer equipment from http://www.michaelbluejay.com, accessed 3 November, 2009

Summary

The 3 “GTA default” designs and the 16 other designs are similar in many respects. However, there are also some very significant differences that have an impact on the energy-intensity of the overall design.

The two groups are not so different when it comes to fuel use. Fossil fuels meet much of the demand for energy in the majority of cases studies here, and all of the buildings remain firmly tied to the electricity grid. Also, all of the buildings are ventilated mechanically by centralized systems. Decoupling ventilation from climate control is a popular approach among both the “GTA” and the “new normal” cases. Recent advances in lamps and light fixtures mean than lighting power density levels at around 18 W/m^2 are achievable with “GTA default”-type lighting plans, based on recessed fluorescent downlights. Occupancy sensors are commonly seen in all types of cases.

Cooling is eliminated in part of a building as often in the 3 “GTA defaults” as in the other 16 cases. The complete avoidance of refrigerant-based cooling appears in only 1 of 19 cases, Artist for Humanity. Other cases show that it is not necessary, in this climate, to eliminate cooling, to achieve “high performance”. The total cooling capacity per floor area in the “new normal” cases ranges from 261 sf/Ton to 972 sf/Ton; more floor area per Ton of cooling seems to correlate to less energy-intensity. Still, cooling represents, on average, only 13% of the total energy used by a non-residential building in this climate (see Figure 4.5.38 and Appendix 5).

The key strategies that distinguish the 16 “new normal” cases are:

- there is a shift away from fossil fuels (4 all-electric designs and 2 that use “bio-fuel”, i.e. waste wood, to meet part of its need),
- ventilation is de-coupled from both heating and cooling in the three least energy-intense designs, but from heating only in the two “GTA default” designs,
- daylight sensors are used often in the “new normal” designs,
- indirect or direct-indirect lighting designs are preferred in the “new normal” approach, achieving LPDs around 10 W/m^{2,}
- there is a strong preference for energyStar-rated office equipment in the “new-normal” cases,
- the least energy-intense designs were early adopters of laptops, flat screens in lieu of CRTs, and centralized printers.

Perhaps most significant is the tactic of using energy to “best effect”, particularly in relation to the seasons. This tactic seems to set the least energy-intense “new-normal” designs apart from the others.

Figure 4.5.41
Order of Operation #5
in the case study buildings

5

Renewable energy sources

kWhr/m2

				5.1 groundsource / watersource	5.2 active solar (air or water)	5.3 photovoltaics	5.4 on-site wind generation	5.5 purchased "green" power	5.6 combustion of "biomass"
				equipment alternatives					
OFFICE	**447**		GTA - Police Station	-	-	-	-	-	-
		271	Herman Miller C1	-	-	-	-	-	◆c
	258		SAS Canadian HQ	-	-	-	-	-	-
		219	Plaza at PPL	-	-	-	-	◆	-
	167		Holyrood RCMP	◆	-	-	-	-	-
		94	Jean Canfield GOC	-	-	◆	-	-	-
	69		Wind NRG	◆	◆	◆	◆	-	◆w
	50		Gilman Ordway	◆	◆	◆	◆f	-	-
PUB. ASSEMBLY		*304*	Alice Turner Library	-	-	-	-	-	-
		293	Heimbold Visual Arts	◆	-	-	-	-	-
	271		GTA - SAC Cambridge	-	-	-	-	-	-
	225		N Jones Courthouse	-	-	-	-	-	-
	173		St. Gabriel's Parish	-	-	-	-	◆	-
	169		PAAM	-	-	◆	-	◆	-
	100		Artists for Humanity	-	-	◆	-	◆	-
EDU		*243*	T.L. Wells Elementary	-	-	-	-	-	-
	160		GTA - Elementary School	-	-	-	-	-	-
	102		AJLC, Oberlin College	◆	-	◆	-	-	-
		74	Clearview Elementary	-	-	-	-	-	-

Notes

◆f	installation planned in future
◆w	two boilers fired by wood pellets
◆c	central plant burns waste wood from furniture manufacturing

Legend

258	**actual energy intensity**
243	*predicted energy intensity*
	7 "new normal"
	9 "green"
	3 "GTA default"

◆	exceeds criterion
◇	at or near criterion
○	does NOT meet criterion
🟧	re climate see Figure 4.5.3

Operation #5, Use renewable energy sources
As illustrated in figure 4.5.41, twelve of the nineteen buildings use energy from a renewable source of one kind or another - in all cases combining electricity generated on the site via photovoltaic collectors with energy from the grid.

It appears, from the matrix, that the level of energy-intensity correlates with the use of renewable energy. This is not a causal relationship; the energy intensity figures quoted throughout this section are total usage; they would be the same whether or not renewable sources supplied the energy (see Figure 4.5.33). Given all of the factors in play, including the owner’s intent in choosing to use renewable energy, and the cost of doing so in today’s market, it appears that PV in particular becomes practical only when the whole-building energy intensity is at or below around 150 kWhr/m^2/yr.

Renewable energy can be used effectively only after the loads in the design are reduced by other means. Figure 4.5.42 shows the size of the arrays at two of the very low-load cases. At Artists for Humanity, a 45 kW array covers the 7,000 sf roof and provides approximately 34% of the annual energy needed in this 23,500 sf building. At the AJLC, the original 60kW-rated (45 kW actual) array covers the whole 4,000 sf roof of the main building, and a 100 kW array was added, after a few years of occupancy, when the 8,500 sf parking lot shelter was constructed. Together these two arrays have provided for all of the demand in the 13,600 sf AJLC building in a particular year. However, the efforts at the AJLC show the challenge in balancing energy demand with available area for a PV array. If either of these buildings were larger, or more energy-intense, then the area of solar collector that would be required to provide a substantial quotient of the energy needed would be impractical - particularly in an urban context. At today’s utility rates, such an array might not be cost-effective in any context.

Some sites permit the use of an assortment of renewable energy devices. For instance, the wind turbine is a suitable installation at Wind NRG, in rural Hinesburg, Vermont. The site at Gilman Ordway, in

Figure 4.5.42
Photovoltaic arrays of various sizes

a (top) - covering the entire roof surface at Artists for Humanity, and
b (bottom) - overflowing onto a shed roof, over the parking lot, at the AJLC at Oberlin

view of the Atlantic Ocean, near the western tip of Cape Cod, also is opportune for a wind turbine - although the historic character of the place may argue against such an installation. At a building like Artists for Humanity (in urban Boston), or even PAAM (which is in a relatively built-up neighbourhood at the east end of Cape Cod), such an installation would not be reasonable.

Ground-source or water-source heat pumps are used where site area and soils conditions permit. Localized failures and the capital of such systems often argues against their use - as was the case at PAAM, Clearview Elementary, and GTA-SAC.

Solar collectors are enjoying a resurgence in demand, particularly in the U.S. Northeast, and parts of Europe, and particularly for the heating of domestic hot water. Figure 4.5.43 shows three types on display at the 2010 conference of the North East Sustainable Energy Association in Boston. Solar thermal collectors are installed on the roofs at Wind NRG and Gilman Ordway; in each case the hot water systems are boosted by solar energy and powered by grid-supplied electricity when solar energy is not sufficient to fulfil the need. Such installations are rare in non-residential applications, but are proliferating in single-family homes at present.

It appears that at these northerly latitudes, no single technology for generating renewable energy on-site is likely to be sufficient to provide all of the energy needs in a non-residential building. The strategy of combining complementary technologies, keeping the local climate in mind, seems to be the most effective in the cases examined here.

Figure 4.5.43
Types of solar collector
a (top) - evacuated tube with fluid coils (Absolute Green Energy)
b (middle) - flat plate solar hot water (Wagner & Co)
c (bottom) - evacuated tube with titanium-coated copper absorber (Viessmann)

Does order matter?

The search for best practices, using the Strategy Grid, has shown that more operations seem to lead to lower energy intensity. However, the relationship between the number of operations and the energy intensity is not evenly linear. This suggests that the quality, integration, or grouping of strategies may matter as much or more than their sheer number. Figure 4.5.44 (overleaf) compares the frequency with which each of the strategies appears in the “new normal” cases to the frequency in the “GTA default” cases. The idea that there is an “order of operations” is validated, to a degree, through this analysis.

Step #1, to “Understand Climate and Place”, clearly is the precursor to the whole endeavour. The design decisions seen in the case study buildings fit well into the Strategy Grid, when it is conceived through the question “what does this place need us to do?”

Step #2, to “Reduce Loads” clearly is critical to lowering energy intensity. The greatest difference between the “new normal” cases and the “GTA defaults” are in this category; eight out of eleven design strategies appearing more frequently, by a significant margin (more than 13%). While the window-to-wall ratio (WWR) is limited to approximately 40% in both groups of cases selected here, high values for the thermal resistance of the enclosure, technically advanced windows, and strategies to control air infiltration are characteristic of a higher percentage of the “new normal” designs than the “GTA default” designs. Solar gains are managed more often in the “new normal” designs than in the “GTA defaults”, through the use of exterior shades on the windows and a shaded or high albedo roof surface. Lighting power density is kept in check. The consistent improvement in the “new normal” designs, as compared to the “GTA defaults”, with respect to so many of the strategies in the “Reduce loads” category suggests that these have a high priority in this climate.

Contrary to many statements in the literature, the designs examined here do allow glass in at least one of the east or west facades to occupy more than 15% of the wall area. Also contrary to the expectations of some, the “new normal” designs seem to be freer than the “GTA default” designs with respect to overall form; in this group, the “new normal” approach prefers a slender floor plate over a compact mass, pairing the strategy with lighting controls, and saving electricity in the process.

Step #3, to “Use free energy” also shows some significant differences between the “new normal” and “GTA default” approaches; six out of eight design strategies are chosen with much higher frequency in the “new normal” group. In fact, “free energy” is almost never tapped, in the “GTA default” designs. When it is, the initiative is so minor that it seems almost accidental - in these cases, only one instance of storage of heat in thermal mass (a given in the renovation at GTA-SAC, due to its solid masonry exterior wall) and one instance of a small amount of heat recovery (at GTA-Police) were observed.

Figure 4.5.44
Summary of best practices

STRATEGIC APPROACH		TACTIC	See Figure 4.6.1	7 full appraisals			GTA defaults			all 16 n-n		
				exceed criterion	number in group	% of group that exceeded	meet or exceed	number in group	% of group that met or exceeded	meet or exceed	number w/info	% of known that met or exceeded
Understand Climate		*average ekWhr/m2/yr for group:*		*132*			*314*			*210*		
COOL - HUMID		*average ekWhr/m2/yr for group (floor-area weighted):*		*174*			*300*			*189*		
2	2.1	solid wall > R-20		3	7	43%	1	3	33%	9	12	75%
Reduce Loads	2.2	roof > R-30		4	7	57%	0	3	0%	7	9	78%
	2.3	window < U_{imp} 0.26		4	7	57%	1	3	33%	14	14	100%
Minimize heat loss	2.4	openings ≤ 40% o/ /a façade area	M2, E2	5	7	71%	3	3	100%	10	11	91%
	2.5	air infiltration "controlled"		7	7	100%	1	3	33%	11	12	92%
	2.6	compact mass - l : w ≤ 1 : 1.5		2	7	29%	3	3	100%	7	13	54%
Manage internal gains	2.7	floor plates ≤ 60' min. 1-way	E2	4	7	57%	1	3	33%	10	16	63%
	2.8	lighting power density ≤ 10W/m2		4	7	57%	1	3	33%	8	9	89%
Manage solar gains	2.9	glass east or west ≤ 15% façade	M2	2	7	29%	1	3	33%	6	11	55%
(maximize in winter, and	2.10	exterior shading of windows	M2, E2, B2	5	7	71%	0	3	0%	12	16	75%
minimize in summer)	2.11	roof white or shaded		7	7	100%	1	3	33%	9	12	75%
Manage building utilization	2.12	modify pattern of use		-	-	-	-	-	-	-	-	-
3												
Use free energy	3.1	orient building spine east-west	M3	3	7	43%	0	3	0%	6	16	38%
	3.2	south façade WWR ≥ 40%	M3, E3, B3	4	7	57%	0	3	0%	12	16	75%
Use passive solar strategies	3.3	store energy in thermal mass		2	7	29%	1	3	33%	4	14	29%
	3.4	operable windows (automatic)		2	7	29%	0	3	0%	11	14	79%
	3.5	night pre-cooling		1	7	14%	0	3	0%	2	15	13%
Use passive ventilation	3.6	displacement ventilation	E3	3	7	43%	0	3	0%	11	14	79%
	3.7	tap into district heating system		0	7	0%	0	3	0%	3	16	19%
Re-capture waste energy	3.8	heat/energy recovery units		7	7	100%	1	3	33%	10	11	91%

STRATEGIC APPROACH		TACTIC	See Figure 4.6.1	7 full appraisals			GTA defaults			all 16 n-n		
				exceed criterion	number in group	% of group that exceeded	meet or exceed	number in group	% of group that met or exceeded	meet or exceed	number w/info	% of known that met or exceeded
Understand Climate		*average ekWhr/m2/yr for group:*				*132*			*314*			*210*
COOL - HUMID		*average ekWhr/m2/yr for group (floor-area weighted):*				*174*			*300*			*189*
4 **Spec. efficient equipment**	4.1	fossil fuel(s)		5	7	71%	3	3	100%	10	14	71%
	4.2	"bio-fuels" and other fuels		1	7	14%	0	3	0%	1	15	7%
	4.3	electricity grid		7	7	100%	3	3	100%	16	16	100%
Fuels	4.4	all-electric with heat pump(s)		2	7	29%	0	3	0%	4	16	25%
	4.5	de-couple vent'n from temp. cntrl	E4	3	7	43%	2	3	67%	10	15	67%
Design efficient HVAC	4.6	efficient components		1	1	100%	0	3	0%	4	5	80%
	4.7	efficient heat distribution		1	1	100%	2	3	67%	5	6	83%
	4.8	simple controls		-	-	-	-	-	-	-	-	-
	4.9	use equipment to best effect		4	7	57%	2	3	67%	10	14	71%
	4.10	no refrigerant cooling		1	7	14%	1	3	33%	4	16	25%
	4.11	specify effective luminaires		6	7	86%	2	3	67%	9	9	100%
Lighting types & controls	4.12	include occupancy sensors	E4	4	7	57%	1	3	33%	12	13	92%
	4.13	include daylight sensors	E4	4	7	57%	1	3	33%	10	11	91%
Choose equip. for occupants	4.14	major appliances eStar		3	7	43%	0	3	0%	4	7	57%
	4.15	desktop equipment eStar		4	7	57%	0	3	0%	5	8	63%
5 AFTER making other choices **Use Renewable Energy**	5.1	groundsource / watersource	M5, E5, B5	4	7	57%	0	3	0%	5	16	31%
	5.2	active solar (air or water)		2	7	29%	0	3	0%	2	16	13%
	5.3	photovoltaics		5	7	71%	0	3	0%	6	16	38%
	5.4	on-site wind generation		2	7	29%	0	3	0%	1	16	6%
	5.5	purchased "green" power		3	7	43%	0	3	0%	4	16	25%
	5.6	combustion of biofuels		1	7	14%	0	3	0%	2	16	13%

In the “new normal” approach, strategies in this category are used in some of the designs, but not used as consistently as are the “reduce loads” strategies noted above. The two “use free energy” strategies with strongest showing are: to open the south facade to more than 40% WWR (57% of “new normal” cases), and to provide heat recovery in the ventilation system (100% of “new normal” cases).

With regard to Step #4, “specify efficient equipment”, the “new normal” cases show some common traits and some differences, in comparison to the “GTA defaults”. In the “new normal”, fuel use is shifted slightly away from fossil fuels towards bio-fuels (waste wood from nearby industry) or all-electric designs. All cases in both groups are firmly connected to the electrical power grid. The HVAC systems in the “GTA default” cases appear no less advanced than those in the “new normal” cases; however efficient lamps, occupancy and daylight sensors, and energy-efficient appliances and desktop equipment are used more often in the “new normal” cases.

Step #5, the on-site generation of renewable energy clearly becomes feasible only within the “exemplary” end of the energy-use spectrum. In the cases examined here, renewable energy appears just below the 150 kWhr/m^2/yr mark, and lower. The average proportion of total annual energy need provided in five designs by site-generated power is 43%.

The idea that the sequence of strategies matters is supported by this analysis. Step #1, to “Understand climate” is evident in all of the “new normal” designs. Strategies to “Reduce Loads” (step #2) distinguish the “new normal” cases from the “GTA defaults” by how consistently many of them are used, not by the degree to which they exceed “normal” practice. Strategies to “Use Free Energy” (step #3) are used a little less often than “reduce loads” strategies in the “new normal” cases examined to date. If their use increases in the future, the degree of impact on whole-building energy intensity may not be as significant as that already realized by heat recovery in the ventilation air stream. Equipment of moderately high to high efficiency is part of most designs in both categories. No instance of a design with exemplary equipment (step #4) combined with moderate or little use of strategies from steps #2 and #3 was observed.

4.6 SYNERGIES AND RISKS WHEN "LOW-LOAD" MEETS "HIGH-SATISFACTION"

In Section 4.2, the Questions of Design Quality (QDQ) were applied to each case study, to record the impressions from the field visits. That exercise provided the raw material for the following analysis, which aims to discover the issues when "low-load" rubs up against "high-satisfaction". The inquiry addresses the following questions:

- Are there specific synergies that can be named?
- Are there risks in certain areas? and
- What strategies did the designers employ, to capture the synergies and resolve the risks?

The case studies were selected because they appeared, at first, to be successful as both low-energy and high-satisfaction designs. The research - in the library and in the field - proved this to be true. Yet, the experience of each building was eye-opening, in ways that the literature was not. For example, one building accommodated the researcher's activities easily, for an entire day, proving that a "green" building may afford as much comfort and flexibility as any other. In contrast, another building made the visitor rather uncomfortable - intentionally. On another field visit, an office building seemed as impressive as could be - as a practical design, perfectly appropriate to its context, and very comfortable for its occupants. Later, a church displayed an even deeper integration of environmental, technical, and - in its case - spiritual concerns. Many more such contrasts might be listed.

Another type of analysis might begin with the site conditions - or the project goals - and work toward a more general comparison. But that has been done, in the published reports about these buildings,

Figure 4.6.1
Synergies and risks, when energy-reduction meets the conditions of high-satisfaction design

Strategic approach to energy-reduction	High-Satisfaction Conditions			
	Meaningful	**Enjoyable**	**Beautiful**	**Clever**
1 **Understand Climate and Place**	**Synergy M1** Elements of local character may help convey message	**Synergy E1** Customization may lift occupants' spirits - esp in 4 seasons	**Synergy/Risk B1** Regional character helps sustain the uniqueness of a place	**Synergy C1** Demands BOTH analysis AND experience
			Synergy/Risk B1 Regional idea of "beauty" may not be "contemporary"	
2 **Reduce Loads**	**Risk M2** Reducing % glass may narrow options for expression	**Synergy E2** Skinny floor plates may increase views & orientation	**Synergy B2** Use of exterior sunshades may add design interest	**Synergy C2** Real load redux implies knowledge & co-ordination
(minimize heat loss, manage internal & solar gains)	**Risk M2** Avoid e- & w- glass may narrow options for expression	**Risk E2** Reducing % glass may result in less comfort or delight		
3 **Use free energy**	**Risk M3.1** To align bldg spine e-w, may negate good urban design practice	**Synergy E3** Attention to ventilation may improve air quality	**Synergy/Risk B3** Passive solar & engaging public space may coincide	**Synergy C3** Use of emerging technology implies cleverness
(passive solar or ventilation, recapture waste energy)	**Risk M3.2** To orient most glass south, may not suit context or message	**Risk E3** Demands of passive solar may challenge functional plan	**Synergy/Risk B3** Non-rectilinear forms may help or hinder passive solar	**Risk C3** Places very significant demand on lead arch't & eng'rs
4 **Specify efficient equipment**	**n / a**	**Risk E4.1** Alternative climate control systems may lower comfort	**n / a**	**Synergy C4** Careful choice of equipment implies cleverness & co-ord
(e.g. HVAC, lighting types & controls, appliances)		**Risk E4.2** Automatic control of lighting may create inconveniences		**Risk C4** Complex systems may be difficult to operate and maintain
5 **Generate renewable energy on site**	**Synergy M5** Renewable e devices may speak of future vision	**Synergy E5** Most systems operate quietly and are relatively compact	**Synergy/Risk B5** Demands of active solar may clash with formal preferences	**Synergy C5** Use of emerging technology implies cleverness
(e.g. PV, solar thermal, wind, geothermal	**Risk M5** Renewables may clash with other messages	**Synergy E5** Less combustion --> cleaner air; off-grid may --> e security		**Risk C5** Added demand on lead arch't & eng'rs, esp. to co-ordinate

and in the “green design” manuals - where the focus tends to be on individual physical elements, not on the underlying architecture. Here, the analysis begins with the challenge to meet both environmental and human goals, and illustrates how an architect might resolves several pairs of intentions. The way in which a design decision captures a synergy or resolves competing priorities is of primary interest.

Several potential synergies and risks can be identified. The most obvious relationships between an energy-reduction operation (from the Strategy Grid) and a conditions of a satisfying design (from the QDQ) are presented in Figure 4.6.1. The next several pages are devoted to a brief discussion of the nature of these relationships - as risks to be managed, or synergies to be captured. Many of the individual risks or synergies could be the object of focus of more in-depth research.

The analysis emphasizes the categories “Meaningful” and “Enjoyable” – because these were identified, in the QDQ, as the most important attributes of a “high-satisfaction” architecture. Fewer examples are given under “Beautiful”, because some already are covered under “Meaningful”. In the last category, “Clever”, the matrix hints at a few challenging aspects of co-ordinating a design team. While these are important to note, this research focusses on the architect’s decisions – not on the overall process of project delivery. Therefore, the analysis touches on the “Cleverness” issues only lightly, and closes with a few examples of Not-so-Clever design decisions – for which the architect in question may have been responsible.

The application of the QDQ helped to articulate how and why a particular design is more or less satisfactory than another. Once this is made explicit, it is possible to appreciate, more fully, the role of architectural strategies that are employed repeatedly.

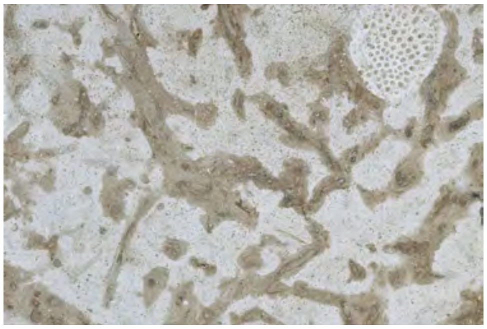
In the QDQ, the first category of design excellence is “Meaningful”. This involves considerations of context, community vitality, welcome, future vision and - above all - the question of what is the intended message of the design.

Meaningful

MEANINGFUL + 1-UNDERSTAND CLIMATE & PLACE

Synergy M1: Through the study of the uniqueness of a climate and place, a designer may adopt architectural elements of local character. To convey a message effectively, it helps to speak a “known language”.

Figure 4.6.2
Synergy by using endemic materials



a (top): Tyndall stone at St. Gabriel’s Church

b (below): Restored wetland at the AJLC at Oberlin College

Examples of Synergy M1:

At St. Gabriel’s - where the message is that worship might involve the appreciation of all of creation - the Tyndall stone cladding, containing fossils is a reminder of the ancient history of the terrain just west of the Great Lakes Basin (see Figure 4.6.2a).

At Oberlin - where the message is that a new relationship between humankind and nature should be established - the “restored wetland”, surrounded by wild native plants, is a powerful symbol. The neighbours (with manicured lawns) are reminded of the original ecology – and how far outside that ecology current settlement practices lie (see Figure 4.6.2b).

At Wind NRG - where the message is that a high-tech manufacturing company is an attractive place to work - the “ski-lodge” exterior, hand-crafted wood millwork and furniture, and painted floor panels speak of Vermont traditions and create a welcoming, comfortable character (outside and inside) for a very unusual high-performance building (see Figure 4.6.3a).

At Artists for Humanity - where the message, to at-risk youth, is”yes you can turn your circumstance into an artful expression” - the metal siding, characteristic of the old dockside sheds around the Boston seaport, and of the building’s immediate neighbours, is used with some added design flair (see Figure 4.6.3b).

At PAAM - where the message is that this place is "in the big leagues" of contemporary art - traditional elements that are associated with the local ocean-side (shingles, board-form concrete, and belvederes) are re-interpreted in a contemporary idiom. The two aspects of PAAM - its membership in the national art scene and its importance as a local institution - are bound together in the very fabric of the building (see Figure 4.6.3c).

Figure 4.6.3
Synergy by speaking a local architectural language

a (top): office building as ski lodge, at Wind NRG

b (middle): corrugated steel siding at Artists

c (bottom): re-interpreting the shingle style at PAAM

MEANINGFUL + 2-REDUCE LOADS

Risk M2: Reducing the percentage of glass (and/or avoiding east- or west-facing glass) may narrow options for expressing a message, or enhancing enjoyability or beauty.

These risks may be perceived by some designers, who like to locate glass to suit the surface of an elevation, and who are not accustomed to working within limitations stemming from an energy-management agenda. In five of the seven case study designs, this perception (if it existed) was overcome by the designers. At the remaining two projects (Artists for Humanity and Gilman Ordway), site conditions would have restricted the amount and orientation of glass, regardless of energy-efficiency goals. In all of the case study designs, the window-to-wall ratio (WWR) is less than 40%. In most, the majority of glass faces south; however, in the five projects where the risk is mitigated, there is some east- and west-facing glass. Several design strategies show how limiting glass area and orientation does not necessarily preclude a very effective expression of a message through the architecture.

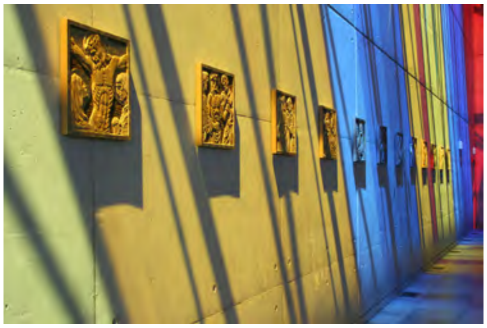
Design strategy M2a: Restrict the WWR to no more than 40%, and introduce daylight of varying quality, from several directions.

At St. Gabriel's, the art installation - through which sunlight casts constantly changing patterns of coloured light on the walls of the nave - creates a very unusual quality of daylight, that turns the contemplative imagination of the worshipper to the movement of celestial elements (see photo, top left). The shafts of coloured light contrast with the large expanse of white daylight coming through the south-facing, fully glazed curtain wall (see Figure 4.6.4a, overleaf). While constraining the ***quantity*** of daylight that enters the whole building enclosure, the ***quality*** of daylight (in all its variety) is not just appealing, and not just integrated - it is the primary vehicle through which the message of the design is conveyed.

At the AJLC at Oberlin College, daylight is introduced from all four directions and from various heights. The effect may not be noticed consciously by everyone who enters the building, but the subtle play of natural light creates the "airy" feeling of the building, particularly on the second floor (see Figure 4.6.4b). From indoors, daylight conveys the primary message of the building (i.e. that humankind ought to be re-connected to natural systems), penetrating fully into the floor plate (which is just 45 feet wide). From outdoors, the building has enough transparency (even at the limited WWR) to invite curious passers-by to look into the main assembly spaces and the Living Machine.

At the Gilman Ordway Building (at Woods Hole Research Center), a small floor plate is illuminated to the core, as at Oberlin, by daylight entering from three sides (see Figure 4.6.4c).

Figure 4.6.4
Mitigating a risk by using daylight in various ways



a (top) - passing through dichroic glass at St. Gabriel's
b (middle) - AJLC, upper level
c (bottom) - Gilman Ordway

(images: a Roberto Chiotti, b Judy Watts Wilson)

Design Strategy M2b: Limit the amount of glass that faces east and west, but use it to maximum advantage.

At Oberlin, west-facing glass is limited to the ends of the main corridors (on both levels) - where it serves as an effective orientation device.

At Wind NRG, east- and west- facing glass make up approximately 16% of the wall area. Windows are situated at the end of circulation spaces - providing orientation and views out over the landscape (see photo, lower left).

Design Strategy M2c: Include high-level openings (very tall windows, clerestories or skylights) for added expressive potential.

In all of the case study designs, natural light enters the building through high-level openings, as well as through windows at eye level. The only design that does not incorporate skylights and/or clerestory glazing is Artists for Humanity. There, the window heads are typically

12 feet above floor level, allowing daylight to penetrate deep into the floor space, and contributing to the "studio" atmosphere (see Figure 4.6.5a). Various tactics that employ the "high-level openings" strategy are noted below.

At SAS, the top three floors are illuminated by a central skylight. This is part of the "iconic" roof element, that communicates the company image to the world. It also defines the atrium, communicating support for - and really accommodating - everyday employee gatherings.

At Wind NRG, the large open offices have high clerestories, while the warehouse has many small acrylic-dome skylights (Figure 4.6.5b).

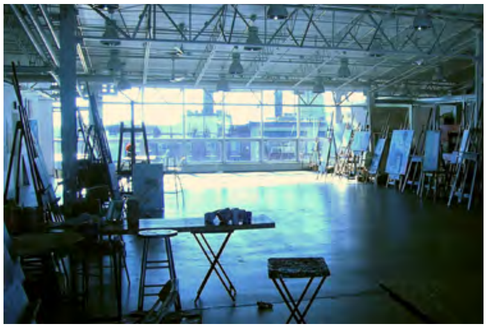
At PAAM, when the large galleries were renovated, skylights were installed. Rather than using clear glass, which would have admitted too much light of too sharp a quality to display the art appropriately, the designers selected insulated fibreglass panels (Kalwall). The result is a bright, diffuse light that shows the work of local art clubs in a professional setting (see Figure 4.6.5c) - yet another expression of the dual mandate of the museum.

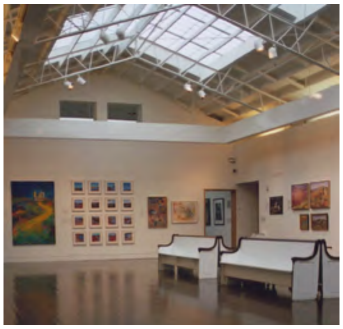
Design Strategy M2d: Maximize glass area, and then use exterior shading devices.

Shading devices express "green" intentions and reduce solar gains. However, shading devices are prone to being "value-engineered" out of a project - before construction, but long after the fundamental design can be re-considered. This occurred at SAS, Oberlin, and Artists for Humanity.

At St. Gabriel's, the south-facing glass is shaded by a deep overhang - the strongest visual element and an integral part of the roof structure. Deletion (if it were ever considered) would offer minor cost savings and clear penalties to comfort, compared to a"hung on" sunshade. The glass also is canted outward at the top, giving further protection from low sun angles and enhancing the contemporary aspect of the design (see Figure 4.6.6a, overleaf).

Figure 4.6.5
Mitigating a risk by incorporating high-level openings





a (top) very tall windows - as at Artists for Humanity,

b (middle) clerestories - as at Wind NRG, or

c (bottom) skylights - as at PAAM.

Figure 4.6.6
Mitigating a risk by using exterior shading devices

a (top) not built at the AJLC, b (middle) part of the roof structure at St. Gabriel's, and c (bottom) supporting PV panels at Wind NRG.

(image a from http://www.mcdonoughpartners.com)

At SAS, the south-east and south-west facades (curtainwall) were meant to include interior light shelves; these were not built. As it is, the large expanse of southwest-facing glass is shaded by a taller building across the street.

At the AJLC at Oberlin, the large expanse of east-facing glass (in the atrium) was to have been shaded by an exterior trellis, but it was not built; excessive solar gains from the east now are noted in the post-occupancy commentaries (see architect's montage, Figure 4.6.6b).

At Wind NRG, even though the window-to-wall ratio is not excessive, south-facing openings are equipped with a continuous awning, that shades the window in summer, and doubles as a support for PV panels (see Figure 4.6.6c, taken in February at 2 p.m.).

At Artists for Humanity, south-facing glass was to have been equipped with sunshades, that were not built. The agency still hopes to install these as a retrofit.

At PAAM, south-east facing glass is shaded by an overhang (integral to the second floor) as well as a horizontal wood canopy (see "Clever" photo, page 59).

Design Strategy M2e: Acknowledge that large quantities of glass are not so desirable anyway, for some reason other than energy performance.

At PAAM, a larger percentage of glass was not desirable in galleries; again, the majority of glass is oriented strategically - to the main public corner, to support the "welcome" message.

MEANINGFUL + 3-USE FREE ENERGY

Risk M3.1: In the literature, it is suggested that a passive solar approach must involve aligning the building spine east-west (see Section 3.5). However, this may not be possible (within the constraints of a given site) or it may negate good urban design strategies.

This perceived risk may be based on a faulty premise. It may not always be necessary to orient the building east-west, to realize a profound level of energy efficiency. To date, no correlation has been observed, among the cases studied. For example, the AJLC at Oberlin (with its east-west spine) and Artists for Humanity (with its north-south spine) have realized approximately the same level of energy-intensity (94 and 88 kWhr/m^2/yr respectively). To discover whether the premise is valid, the power of building orientation - to influence energy use - will be tested, in the Study of Design Parameters.

Risk M3.2: Orienting most glass to face south may not suit the context or the preferred expression.

The issue is in evidence at all of the case study designs. One way of resolving it is illustrated by SAS (Figure 4.6.7a), where the north and east facades (with 4% and 6% WWR) compensate for the south and west facades. At all of the case study buildings - except Gilman Ordway - either the main entrance or the primary space faces south; therefore, the designers were able to orient most glass to face south.

At St. Gabriel's (Figure 4.6.7b) and Oberlin, the large south- and east-facing window units are triple-glazed.

At Wind NRG, all window units are triple-glazed, regardless of orientation.

At Gilman Ordway, most glass faces north. It is meaningful for researchers who study forests to view the forest that they occupy - from their offices, labs, and meeting rooms. In the conference room, all units are triple-glazed (see Figure 4.6.7c).

Figure 4.6.7
Three ways to manage a limited amount of glazed area

a (top) create small openings on "back" facades, as at SAS, b (middle) face primary spaces southward, as at St. Gabriel's, c (bottom) use high-R-value glass - northward - as at Gilman Ordway

(image a Doors Open brochure, c Judy Watts Wilson)

Figure 4.6.8
Capturing a synergy or mitigating a risk by displaying or hiding renewable energy devices

a (top) - conveying a message at the AJLC at Oberlin
b (middle) - symbolizing the business at Wind NRG
c (bottom) preserving the heritage, at Gilman Ordway.

(image c Charles C. Benton)

Design strategy M3.2a: Use or create a site at which the natural location of the building entrance faces south.

At SAS, Oberlin, Wind NRG, and PAAM, most glass surrounds the entry facade, and faces the main street (southeast to southwest).

Design strategy M3.2b: Orient the primary spaces in the building to face south:

At St. Gabriel's, the entrance faces east, but the Nave - and most glass - faces south. This introduces elements of creation into the experience of worship, and captures passive solar gains in the main assembly space (see Figure 4.6.7b).

At Artists for Humanity, all glass faces either north or south, and the primary spaces run right through the building. There is some sacrifice in daylight quality (see Figure 4.6.5a), yet the energy-intensity of the whole building is very low. Given the urban design constraints, one alternative would have been to introduce skylights - but this would have diminished the amount of roof area available for PV.

MEANINGFUL + 5-GENERATE RENEWABLE ENERGY ON SITE

Synergy M5: The display of renewable devices may speak of a future vision that includes energy efficiency and/or energy security.

The seven case studies include a range of approaches renewable energy devices. At Gilman Ordway and PAAM, Although renewables are used, display is avoided - in both cases, the preservation of heritage character (building and immediate surroundings) takes precedence. At St. Gabriel's and SAS, renewables are not used. However, in three cases, the architects seized the opportunity that the presence of renewables offered - to advance the message of the design, by displaying the devices "front and centre", where they can't escape notice by a casual passerby.

Examples of Synergy M5:

At the AJLC at Oberlin, PV panels clearly are visible, as they cover the entire main roof of the building (see Figure 4.6.8a). There is a risk in co-ordinating roof shapes to suit the required orientation of active solar devices (for which see Not-so-Clever, Figures 4.6.16 and 4.6.17). Also on display at Oberlin, there is a PV tracker (placed between the building and the sidewalk), and a gnomon and sundial (in front of the front door).

At Wind NRG, PV "trackers" line the approach driveway to the building. Also, the roof of the main building is angled to capture summer gains (maximizing annual production, rather than winter production).

At Artists for Humanity, PV panels, which cover the roof, are not visible from the adjacent sidewalk. However, they clearly are the reason for the roof slope, and are visible from the upper storeys of several buildings in the surrounding neighbourhood.

Risk M5: The display of renewable energy devices may contradict a prime intention of the design.

- This risk was mitigated, with some success, at Gilman Ordway. A flat roof area was created, surrounded by a decorative parapet. Behind this, solar thermal panels are situated, out of view (see Figure 4.6.8c).

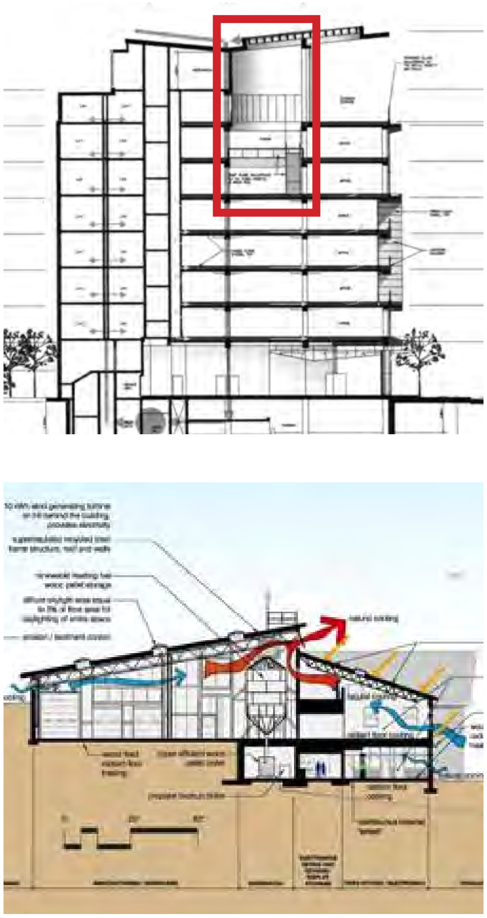
In the QDQ, the second category of design excellence is "Enjoyable". This involves a nurturing quality, comfort (thermal, visual and acoustic), planning for superb functionality, and the question of whether the design lifts the spirit. It is a very challenging category to capture in the visual medium of photography.

Enjoyable

ENJOYABLE + 1-UNDERSTAND CLIMATE & PLACE

Synergy E1: Avoiding a "one-size-fits-all" approach means customizing a design. An understanding of conditions - throughout the four seasons in the Great Lakes Basin - may lead a designer to find elements that both lower energy use, and lift the occupants' spirits.

Figure 4.6.9
Synergy: atria are enjoyable, allow daylight into a building, and may assist with airflow



a (top) - at SAS (image NORR Architects from Clusiau 2007)

b (bottom) - at Wind NRG (image Jerry Bridges/Taze Fulford, from US DOE)

A synergy - between the enjoyment people get, from gathering in a communal space (away from the work room) and the need people have, during the winter, to be exposed to natural light - is seen in the enclosed atria that are part of three of the designs. Although the buildings in question all are based on generic plan types, each has a stronger, more unique character, as a result of the inclusion of an atrium. At SAS, the atrium is centred on the plan, and serves the top three (of eight) stories (see Figure 4.6.9a). At Oberlin, the atrium is on the end of a double-loaded classroom wing. At Wind NRG, the atrium is centred on the plan, connecting the warehouse, mezzanines, and office areas (see Figures 4.6.9b).

A synergy - between the enjoyment people take, by breaking away from work to a natural setting, and the capacity of that setting to serve as a source of energy-exchange - is seen in the outdoor landscapes that are developed as extensions of the building that they surround. These are enjoyable because they change through the seasons, and just looking out at them, from indoors, breaks the monotony of work. Also, building occupants or visitors may go out and use the landscape during lunch breaks, or other short periods of respite. With the exception of SAS (which is built to the edge of the sidewalk), all of the case study designs include a carefully developed landscape. (And SAS has its urban version, in the large elevated terrace, shown in Figures 4.2.14 and 4.2.18). In the five cases listed below, the landscape is both a strong visual extension of the building - and an essential part of the climate control system.

Examples of Synergy E1:

At St. Gabriel's, the garden is part of the worship experience - either by looking at it, from inside, or by walking in it, and viewing the "stations of the cosmic earth". As part of the decision to bury parking below grade, and reduce the amount of hardscaping, it also avoids any urban heat island effect that might have been generated by a parking lot at grade.

At the AJLC at Oberlin, the landscape may not be enjoyed by everyone - but it is a point of interest for some. Its primary purpose is didactic, and it is not (at present) connected to the Living Machine, or to the building (see Synergy M1, above).

At Wind NRG, the artificial pond looks attractive, and is outfitted with a group of cottage chairs, implying occasional use for relaxation. It also is used to help cool the building (see Figure 4.6.10 a & b).

At Artists for Humanity, even in this "hard" urban context, there is a small sunken courtyard, with turf grass, which is used during gallery openings, and for more casual gatherings (see Figure 4.6.10c). It also assists ventilation on hot summer evenings.

At PAAM, a similar pattern is part of the design. During fair weather, when the large corner window can be opened fully, the small grassy area becomes an extension of the gallery. At all times, the benches and sculptures invite passersby to "taste" a sample of the gallery experience, if even for a few moments (see Figure 4.2.60).

Figure 4.6.10
Synergy: landscapes are enjoyable and may assist with climate control inside the building

a & b (top, middle) - Wind NRG
c (bottom) - Artists for Humanity

(image b Andrew Shapiro, image c from USGBC Oct. 2006)

ENJOYABLE + 2-REDUCE LOADS

Synergy E2: Skinny floor plates increase views, penetration of daylight, and sense of orientation.

A “skinny” floor plate may incur greater energy to compensate for heat loss) than a “fat” floor plate. In a floor plate that is narrower than 45 feet, if the window head is at least 8 feet above the floor, daylight penetrates to the core. If daylight is available to such a plan, and if daylight sensors are used, then the energy needed for artificial light is reduced significantly. (For the proportions of the case study designs, see Figure 4.6.-.) The conditions under which this reduction is enough to offset added energy needed for heating are to be identified, in the Study of Design Parameters.

Examples of Synergy E+2:

At SAS, although the floor plate is square, it is only 42 x 33 m. (139 x 109 ft.). On the atrium floors, the maximum distance between the exterior wall and the edge of the atrium is approximately 12 m (40 feet). Because the window head is at 9’-8”, daylight penetrates to 24’ inside the building. On the top three floors (where daylight enters from both the perimeter and the atrium) artificial lighting may be switched off, most of the time, on many days of the year (see “Enjoyable”, Figure 4.6.9).

At the AJLC at Oberlin and Gilman Ordway, similarly, floor plates are 13.7 m (45 feet), and 16.4 m (54 feet) wide, respectively. Daylight penetrates from two sides, to the core (already mentioned - see Design Strategy M+RL 1).

At Wind NRG, the office floor plate is 7.3 m (24 feet) wide, and the warehouse is 24.3 m (80 feet) wide. In both cases, daylight penetrating the width of the floor through windows on one side is supplemented by daylight entering through high-level glazing, at the midline of the plan (see Figure 4.6.9).

Risk E2: Too little glass may mean not enough daylight for visual comfort.

Design strategy E2: Design the facades with between 20% and 40% window-to-wall ratio:

The whole-building WWR, in the case studies, ranges from 14% (PAAM) to 43% (AJLC at Oberlin). (For a summary of the WWRs, see Figure 4.5.20.) Several cases are in the 20-30% range (Artists for Humanity, St. Gabriel's and Wind NRG). In no case is there a sense that there is too little natural light, even at the very centre of these plans. And, in every case, the energy-intensity of the building is exemplary.

Conversely, visual comfort may be challenged by glare, particularly through facades with a WWR in the 60% range. This can be seen in the south-facing offices at Artists for Humanity, where the facade is a curtain-wall that is 63% glass (see 4.6.11b). This might have been an unsatisfactory condition at Wind NRG too - however, this south-facing wall is only 37% glass. The portions of solid wall at Wind NRG afford much-needed relief from glare on a sunny winter day (see Figure 4.6.11a). Even with this restriction, in the Post-Occupancy Evaluation (POE) at Wind NRG, survey respondents indicated a higher-than-usual rate of complaint that there is too much natural light, although, paradoxically, glare was not reported as the problem (Baird 2006).

Figure 4.6.11
Risk: facades with 40% and 60% window-to-wall ratio

a (top) 40% allows abundant natural light for administration and assembly functions - at Wind NRG

b (bottom) 60% (if south-facing) lets in too much light for visual comfort, and requires shading devices - at Artists for Humanity

ENJOYABLE + 3-USE FREE ENERGY

Synergy E3: Careful attention to the design of climate control systems (for energy-efficiency) may improve - not diminish - indoor air quality

Example of Synergy E3:

At the AJLC at Oberlin, Wind NRG, Artist for Humanity, and Gilman Ordway, ventilation and space conditioning have been decoupled (see diagrams on pages 34, 40, 46 and 52). In all of these cases, occupants receive 100% fresh air. When an effective heat recovery system is used, no stale air need be recirculated.

Risk E3: "Free energy" strategies (e.g. to capture solar gains or natural ventilation passively) may conflict with functional requirements (e.g. for privacy or security).

In a building with more complex functional requirements (such as a hospital, police station, or multi-tenant office building), this risk might exist at the level of the overall arrangement of spaces (see also the note under Risk M3.2). If there were such challenges in the case studies, they were resolved to the point of being undetectable. The risk still exists, however, at a finer level of detail: having located the functional spaces satisfactorily, there may still be a conflict between the need for an internal demising wall (for privacy or security control) and a more open interior (to permit passive flow of energy or air).

Design strategy E3, between perimeter spaces and corridors, eliminate partitions altogether, or introduce glazed transom panels.

At St. Gabriel's, transom glass is used to help illuminate the corridor in the administrative areas.

At Oberlin, similarly, transom glazing is typical in the corridor on both floor levels (see Figure 4.6.4b).

At Wind NRG, the "partition" between the offices and main corridor has been re-conceived as a series of millwork units (see Figure 4.6.12). The security risk is negligible in this case, since the whole building is occupied by a single business. However, the risk of elevated noise level is realized; a much higher than average rate of complaint about this was noted among survey responses to the POE.

Figure 4.6.12
Mitigating a risk by using screens or transom glazing

e.g. along the corridor at Wind NRG. This passive tactic may pose a risk to security and/or acoustic comfort.

ENJOYABLE + 4-SPECIFY EFFICIENT EQUIPMENT

Risk E4.1: The use of alternative climate control systems may lower thermal comfort.

With respect to the three case study designs that incorporate a Direct Outdoor Air System (DOAS) rather than "conventional" VAV, some post-occupancy information is available regarding thermal comfort. In only one case (Wind NRG) is the data collected and analyzed with sufficient rigour to be relied upon for future design consideration. (This points to a need for more and better study of this issue.)

Evidence of Risk E4.1:

At the AJLC at Oberlin (which has a DOAS), thermal comfort is reported, by anecdote, as "uneven", with not enough heat in the small rooms. The reasons are not well understood. Whether this is a more frequent - or more severe - problem than in the average College building is not known.

At Wind NRG (which has a DOAS), and where the climate control systems may be described as "alternative", some complaints about thermal comfort were received in the POE survey. The instability of the temperature indoors, in both winter and summer, and the high levels of humidity in summer were noted more frequently than the examiners' database suggests is the norm. However, the overall consensus about temperatures in winter, reflected fewer complaints than in most buildings.

At Artists for Humanity (which has a DOAS), the users generally are on their feet and active. Yet they report a wider than average gamut of temperatures in the building. This is not perceived as an irritant; conditions are better than the old warehouses that the agency occupied, before moving into its own building. The building has no mechanical cooling, and it was forced to close, during a few summer days when it became too hot to work indoors. Perhaps due to the timing (and perhaps because it is a not-for-profit agency), this was not seen as a severe inconvenience. On another note, a 7°F gradient exists on a sunny day - between the area of the studio in sun and area not in sun (even in late November). This condition is somewhat irritating to painters, and would be rectified if the exterior sunshades (from the original design) were installed.

At PAAM, an anecdotal complaint from staff (during a tour on clear, dry day in October), is that it is too cold too often - suggesting that the building is over-air-conditioned. The post-occupancy correspondence also indicates several ongoing problems with the climate control systems - having to do with the management of humidity. However, the systems at PAAM are packaged HVAC systems in common use today - i.e. not as “alternative” as the systems in the other six case study designs.

Risk E4: Automatic control of lighting may be a nuisance.

Evidence of Risk E+EQ 2:

The sense of loss of direct control is an irritant in some cases. This may be a two-way challenge: people need time to become accustomed to the new technology, and the technology must continue to evolve, to respond appropriately to a range of scenarios.

At St. Gabriel’s, the lighting in the nave is on timers (see Figure 4.6.13). There was a “breaking-in” period of approximately six months, right after occupancy, when the schedules required several adjustments.

At Wind NRG, in the office areas, daylight sensors control dimmable indirect fluorescent lighting. During the tour, it was noted that the lights were on, even though daylight levels were extremely high. The sensors are subject to over-ride by a timer. Control over lighting, heating and cooling received slightly higher than the average number of complaints in the POE.

ENJOYABLE + 5-GENERATE RENEWABLE ENERGY ON SITE

Synergy E+GR 1: Many renewable energy generation devices operate quietly and are compact - relative to devices that must contain combustion and/or large fans.

This includes: PV panels, solar thermal (water) panels, and ground-source (or water-source) heat pumps. At Wind NRG, compressors for the water-source heat pump system are incremental (see Figure 4.6.14). This was the quietest mechanical equipment room encountered by the researcher in 22 years.

Synergy E5: Less combustion implies cleaner air outside, which may imply cleaner air inside.

This synergy is speculative. There is a large body of literature on the health effects of pollution, and its effect usually is studied more widely than at the single-building level. The case study buildings have not been examined with respect to this issue. However, in one case, a third-party report - at Artists for Humanity (ICBE 2006) - examined the GHG emissions emanating from buildings in several neighbourhoods in Boston.

Synergy E5: Grid independence = energy security (in the event of a catastrophe or severe price escalation).

Among the case studies, the only building that was operating during the failure of the power grids in eastern North America (on 15 August 2003) was the AJLC at Oberlin College. It was operating at minimal occupancy, during summer recess. In a crisis, the case study buildings in the U.S. most likely could continue operating for several days, without severe inconvenience (PAAM might be the exception). In contrast, the two in Toronto probably could not, as they are dependent on the natural gas and electricity grids. In another sense, as the current wave of rampant price escalation for oil and gas continues, every one of these designs delivers even better value than may have been, perceived, during the initial design stages.

Figure 4.6.13 (top)
Risk: lighting controls may save energy but may cause inconvenience

e.g. indirect fluorescents are on timers at St. Gabriel's.

Figure 4.6.14 (bottom)
Synergy: devices that generate renewable energy may be quiet and compact

e.g. several incremental compressors for water-to-water heat exchange at Wind NRG

In the QDQ, the third category is “Beautiful”. This involves the use of daylight, the arrangement of materials and spaces in an appealing and memorable way, and the question of “contemporary sensibilities”.

Beautiful

Daylight can convey meaning, and it also contributes to beauty. The principal “contemporary sensibilities”, as defined in the QDQ, are:

- connect internal activities to outdoor public spaces,
- use non-rectilinear or “free” forms,
- use contrasting surface textures,
- employ out-of-place or out-of-scale materials, and
- incorporate handcraft in permanent building elements.

Figure 4.6.15
Synergy: exterior sunshades

add design interest and reduce solar gains - on the southeast facade of PAAM

In architectural circles, the question is asked, whether “contemporary sensibilities” might conflict with energy-reducing strategies. The presence of both goals might produce either a synergy or a risk - depending on the circumstances.

BEAUTIFUL + 1-UNDERSTAND CLIMATE & PLACE

Synergy/Risk B1: A design that arises from a regional sensibility returns a contribution toward sustaining the uniqueness of a place.

This is the reciprocal effect of communicating meaning using regional character. In Synergy M1, a tradition was drawn from a local community and used to enhance a design. Here, the focus is on the impact of such a design on the overall character of its place. There be a risk, where the regional idea of “beauty” differs widely from ideas of “contemporary” style that are of interest in wider culture.

This can be seen by contrasting Wind NRG with PAAM. In each case, the architect captured synergies by holding “understanding the place” in higher priority than simply trying to replicate an appearance that would be considered, in some circles, to be “contemporary”.

Some may consider that the way that PAAM captures a synergy between regional character and contemporary sensibility to make it a “better” design than Wind NRG. However, it would have been very risky to impose the contemporary sensibilities of PAAM on the Wind NRG building. The elements would have to change (the shingles and belvederes, characteristic of Cape Cod style, do not fit the Vermont mountains particularly well). And the constituency served by the two designs - visitors and occupants - have very different expectations. PAAM caters to a clientele that travels widely and is familiar with current trends in the urban art scene. Wind NRG caters to long-term employees who have chosen to live in the Vermont hills, because this area appeals to them.

BEAUTIFUL + 2-REDUCE LOADS

Synergy B2: The use of exterior sunshades may add design interest.

Sunshades assist when a large expanse of glass is wanted, to convey a message (see Risk M+RL). They were designed into all seven cases, except Gilman Ordway, where they exist in the form of a porch around the historic house. If they withstand the tests of budget control exercises, sunshades add interest to a facade, as at PAAM (see Figure 4.6.15).

BEAUTIFUL + 3-USE FREE ENERGY

Synergy/Risk B3.1: The demands of passive solar may coincide with an interest in displaying internal activities to the street.

However, if the street that the building must face does not offer a favorable exposure for solar gain, then there is a Risk.

Synergy/Risk B3.2: The use of non-rectilinear forms might help or hinder design for either capture or avoidance of passive solar gains.

A synergy is captured in designs outside the case study set - such as the Jean Canfield GOC Building in Charlottetown (where the floor plate is angled to face due south) or the York University Computer Science Building (where east- and west-facing elevations have “sawtooth” openings, to avoid unwanted solar gains.

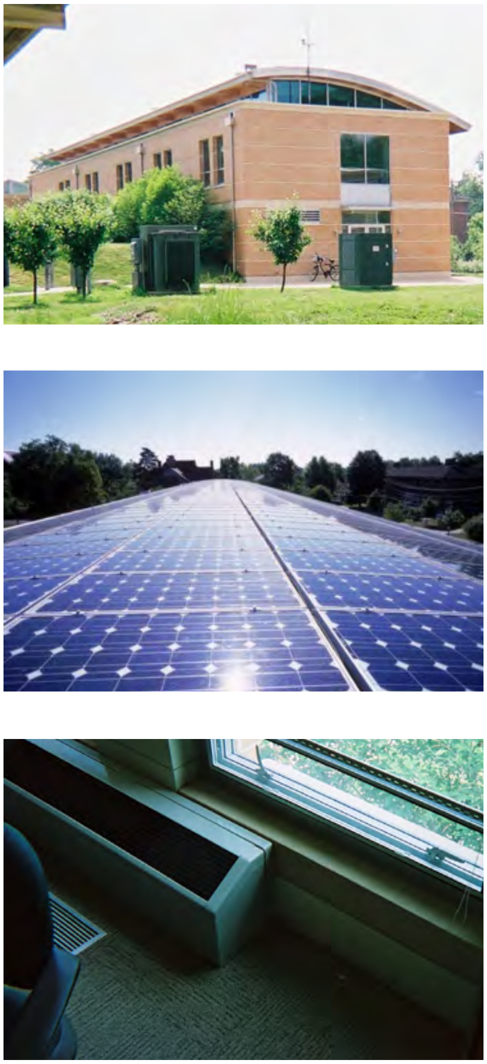
BEAUTIFUL + 5- GENERATE RENEWABLE ENERGY ON SITE

Synergy/Risk B+GR: The demands of active solar may not fit prevailing contemporary formal preferences.

The use of non-rectilinear forms (an aspect of “contemporary sensibility”) might either help or hinder the generation of renewable energy, depending on the form that is chosen, and the demands of the energy technology. For example, the combination of a curved roof and PV panels is not synergistic, at the AJLC at Oberlin, for which see “Not-so-Clever”, below.

The last category in the QDQ is “Clever”, involving the degree to which technical strategies drive the overall building form, the use of unusual technology, and the integration of architectural and engineering design.

Figure 4.6.16
Not-so-clever details at the AJLC at Oberlin



a & b (top, middle) - the curvature of the roof does not all PV panels to face the sun

c (bottom) - heat-pump units submerged below the floor

(image b Robb Williamson)

Not-so-Clever

So far, all of the examples have shown the cleverness of the design teams in capturing synergies and mitigating risks - to realize a meaningful, enjoyable and beautiful architecture. This category is illustrated differently than the others. Here, a few examples of less-than-clever details in some of the designs are featured.

This is not intended to detract from the real results observed in every case. Rather, it is to learn from the few mistakes that were made - mainly in detailing - that anyone would want to avoid in the future.

At the AJLC at Oberlin, approximately 80% of the PV panels are oriented favourably towards the sun; the other 20% are laid flat or tipped slightly toward the north (see Figure 4.5.16a & b). This would account for the difference between the rated capacity of the array (60 kW) and the actual peak generation (45 kW). While this may have a rationale (that is not disclosed in the literature), it seems surprisingly wasteful - especially in a building with the didactic program of the AJLC.

Also at the AJLC at Oberlin, some of the in-room heat pump units are submerged below the access floor (see Figure 4.5.16c). This presents an unnecessary inconvenience to those who perform regular, preventative maintenance.

At Artists for Humanity, the idea to use recycled windshields in the guardrails was conceived and executed by a local artist (see Figure 4.6.17a). As the make and model of the contributing vehicle becomes obsolete, it is difficult to foresee how replacements will be detailed.

At Gilman Ordway, it is unfortunate that the mechanical equipment (as important as it is) occupies a corner office on the third floor, with an ocean view (see Figure 4.6.17b).

At PAAM, a sprinkler head was required in the each of the "belvederes" - a small thing, but noticeable in this otherwise finely crafted design (Figure 4.6.17c).

What would the designers themselves wish to do differently if they could start one of these projects all over again? At Wind NRG, the answer can be seen in the second phase of construction. This analysis has focussed on the Phase 1 building, for which ample data - including post-occupancy opinions - is available. At the time of the field visit, the construction of an extension - which will nearly double the size of the building - was underway. Even after the considerable success of Phase 1, the owner and design team at Wind NRG are planning substantial changes in Phase 2. For instance:

- the exterior wall assembly has even greater thermal resistance, in part due to the use of wood studs, rather than steel (made possible because the floor area of Phase 2 is slightly smaller than Phase 1),
- the controls on the in-slab radiant heating systems are being greatly simplified, to be controlled in only 5 zones (the Phase 1 system, with its 40 zones, was described as "a house of cards" that requires constant maintenance),
- rather than using the pond water (which reaches 70°F by May) as a source of cooling, Phase 2 will draw on the "coolth" of well water,
- acoustic deck will be used in Phase 2 (it was not used in Phase 1) to absorb noise where the structure is exposed, and
- dimming controls on T8 lamps are to be improved.

Figure 4.6.17
Assorted "not-so-clever" details

a (top) - guardrails at Artists

b (middle) - a room with a view, at Gilman Ordway

c (bottom) - sprinklers in the skylight, at PAAM.

Figure 4.6.18
Summary of design strategies to resolve risks

Risks M2: Reducing the percentage of glass - or avoiding east- or west-facing glass - ***may narrow options for expressing a message, or enhancing enyoyability or beauty.***

Alternative Design Strategies to mitigate:

- M2a Restrict the WWR to no more than 40%, and introduce daylight, of varying quality, from several directions.
- M2b Limit the amount of glass that faces east and west, but use it to maximum advantage - for orientation, views, and/or light quality.
- M2c Include high-level openings (very tall windows, clerestories or skylights) for added expressive potential
- M2d Maximize glass area, and then use exterior shading devices for expression and reduction of solar gains.
- M2e Acknowledge that large quantities of glass are not so desirable anyway.

Risk M3.1: Aligning the building spine east-west (for passive solar) ***may not be possible, or may negate good urban design strategies.***

- M3.1 May be based on a faulty premise.

Risk M3.2: Orienting most glass to face south ***may not suit the context or the preferred expression.***

Alternative Design Strategies to mitigate:

- M3.2a Use or create a site at which the natural location of the building entrance faces south.
- M3.2b Orient the primary spaces in the building to face south.

Risk M5: The display of renewable energy devices ***may contradict a prime intention of the design.***

Design Strategy to mitigate:

- M5 Locate devices discretely - e.g. behind a parapet, or on a high roof.

Risk E2: Too little glass ***may mean not enough daylight for visual comfort.***

Disproved by case studies. Keep the whole-building WWR between 20% and 40%. Employ carefully designed shading devices at facades with more than 40% WWR.

Risk E3: "Free energy" (passive) strategies ***may conflict with functional requirements (e.g. for privacy or security).***

Design Strategy to mitigate:

- E3 Along corridors, eliminate partitions, or introduce glazed transom panels.

Risk E4.1: The use of alternative climate control systems may lower thermal comfort.

Design Strategy to mitigate:

- E4.1 Risk is in evidence, but there is not enough information to determine whether DOAS is equivalent to or worse than conventional systems in this regard. More POEs are needed.

Risk E4.2: Automatic lighting controls may be a nuisance.

Design Strategy to mitigate:

- E4.2 Risk is in evidence, further familiarity and development of devices is needed.

Summary of the analysis of Synergies and risks

When a "low-load" approach meets a "high-satisfaction" goal, a design strategy may capture a synergy - or it may resolve the risk of one objective overshadowing the other. In either case, the process of "teasing out" the "how and why" has confirmed some expectations, negated others, and yielded a few surprises. Also, it has helped to refine some questions that may be asked in the more quantitative Study of Design Parameters (in Chapter 5).

A number of important synergies are captured repeatedly in several of the case study designs. The strongest of these are in the "Meaningfulness" category. The synergy between understanding climate and place and communicating a message is at work in most of the designs. And it has proven to be a precursor to making effective decisions throughout the design process. The architects who captured this synergy did so by selecting locally-significant exterior cladding materials, and re-interpreting them in the facades, and by arranging spaces to admit daylight in interesting and meaningful ways.

The next-strongest synergies are in the "Enjoyable" category. Again, an understanding of climate and place was key. Here, tactics used to reduce loads very often also improve comfort and lift the spirits of those who experience the buildings first-hand. The strategies used most frequently included: introducing an atrium into an otherwise generic plan, developing the surrounding landscape (for both aesthetic and practical purposes), controlling daylight that enters work areas, and designing the climate control systems with care.

A few synergies also exist with respect to the generation of renewable energy. Devices (such as PV trackers) are, in some cases, effective communication tools, and may contribute to an enjoyable (quieter, cleaner) building.

The case studies also show how strategies to reduce energy-intensity present challenges and constraints to a designer who is committed to realize a highly satisfying architecture. The converse risk also exists. If satisfaction is allowed to dominate, it may prove impossible to bring the energy-intensity of a design to extremely low levels. The major risks – and the mitigating design strategies – as seen in the case studies, are summarized in Figure 4.6.18.

In general, these designs show how synergies may be captured, and how the risks can be resolved - through deft decision-making by the architectural designer. This exercise leaves the following specific questions to test in the Study of Design Parameters:

1. Does the orientation of the building spine matter? The cases shown here include designs with east-west spines and north-south spines, at equally low energy-intensities. This suggests that the answer is “no” - for civic buildings in the Great Lakes Basin. However, a quantitative analysis will confirm whether building orientation affects the energy intensity of a civic building of 10,000-100,000 square feet of floor area, and, if so, how much.

2. What are the conditions in which a skinny floor plate yields a favourable trade-off - between the added energy needed for heating and the energy not needed for lighting? The skinniest floor plates among the case studies happen to be the least energy-intense. Some dependence on the thermal resistance of the enclosure and the overall size of the floor plate is expected. Again, the quantitative analysis will confirm how much dependence there is on each factor.

4.7 NOTES ON CAPITAL COSTS

In Section 3.6, commentary was made about five recent studies that suggested there is a cost premium associated with each level of green building rating – and that this premium may apply, no matter where or when a building is to be constructed. These studies were shown to vary widely in methodology, and therefore in their results. Because the studies focused exclusively on cases in the U.S., and drew data from diverse places and times, their results were not particularly relevant to current market conditions on the Canadian side of the Great Lakes Basin. (For instance, bidding conditions in Pittsburgh in 2003 were, no doubt, different from conditions in Toronto in 2007 – but the need to quantify or even qualify the degree of difference was only remarked upon, as a caveat, in two of the studies, and not presented in detail in any study.)

Although it may be troublesome to base a cost comparison on LEED level - because there are low-cost as well as high-cost ways to reach each level – this was attempted in the five cost studies. Only Matthiessen and Morris concluded that there is no statistically significant difference in the cost of LEED-seeking and non-LEED buildings. Their analysis, which used the largest pool of data and was made from the perspective of experienced cost analyst Davis Langdon, cautioned readers against budgeting buildings "on averages". To complement this advice, from the perspective of a consulting architect, Busby proposed a more qualitative compass, pointing to seven factors that, in his experience, have driven the cost of "green" buildings. His approach is credible, because it begins to recall a wider range of influences than merely LEED level – a range that includes design factors as well as market factors, and is in play in any real project. Because Busby's factors are presented as very rough approximations, rather than hard figures, he leaves room for other factors to be in play as well.

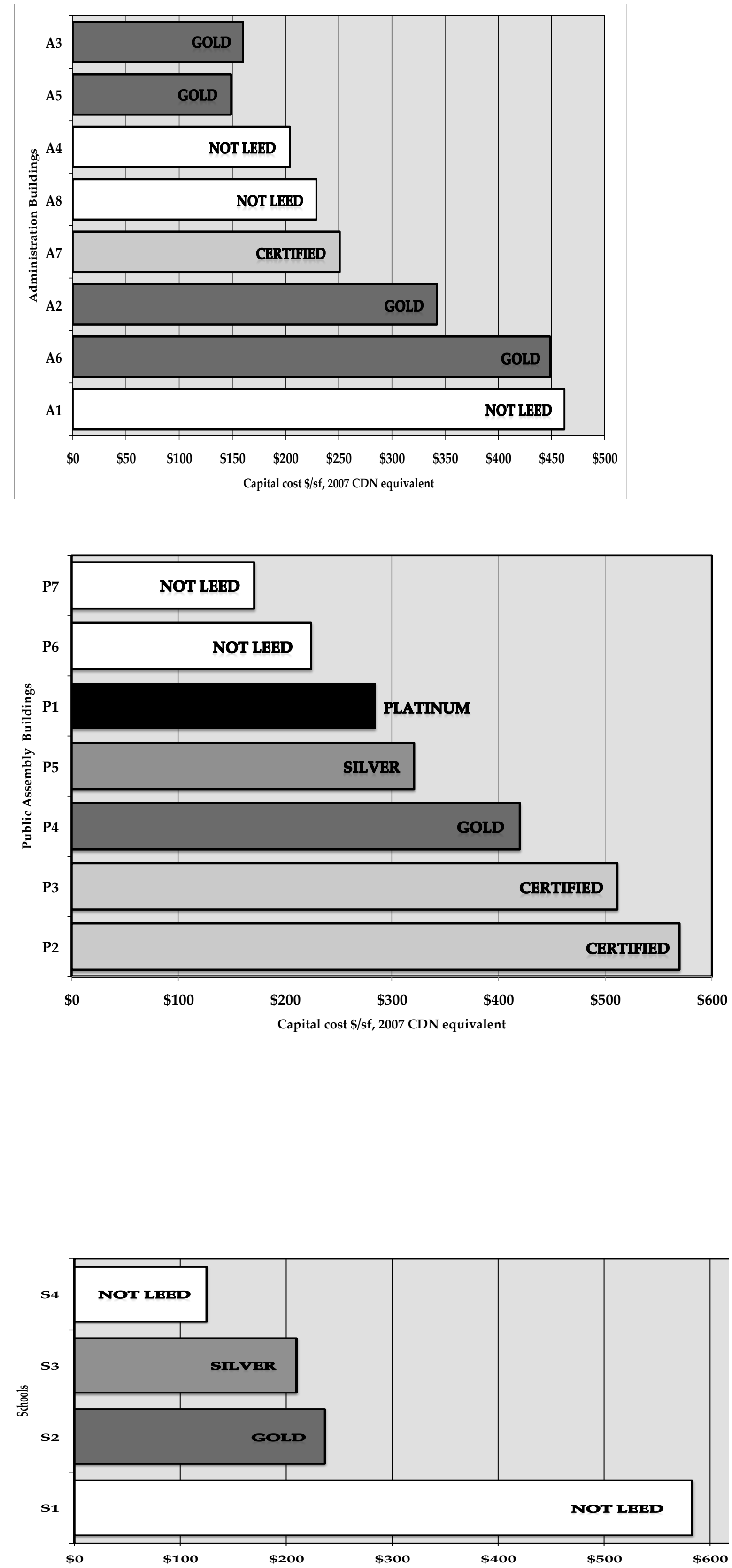
In this section, the 19 case study buildings will be considered, to see whether their track record sheds any further light on the question whether a "green" design costs more, automatically, than a "default" approach. First, from the case study reports, the cost of construction was isolated; this was verified where possible, during the interview process. This figure reflects the contractor's bid only; it excludes the

Figure 4.7.1
Capital cost of case study buildings, in relation to LEED level

a (top) - Administration

b (middle) - Public Assembly

c (bottom) - Schools



Legend

A1-Gilman Ordway
A2-Jean Canfield
A3-Wind NRG
A4-Holyrood RCMP
A5-Plaza at PPL
A6-Herman Miller C1
A7-SAS
A8-GTA Police

P1-Artists for Humanity
P2-Heimbold Vis. Arts
P3-N Jones Courthouse
P4-St. Gabriel's
P5-PAAM
P6-Alice Turner Library
P7-GTA SAC

S1-AJLC at Oberlin
S2-Clearview Elementary
S3-T.L. Wells Elementary
S4-GTA School

☐ not LEED
░ LEED Certified
▒ LEED Silver
▓ LEED Gold
■ LEED Platinum

cost of land, and excludes “soft costs”, such as furnishings and design consultants’ fees. Next it was noted that the 19 cases were constructed in diverse locations, over a six-year period between 1998 and 2004. In order to make a fair comparison, the reported costs would have to be normalized. By multiplying the construction costs of the ten U.S. projects by a factor of 1.2, all figures were brought an approximate equivalent in Canadian dollars. A rate of 4.5% inflation (compounding) was applied for every year between the year of construction and 2007.

In Figures 4.7.1a, 4.7.1b, and 4.7.1c, the case study buildings are grouped according to use, and the construction cost of each is plotted, showing its level of LEED rating, or its non-participation in that system. This comparison shows a similar pattern as seen in the Matthiessen and Morriss results (see Figure 3.6.2). First, there is a wide variation in price point, even among buildings of similar occupancy (e.g. compare A3 to A1 or P7 to P2). Second, there is no consistent line - from low-cost, non-rated or LEED Certified buildings, to higher-cost LEED Gold or LEED Platinum buildings - as was implied by the BNIM, Kats, GSA, and McAuley studies. Non-LEED buildings are, in some instances more costly than their LEED counterparts (for example, compare A1 to A6 and A2, or S1 to S2). This analysis suggests that a building of any rating level may be constructed at any price point.

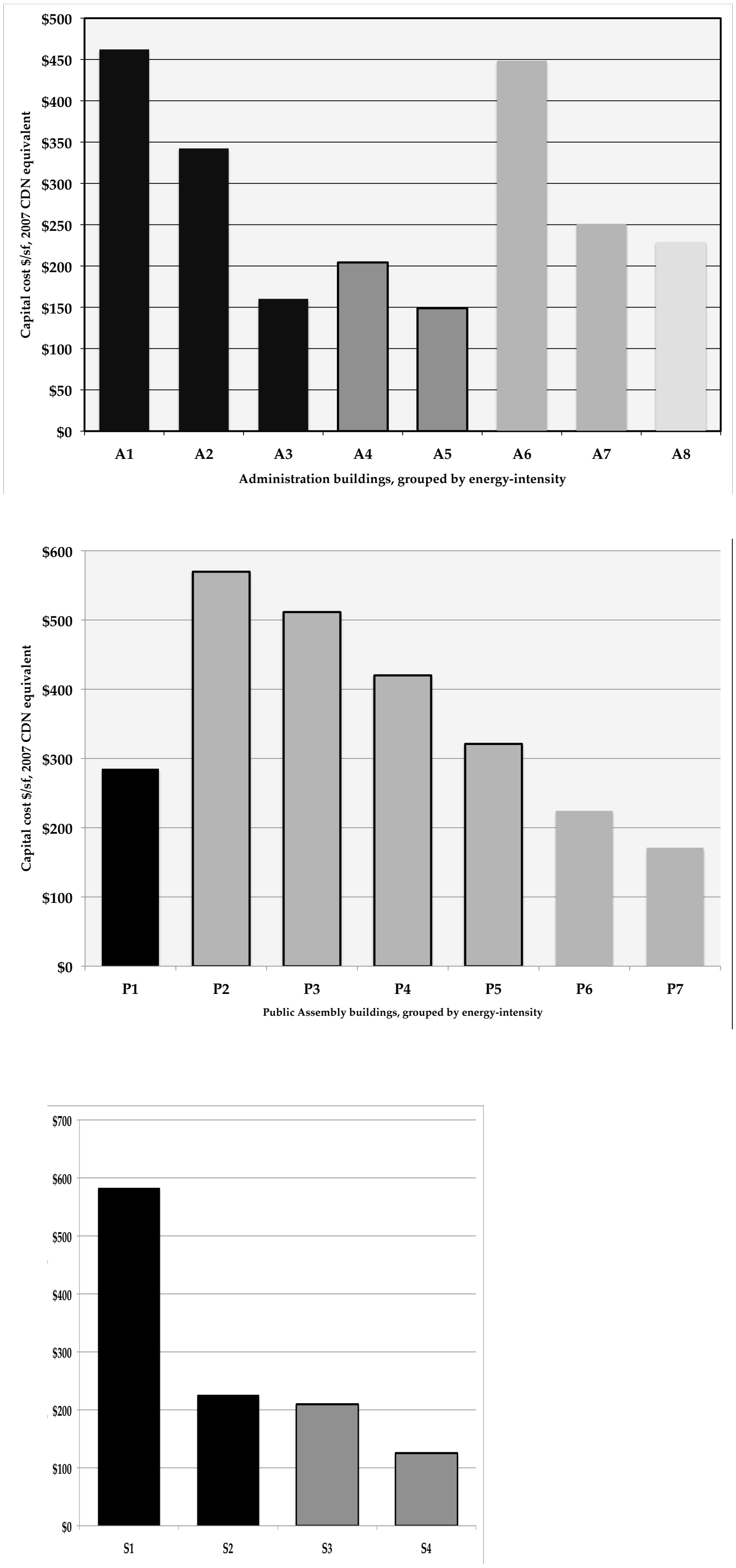
From the perspective of someone wanting to believe that there is a cost premium that may be associated, consistently, with each LEED level, a question that might then be asked is, what accounts for the difference in costs between the buildings of similar use? If it isn’t LEED rating level, then what might it be? Section 3.4 showed only a very weak correlation between real reduction in energy-intensity and LEED level, and Section 4.5 showed many of the things that reduce energy use are costly, such as extra insulation, better windows, and more controls on lighting. Was energy-efficiency perhaps a stronger driver of costs than LEED level?

Figure 4.7.2
Capital cost of case study buildings, in relation to energy intensity

a (top) - Administration

b (middle) - Public Assembly

c (bottom) - Schools



Legend

A1-Gilman Ordway
A2-Jean Canfield
A3-Wind NRG
A4-Holyrood RCMP
A5-Plaza at PPL
A6-Herman Miller C1
A7-SAS
A8-GTA Police

P1-Artists for Humanity
P2-Heimbold Vis. Arts
P3-N Jones Courthouse
P4-St. Gabriel's
P5-PAAM
P6-Alice Turner Library
P7-GTA SAC

S1-AJLC at Oberlin
S2-Clearview Elementary
S3-T.L. Wells Elementary
S4-GTA School

⬜ >421 kWhr/m^2/yr
▨ 251-420 kWhr/m^2/yr
▩ 101-250 kWhr/m^2/yr
⬛ <100 kWhr/m^2/yr

In Figures 4.7.2a, 4.7.2b, and 4.7.3c, the cost data is re-sorted, to try to answer the question noted at the end of the previous paragraph. Again, there is a wide variation in cost, even among buildings of similar occupancy and similar energy-intensity. There are very energy-efficient buildings that were constructed at relatively low cost (see the black bars representing <100 kWhr/m^2/yr), and other buildings that use more energy, that were constructed at twice the cost (compare A6 to A3 or P2 to P1). If, as this analysis suggests, energy-intensity alone is not such a strong driver of overall cost, then one might next ask what accounts for the difference shown here - is it design aspirations, or market factors, or both?

To answer such a question, a further, qualitative analysis is presented in Figure 4.7.3 (overleaf). First, a project close to the average for each occupancy class is taken as a baseline. Then, the reasons why each of the other projects cost more (pale grey field) or less (black field) than the baseline project are noted. The Busby factors account for some of the differences. However, there are even more market influences and design factors at play, as noted in the “Commentary” column.

This comparison of the 19 case study buildings proves once again that market factors exert a strong influence on the cost of “green” buildings, just as they do on any building. Qualitative design goals also exert a strong influence. It is very difficult, if not impossible, to frame a one-size-fits-all rule to predict how much influence is exerted on capital cost by LEED level, or energy-intensity, or design goals, in isolation from one another. The assumption that a “green” building must cost more than a “non-green” building is a fallacy and, if asked “how much does it cost to make this project green, or low-load?”, the most prudent answer an architect to offer still is, “it depends”.

Figure 4.7.3
Factors influencing the capital cost of the case study buildings

	Project		**Costs**		**E-int.**	**Factors that drive construction cost**		
		Year Occ.	**Orig.** $ var.	**2007** $ CDN	kWhr/ **m2/yr**	**Mkt Char**	**Most significant Market influences**	**Most significant Design factors**
ADMINISTRATION	**GilmanOrdway** WoodsHole, MA	2000	$323	**$462**	50	**hot**	*remote location* *limited local skilled labour*	*reno historic bldg, add on hill* *premium enclosure & systems*
	HermanMiller C1 Zeeland, MI	2002	$300	**$449**	271	**hot**	*relatively small project* pre-design & post-occ. study	high-quality reno of interior extra care re lighting design
	Jean Canfield CharlottetownPEI	2004	$300	**$342**	94	**hot**	*somewhat remote location* *limited local labour*	*durable finishes, added arch'l* *parts e.g. extr'r sunshades*
	SAS Building Toronto, ON	2005	$220	**$251**	258	**hot**	worldwide material shortage local labour shortage	u/g parking, atrium, details, rainwater cisterm
	GTA - Police Sta. Vaughan, ON	1995	$135	**$229**	447	recess.	North America-wide slump local skilled trades need work	repeat design, well co-ord docs complex struc in basement
	Holyrood RCMP Holyrood,NF	2002	$179	**$204**	167	**?**	small building, remote loc'n open accessible site	Trombe wall even more simple shape
	Wind NRG Hinesburg, VT	2004	$117	**$160**	69	recess.	open accessible site local skilled trades need work	*unusual m/e systems* *rel. hi-perf enclosure*
	Plaza at PPL Allentown, PA	2003	$104	**$149**	228	recess.	fast schedule, open site local skilled trades need work	simple shape, simple cladding rel. conventional m/e
				$281	*average*			
PUBLIC ASSEMBLY	Heimbold Bronxville, NY	2004	$416	**$570**	293	**hot**	*large u/g cosntruc. in rock* *phys. access challenging*	*rel'ly complex program* *ext'r shades, var. ext'r mat'ls*
	N Jones Cthouse Youngstown, NY	2002	$342	**$511**	225	?	local economic downturn *v. early use of LEED*	*v. high-quality durable fins.* *articulated façade*
	St. Gabriel's Toronto, ON	2007	$420	**$420**	173	**hot**	*mat'l & labour shortage* *delayed munic. approvals*	*u/g parking* *higher qual. mat'ls than Artists*
	P. Art Assoc. ProvincetownMA	2006	$256	**$321**	169	avg.	*remote loc'n; lim. local labour* *operated during reno & add*	*custom windows, Kalwall* *complex func'ns for sm. bldg.*
	Artists-Humanity Boston, MA	2004	$208	**$285**	100	avg.	construc. mgr. on team early v. flexible pro-active owner	very simple interior well co-ordinated docs.
	Alice Turner Saskatoon, SK	1998	$151	**$224**	304	?	multi gov't -> bidder confid. open accessible site	*more extensive int'r finishes* no renewable energy equip.
	GTA - SAC Cambridge, ON	2004	$150	**$171**	271	**hot**	cost includes approx. value of donated materials	adaptive re-use (msnry shell) very simple interior
				$357	*average*			
SCHOOLS	**AJLC at Oberlin** Oberlin, OH	2000	$357	**$583**	94	?	*relatively small project* *v. early green project*	*lots of systems* *v. high owner goals*
	Clearview Elem. Hanover, PA	2002	$158	**$236**	74	?	flat site, suburbs new procedures des & POE	varied massing, clerestory hi-perf windows, UFAD
	T.L. Wells Elem. Scarborough, ON	2005	$192	**$210**	243	**hot**	*first attempt for large Board*	even more varied massing unusual climate cntrl. sys.
	GTA - Elem. Sch. Brampton, ON	2006	$120	**$125**	225	**hot**	*mat'l & labour shortage* all owner procedures known	repeat design, well co-ord docs very simple shape
				$289	*average*			

Legend:

drives costs up, rel. to baseline

baseline for the group

drives costs down, rel. to baseline

Commentary	**Busby factors** **LEED Level**	**Owner Flex**	**Bldg Energy**	**Proj Size**	**Mkt. Mat'y**	**TDD/** HDD	**Team Exper.**
Market and design: 4 significant drivers UP, relative to the baseline project Busby factors: 2 account for extra cost / 3 suggest savings	not	some flex	med-high	S	familiar	**3,596** 3,199	lots
Market and design factors: 1 significant driver UP + 3 other drivers UP Busby factors: 3 account for extra cost / 0 suggest savings	Gold	some flex	med-high	M	not famil	**4,074** 3,613	?
Market and design factors: 4 significant drivers UP Busby factors: 1 accounts for extra cost / 2 suggest savings	Gold? target	some flex	med-high	L	not famil	**4,471** 4,367	lots
BASELINE, against which ***all other ADMIN. projects are compared***	Silv.	some flex	med-high	L	not famil	**4,318** 4,066	rel. little
Market and design factors: 4 drivers down (DN); bidding strong DN Busby factors: 2 suggest extra costs / 1 accounts for savings	not	constrained	med-high	M	n/a	4,318 4,066	n/a
Market and design factors: 2 drivers UP / 2 drivers DN Busby factors: 3 suggest extra costs / 1 accounts for savings	not	constrained	med-high	S	not famil	4,471 4,367	some
Market and design factors: 2 UP / 2 DN; local market & team strong DN Busby factors: 2 suggest extra costs / 4 account for savings	Gold	much flex	med-high	M	familiar	4,534 4,262	lots
Market and design factors: 4 drivers DN, local market strong DN Busby factors: 2 suggest extra costs / 0 account for savings	Gold	some flex	med-high	L	not famil	3,645 3,241	some
Market and design factors: 4 drivers UP Busby factors: 1 accounts for extra cost / 2 suggest savings	Cert.	much flex	med	M	not famil	3,816 3,394	some
Market and design factors: 3 drivers UP / 1 major driver DN Busby factors: 2 account for extra cost / 1 suggests savings	Cert.	some flex	med	M	not famil	3,794 3,403	rel. little
Market and design factors: 4 strong drivers UP Busby factors: 2 account for extra costs / 3 suggest savings	Gold	some flex	med	M	not famil	4,318 4,066	some
Market and design factors: 4 significant drivers UP Busby factors: 2 account for extra costs / 1 suggests savings	Silver	some flex	med	M	not famil	**3,596** 3,199	rel. little
BASELINE, against which ***all other PUBLIC projects are compared***	Plat.	much flex	med	M	fairly famil	3,562 3,130	rel. little
Market and design factors: 3 strong drivers DN / 1 UP Busby factors: 2 drivers UP / 3 drivers DN may be stronger	not	much flex	med	S	not famil	5,969 5,852	some
Market and design factors: 4 significant drivers DN Busby factors: 0 suggest extra costs / 2 account for savings	not	much flex	med	M	n/a	4,318 4,066	n/a
Market and design factors: 4 significant drivers UP Busby factors: 2 account for extra costs / 2 suggest savings	not	much flex	med-low	S	not famil	3,793 3,403	lots
BASELINE, against which ***all other EDU. projects are compared***	Gold	some flex	med-low	M	familiar	3,645 3,241	lots
Market and design factors: Busby factors: 1 suggests extra costs / 3 account for savings	Silver	some flex	med-low	M	not famil	4,318 4,066	some
Market and design factors: 1 strong driver UP / 3 drivers DN Busby factors: 0 suggest extra costs / 2 account for savings	not	some flex	med-low	M	n/a	4,318 4,066	n/a

4.8 SUMMARY OF FINDINGS IN THE ANALYSIS OF CASE STUDIES

This phase of the research has demonstrated success that is real and measurable, in both qualitative and quantitative terms. The methods of analysis used here also have shown how to discuss energy use and design quality in relation to one another, while maintaining a focus on the decisions that fall to the architect. As a result, the questions posed in Section 4.1 now can be answered, as follows.

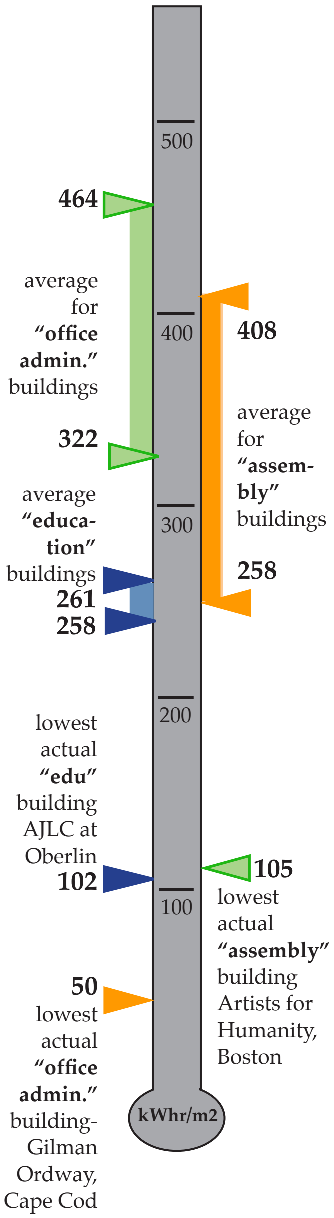


Figure 4.8.1
The range of actual energy-intensities seen in the Analysis of Case Studies.

How much satisfaction can a "low-load" design offer?

The qualitative appraisals (in Section 4.2) have shown the seven "new normal" designs to be more meaningful, beautiful, clever and natural than the three "GTA default" designs. However, there are strengths and weaknesses inherent each approach.

All seven of the "new normal" cases show strength in relation to all five categories of the Questions of Design Quality (QDQ). The designs employ various material palettes, a range of organizing principles, and several stylistic sensibilities. "Meaningfulness" is perhaps best represented by the play of light in space at St. Gabriel's Passionist Church. Enjoyability is well-documented in a post-occupancy evaluation of Wind NRG. Contemporary sensibility is obvious at PAAM (see Figure 4.8.1), cleverness at Artists for Humanity, and naturalness at Gilman Ordway. While achieving these attributes, the range of energy-intensities at which these cases operate is well below the range of averages for buildings of similar type in similar climates (see Figure 4.8.2, opposite).

More study is needed to determine whether the "new normal" designs are more or less satisfactory than "normal" buildings, with respect to the Enjoyability questions. Thermal comfort, humidity control, acoustic privacy, and space planning in the "new-normal" buildings are not perfect - but nor are they perfect in the "GTA defaults". More structured post-occupancy evaluation of both groups of cases is required.

The "new normal" cases are distinct from the "GTA defaults" in their response to the first two "naturalness" questions, regarding the potential of a design to fit into, and offer benefit to, surrounding natural systems. The evidence shows that when the "naturalness" questions are asked by a designer, "high satisfaction", in all its facets, may be enhanced even as energy use and GHG emissions are greatly reduced.

How much lower than "normal" can the energy-intensity be?

Section 4.3 shows that it is possible to lower energy-use to as little as one-sixth of today's average and, therefore to emit a small fraction of the greenhouse gases emitted by an "average" civic building. Small, medium-sized and large buildings seem to have equivalent potential to be very energy-efficient.

Figure 4.8.1 compares the lowest energy-using office, assembly building, and school, from among the case studies, to the Canadian averages for each category of use. Office buildings show higher averages than the other uses, due to their sustained and relatively intense occupancy for long hours. Assembly buildings are characterized by bursts of high-intensity use, as in a church service or a courthouse. School buildings have the lowest average with the tightest range - because their pattern of use is consistent over the fewest hours per year, and their occupant load is the most tightly controlled.

There are significant challenges with the fidelity of the information that is available, at present, about energy use in both "green" and "normal" buildings. Predicted levels of energy use are reported more often than actual levels - but neither level is presented regularly in the case study literature. (For instance, actual end-use data is not automatically posted with any of the green building ratings.) During this study, the pursuit of data revealed that it is rare for a building to operate at its simulated energy use, or to operate at a perfectly consistent rate from year to year (see, for example, the Intensometer for the AJLC, in Figure 4.2.25). When data is published, a record for more than one year is available in very few instances.

Challenges in realizing the energy-efficiency that is predicted in the models arise because: the building is not built as designed, it is used more intensely than anticipated, or it is not operated as carefully as hoped. Among the cases studied here, the actual energy use often was found to be 30% greater that the than the energy model had predicted. As this study was nearing completion, two public presentations highlighted ways in which simulations usually are incomplete (Gifford 2009, Carpenter 2009).

Nevertheless, as the cases examined here show, office, public assembly buildings and schools, in the Great Lakes Basin and North Atlantic region, are running today at 15-30% of today's average level of energy-intensity, and providing ample satisfaction.

Must "low-load" be at odds with "high satisfaction"?

In the cases examined here, there is little evidence that reducing energy use and GHG emissions has constrained the architects' ability to attain high levels of design quality.

The analysis in Section 4.6 focused on the balance between "low-load" and "high-satisfaction" goals. Numerous "energy-reduction operations", defined in the Strategy Grid, are linked to the attainment of satisfying design conditions - as either synergistic, or potentially risky. The potential synergies are roughly equal in number to the potential risks, and there are several ways to mitigate each risk.

Synergistic effects result from: introducing an atrium into an otherwise generic floor plan, extending the design out into the landscape, choosing a skinny floor plate, paying close attention to ventilation design, and including devices that generate renewable energy at the building. Each of these design strategies can serve both aesthetic and practical purposes.

Points of potential conflict exist, where making a design "meaningful, enjoyable, beautiful and clever" is potentially at odds with pursuing one of the energy-reduction operations. The designers of the "new normal" buildings used a rich array of strategies to resolve competing priorities. For instance, through a restricted quantity of window area (to keep the heat in), they admit a wide range of interesting qualities of daylight. Coloured light, high-level daylight, multi-directional light, and daylight diffused or shaded by integral devices (awnings, canopies, etc.) are essential elements of the architects' palette, in these high-performance buildings.

Figure 4.8.2
PAAM: Meaningful, enjoyable, beautiful, clever and natural

A passive solar approach often is touted in the literature as an essential device for lowering energy use. However, the case studies suggest that this may be an over-simplification of an issue that is at play in some circumstances, and not in others. For instance, the orientation of a building spine may not contribute as much to lowering energy use as is commonly suggested. Orienting glass southward seems to be helpful, but may not have as much power as insulating well. Avoiding east- and west- facing glass is not an essential tactic, by the evidence of these case studies. There are risks with east- and west- facing glass, but, like so many others in this area, they can be mitigated by careful design. Questions regarding specific operations such as these will be explored further, in the Study of Design Parameters, in Chapter 5.

The way to resolve a few of the risks inevitably will be the subject of ongoing debate among design professionals. For instance, alternative climate control systems and lighting controls are employed extensively in the case studies, to save energy. These are the subject of some negative feedback – regarding comfort and convenience – from building occupants. However, little comparative study has been done, to determine whether these emerging technologies are more or less problematic than their "conventional" (i.e. since the 1950s) counterparts.

Finally, there is the issue of resolving today's "contemporary sensibilities" with a design approach that may involve passive solar strategies, active solar devices, or, more fundamentally, an interest in bioclimatic regionalism. Even this small set of cases contains examples of great success and slightly less success in this regard.

Figure 4.8.3
Wind NRG: Proof positive of the synergy of "low-load" and "high-satisfaction"

(image Carolyn L. Bates)

How do client, architect and context combine most successfully?

Section 4.4 shows that, in these cases, “low load + high satisfaction” architecture is most often achieved by a client wanting both “green” design and iconic architecture, working with an architect whose practice emphasizes “service” or “ideas and service”.

The clients of several dispositions initiated these projects. Some, but not all, are “deep green”: the Woods Hole Research Center, the Faculty of Environmental Studies at Oberlin College, and Wind NRG have core values that demand that they “walk the walk”, when they make a new building. At the other end of the spectrum, clients like SAS and PAAM asked their architects for iconic architecture, in order to communicate a message about their business - not about their “green”-ness - to their clientele. A third type includes clients like Artists for Humanity and St. Gabriel’s Parish, who perceive environmental stewardship as compatible with their public-service or social-assistance mandates. The cases here suggest that a client with any of these contrasting dispositions can realize a “low-load + high-satisfaction” building, but that the “deep greens” have been, to date, the most likely to realize the most exemplary levels of energy-efficiency.

When Maister’s typology of professional service firms is used to categorize the architectural practices concerned, the firms that place singular emphasis on “new ideas” are in the minority, and those that emphasize pure “delivery” are not present. Most common were the “idea-service” firms, offering a modest level of research and innovation, coupled with extensive client interaction. In all seven of the “new normal” cases, the team also included a specialist in building science and/or energy simulation. It appears as though no single type of architect has a lock on achieving very low levels of energy intensity or high levels of satisfaction.

Figure 4.8.4
The AJLC: a “deep green” client and an “Idea” architect, working in a suburban location
(image: Robb Williamson, courtesy of NREL)

There is no evident correlation between level of overall success and physical context, or between level of energy-efficiency and context. Urban, suburban, and rural projects have been shown here to be successful as both low-load and high-satisfaction. In summary, architects of various stripes, in contexts of various natures can realize a “new normal” design. Client disposition exerts a very powerful leverage upon the degree of both qualitative and quantitative performance.

Must "low-load + high-satisfaction" mean more cost?

In a word, no. In Section 4.7, the cases were compared to see if LEED level, energy-intensity, or some other parameter drives the cost of low-load buildings with any consistent force.

When the construction costs of each of the 19 designs was brought to an approximate equivalent (2007 Canadian dollars), the first analysis yielded results very similar to the findings in the two Matthiessen and Morriss studies (2004, 2007). Among these cases, there is no consistent correlation between LEED level and capital cost. For instance, the LEED Platinum building, Artists for Humanity, was realized at close to the average cost for its occupancy class (public assembly). Several non-LEED designs were more costly to construct, and LEED Gold designs were seen at a 3-fold range of price points (see Figure 4.7.1).

When the construction costs were compared to energy-intensity, again no consistent pattern was observed. Relative to their counterparts, some very energy-efficient design were costly; others were not.

A more holistic analysis used both the Busby factors (described in Section 3.6) and a full list of design and market factors, that are known to drive the cost of all construction projects. The Busby factors explained some of the differences in cost between cases of similar occupancy, but they showed, once more, that LEED level alone is a poor predictor of the cost premium in a given case. Design quality certainly has an impact, and it is very difficult to separate the cost of a "quality" decision from an "energy-saving" decision - particularly in these very well-integrated designs. The general tenor of the time and place - that is , the condition of the construction marketplace - appears to account for most of the difference in cost between one building and another. Issues of constructability, such as site access, the availability of skilled labour, and an intangible "wierdness factor" (from a bidders' perspective) are strong drivers of construction costs - in a "low-load + high-satisfaction" building, just as in any other building.

Figure 4.8.5
Artists for Humanity: very low-load, and very high-satisfaction on a very tight budget

(image from USGBC, Oct. 2006)

What are the best practices that lower energy-intensity, in the Great Lakes Basin?

In Section 4.5, the analysis using the Strategy Grid compares the design approach in the "new normal" cases to that in the "GTA default" cases. The seven "low-load + high-satisfaction" designs demonstrate a wide variety of implementation tactics. Although the impacts of specific design strategies are not quantified through the case study method, the diversity of strategies that an architect might employ is amply represented. In all of the "new normal" cases, strategies from all five steps in the Strategy Grid are used. This analysis shows that lowering environmental loads requires a combination of several strategies in one design, using an approach that is driven by an understanding of climate.

Understand Climate and Place

The "cool-humid" climate that is the object of this research is defined as one in which heating degree days (HDDs) far outweigh cooling-degree days (CDDs). Design priorities in such a climate clearly must emphasize measures that keep the heat in. Weather data for cities in the Great Lakes Basin, compared to similar data for other North American locations, shows that diurnal and seasonal temperature swings in this region are very high, precipitation is relatively moderate, and CDDs are numerous enough that responsiveness to hot, humid weather is essential. Insolation here is midway between the greatest and least extremes worldwide - sufficient to generate electricity for at least part of the year. Step #1 is the prerequisite to reducing energy use, because it is used to define the specific strategies that make up all of the subsequent steps.

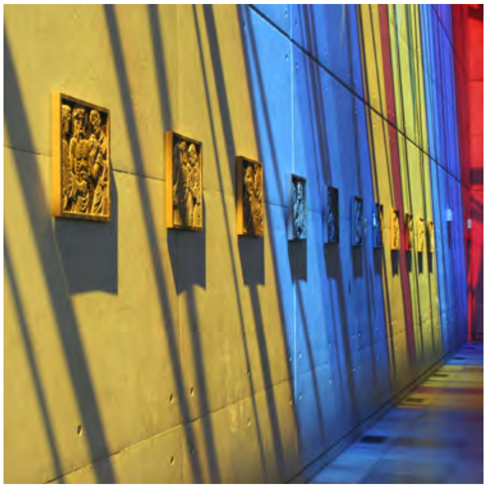


Figure 4.8.6
St. Gabriel's Passionist Church: an experience of natural systems during worship

(image Roberto Chiotti)

Reduce loads

A look at the strategies in step #2 begins to show how the "new normal" cases differ from the "GTA defaults". In the low-load cases, average thermal resistance values for walls, roofs, and windows exceed both the minimum requirements of the Ontario Building Code (OBC) and standard practice in institutional construction in the GTA, by a substantial margin (see Figure 4.5.23). Air-tightness is verified, using thermography and pressure tests. Lighting power density is held to around 0.9 W/sf; this is possible because of improvements in lamps in recent years. The average window-to-wall ratio (WWR) in the "new normal" cases is similar to that in the "GTA defaults" - roughly 30%. Exterior sunshades on windows and shading of roofs is a feature in roughly half of the "new normal" designs.

Use "free" energy
The effect of passive solar strategies on the energy-intensity of a non-residential building seems to be minimal, at least in the cases examined here. Step #3 includes many strategies not used in the GTA default designs. With the exception of heat recovery ventilation, these strategies do not show strong correlation to energy intensity level.

Building orientation does not correlate consistently with low energy intensity. Opening the south facade to the sun seems to correlate more clearly. Storage of heat in thermal mass, other than floors, is rare. Operable windows are common, and automatic operators are used in two of the lowest-energy cases. Night pre-cooling is used in only one case - that involves manual operation and considerable flexibility from building occupants. In only 3 cases, ventilation air is distributed (at relatively low velocity) from under the floor. Heat recovery equipment seems to be an essential component of nearly all of the lowest-energy buildings. In a few instances, waste heat from a nearby industrial process has been captured.

Specify efficient equipment
The "GTA default" approach is similar to the "new normal" approach in many ways, with respect to equipment choices. Most cases continue to use fossil fuels, and all are connected to the electricity grid. De-coupling ventilation from climate control is popular in both groups of cases, although the "new normal" approach de-couples both heating and cooling, while the "GTA" approach tends to de-couple only heating. With respect to efficient lamps and light fixtures, occupancy and daylight controls on lights, energy-efficient appliances and desktop equipment, the "new normal" designs go further, more consistently than the "GTA" defaults.

Use renewable energy sources
At present, on-site generation of energy is incorporated only in the designs that draw less than 150 kWhr/m^2/year.

Figure 4.8.8 (overleaf) presents a summary of the observations about the architectural parameters, and a list of questions to be answered in the Study of Design Parameters.

Figure 4.8.7
SAS Institute (Canada): even significant recent accomplishments suggest areas for further study

Figure 4.8.8
Summary of "best practice" strategies and questions for further study

REDUCE LOADS		Significant Effect
2.1	**Exterior wall ≥ R-20**	Met in nearly all cases; exceeded in few. Highest is R-25.
2.2	**Roof ≥ R-30**	Met in most cases; highest is R-45, used in the least energy-intense cases.
2.3	**Window ≤ U 0.26**	Met in all cases; lows are 0.14 - 0.19 of which 2/3 are least e-intense cases.
2.4	**Air infiltration controlled**	Insufficient info re specific measures taken in the field.
2.5	**WWR bldg. ≤ 40%**	Met in all cases; range among 4 least energy-intense is 21.7% to 43.0%.
2.6	**Compact mass**	-
2.7	**Floor plate ≤ 60' in one direction**	Met in least e-intense cases in each category of use; one with clerestories.
2.8	**LPD ≤ 0.9 W/sf**	Met or exceeded in the 2 least e-intense cases in each category of use.
2.9	**WWR e+w ≤ 15%**	-
2.10	**Exterior sunshades**	-
2.11	**Roof shaded or white**	-
2.12	**Pattern of use**	Insufficient info.

USE FREE ENERGY		
3.1	**Building spine east-west**	-
3.2	**WWR south ≥ 40%**	-
3.3	**Thermal mass**	-
3.4	**Operable windows**	Used in most cases; 3 least energy intense cases use auto-operators.
3.5	**Night pre-cooling**	-
3.6	**Displacement ventilation**	-
3.7	**Heat recovery ventilation**	Use in 8 least energy-intense cases.
3.8	**District heat**	-

EFFICIENT EQUIPMENT		
4.12	**Occupancy sensors**	Used in 13/15, and 5/6 "new normal" cases, but only 1/3 "GTA defaults".
4.13	**Daylight sensors**	Used in 10/12 cases.

Little or Questionable Effect	Question
-	Which load is greater - enclosure or internal?
-	
-	
-	
-	How much would 20%, 40%, 60% WWR matter?
Least energy-intense cases are not compact (small GFA per surface area).	How much does plan form drive e-intensity?
-	See 2.6.
-	
Lower values in "new-normal" cases than in "GTA defaults"; in only 2 cases, both e&w are ≤ 10%; least e-intense cases allow approx. 18%.	How much does WWR on e+w drive e-intensity, in the Great Lakes Basin (GLB) vs. elsewhere?
Used in 12 of 16 cases, at all levels of energy-intensity.	How much impact from sunshades in GLB vs. elsewhere?
Correlation to energy-intensity appears weakly.	How much impact from white roof vs. BUR surface?
Met by 4/6 cases under 100 kWhr/m^2/yr; but not by the least e-intense. Also met by 1 case over 250 kWhr/m^2/yr. Not needed by 5/6 cases between 100 and 250 kWhr/m^2/yr.	How much impact does rotating from n-s to e-w have, in GLB vs. elsewhere?
Met by 4/7 "new-normal" cases, but not by the least e-intense.	How much impact from WWR on south façade, in GLB vs. elsewhere?
Exposed concrete floors used in 3/11 cases; exp. conc/msnry walls in 2/11.	Cannot simulate.
-	Cannot simulate.
Used in only 1/19 cases.	Cannot simulate.
Atria in 8/10 cases; UFAD in 3/7 "new-normal" cases.	Cannot simulate using tools selected.
	How much impact from HRV, according to simulator?
Used in 3 projects, where available on a "campus", or from municipality.	A source of energy, not a driver of e-intensity.
-	How much impact from occupancy sensors?
-	What is the impact of daylight sensors when combined with 2.7 ?

Order matters

This analysis has shown that "understand climate" and "reduce loads" are clear prerequisites to lowering energy intensity. The use of free energy is an emerging practice that seems to be applied sporadically and may yield inconsistent results. Specifying efficient equipment seems to go hand-in-hand with strategies to "reduce loads"; in no case did a design excel with respect to step #4 and show poorly with respect to step #2.

Reflecting on the process ...

This analysis has proved that the potential exists to lower the overall energy use of a building is real and significant - and that design quality need not be sacrificed, when realizing this potential.

One hunch that was confirmed during the exercise is that the gap between a first-hand experience and a second-hand report is a quantum one. The literature that has been published about these buildings – however voluminous, or well-illustrated - is no substitute for the opportunity to look in, and be in, the real thing.

Another hunch, amply confirmed through the interview process, is that there is an acute need for more structured post-occupancy evaluations (POEs) of "high-performance" buildings. The absence of rigorous POEs is particularly striking when one remembers the claims that "green buildings" afford greater support for employee health and productivity than other buildings.

Figure 4.8.9
The Gilman Ordway Building at the Woods Hole Research Center*:*

Natural daylight, an exemplary enclosure, and efficient equipment combine in the most energy-efficient cases

(image: Judy Watts Wilson)

These claims may be true – but the data to prove it are rarely collected, and even more rarely issued into the public realm.

The QDQ proved itself a useful lens through which to view design quality. By choosing not to apply a numerical score to design success, the breadth and depth of the architect's range of approaches has been illustrated. The Intensometer and Strategy Grid also proved useful, as frames of reference and ways of organizing information about several buildings, for comparison. All three instruments can be applied widely, in future consulting practice.

The general principles, outlined above, were gleaned from working with the idea of an "Order of Operations" - and all are valuable to keep in mind in future consulting practice, as the study progresses. Now that the critical architectural strategies have been identified, their relative power may be explored further, in the next research exercise.

5

STUDY OF DESIGN PARAMETERS

5.0 TECHNIQUE: HOW MUCH DO EARLY DECISIONS INFLUENCE ENERGY-INTENSITY?

The next exercise is conducted in the controlled conditions of the computer lab, away from the world in which the “new normal” cases were constructed. For the purpose of an experimental analysis, several office buildings are designed, as realistic, but generic “types”. Certain aspects of each design, that normally would vary, are frozen, temporarily. Site topography, the functional program of a specific group of occupants, the aesthetic ambitions of a particular architect, and the constructability challenges in a given time and place are set as constants. With these factors set aside, the architectural parameters - including form, orientation and enclosure specification - are then varied, one at a time, and the impact on the annual energy use of the building is observed.

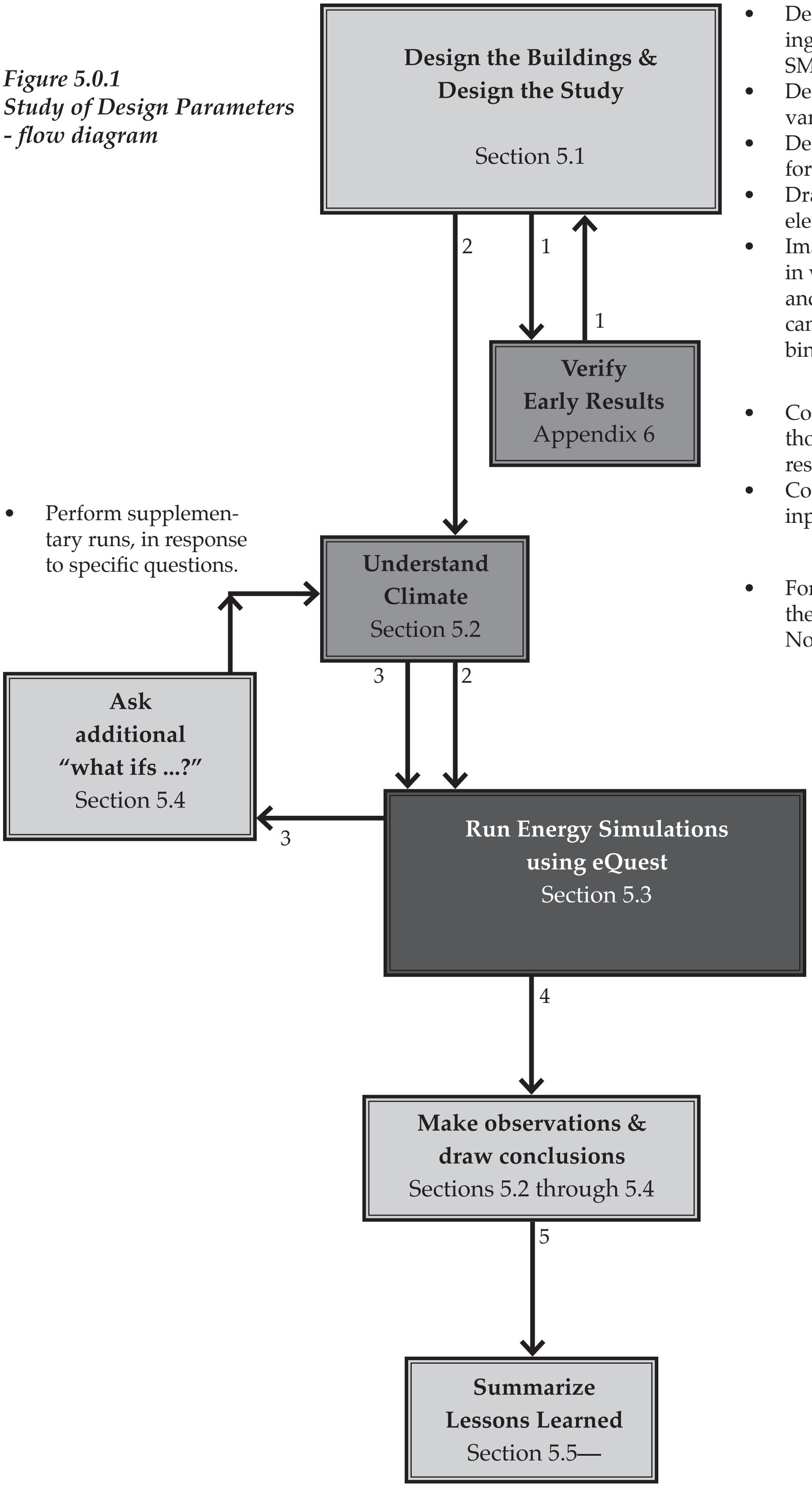


Figure 5.0.1
Study of Design Parameters
- flow diagram

- Design typical office buildings, with square floor plates, SM, MD, and LG-sized.
- Design long, and H-shaped variations of the floor plates.
- Develop four enclosure performance levels.
- Draw typical wall section & elevations.
- Imagine a matrix of "types" in which form, orientation and enclosure parameters can be tested in various combinations.

- Compare early results with those obtained by another researcher.
- Co-ordinate and perfect the inputs.

- For selected types, compare the results in 4 different North American climates.

- Perform supplementary runs, in response to specific questions.

- Perform simulations for all types in "Macro-matrix 1" and look for patterns among the outputs.

Figure 5.0.1 shows an overview of the Study of Design Parameters. Designing the study involved documenting the constants and variables to be used throughout the energy simulations, and articulating the expected behaviour of the types. In Section 5.1, the inputs used in the computer simulations are described in detail, as is the process by which the results were verified. Designing the building types was a relatively simple exercise, that relied upon common practice in late 20th-century North America.

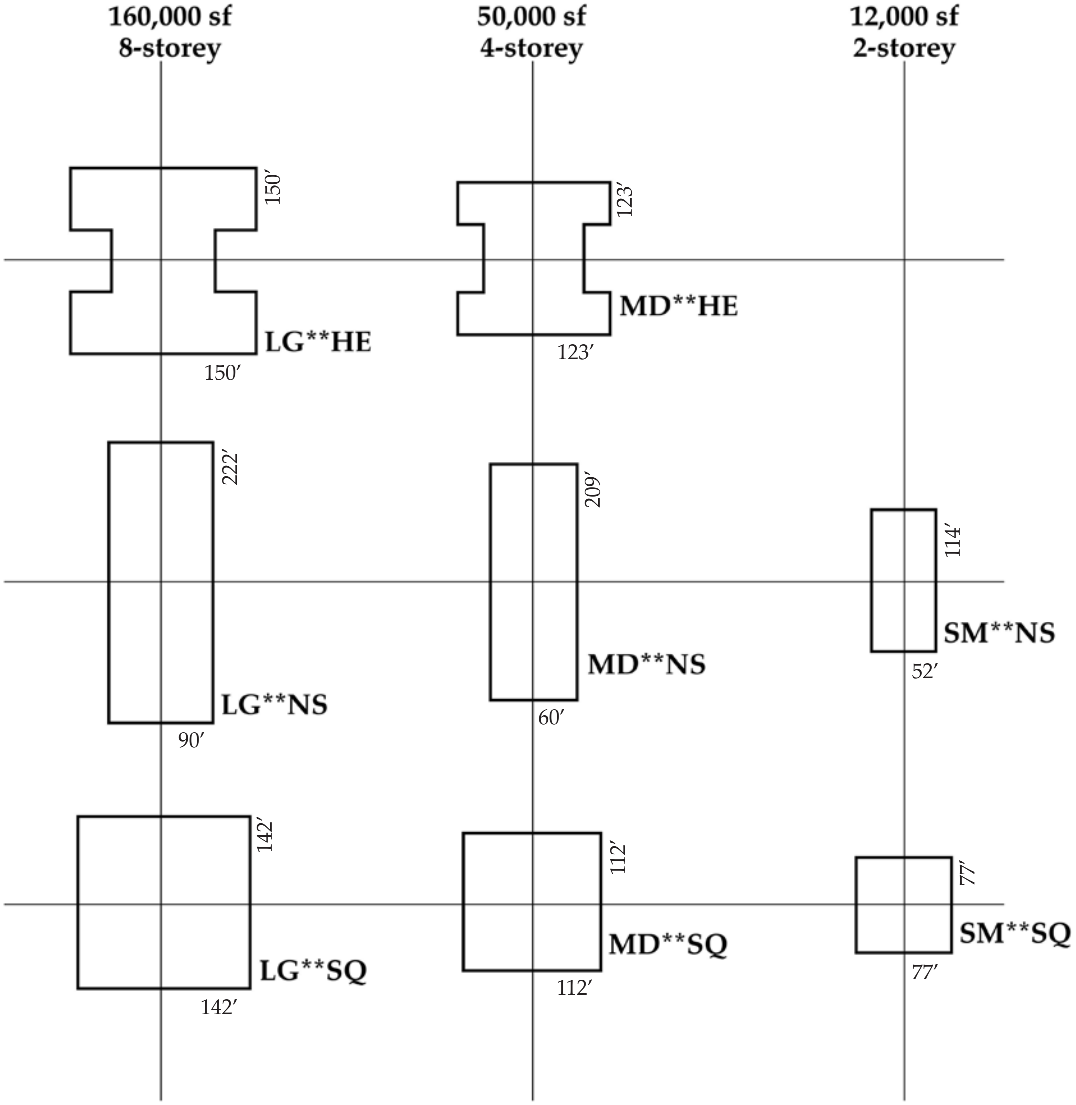
In Chapter 4, the imperative "Understand Climate" was shown to be an essential first step in the "new normal" design approach. Therefore, this study begins by comparing energy use patterns in Toronto where the theoretical building types are situated, to patterns in other places. In Section 5.2, the energy-use profile of one building type, drawn from the center of the range of types, is simulated in Toronto, Regina, Seattle, Phoenix and Miami.

Next, 156 simulations are conducted, to build "Macro-matrix #1, so that general trends may be observed in the energy-intensity figures and energy-use profiles of the various generic "types" - this time, with a focus on Toronto only. The potential power of building plan form, building orientation, window-to-wall ratio (WWR) and enclosure performance level is presented through the results in Section 5.3.

In Section 5.4, a check back to the Strategy Grid provokes several "what-if?" questions about the results in "Macro-matrix 1". The list of questions posed at the end of Chapter 4 is revisited, and five supplemental series of simulations are constructed. These test strategies that were not used in the designs of the original types, including: daylight sensors, sunshades, and window orientation.

Section 5.5 provides a summary of what was discovered about the power of various design parameters through this method. Overall form, orientation to the sun, and enclosure performance may exert a significant influence on energy use – the key question being ***"how much"?***

Figure 5.1.1
Office building types tested in the Study of Design Parameters



5.1 QUESTIONS ASKED IN THE STUDY OF DESIGN PARAMETERS

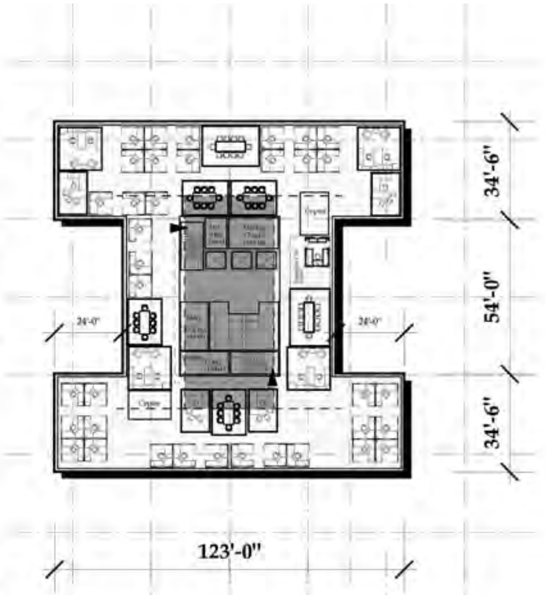
The "types" are designed to probe first into the power of building form. This is necessary, because statements in the literature are at odds with observations made, so far, in this research. In the literature, building form is declared a powerful driver of energy use (see Section 3.5). Yet, the Intensometer has shown a six-fold gamut in the energy-use of so-called "green" buildings, of similar size, shape and use - and, in the search for best practices, building form did not seem to correlate to very low levels of energy intensity (see Sections 4.3 and 4.5). Contrary to expectations, the least energy-intense cases were more spread out in plan form than compact, and tended to have one plan dimension less than 60′. Therefore, the first question is - how wide would be the potential gamut of energy intensity among several office buildings, if form alone were varied, and all other characteristics were kept consistent? Figure 5.1.1 presents an overview of the building types that were designed for this study, and the nomenclature used to identify them.

In the literature, there also are many references to "skin-dominated" and "internal-load-dominated" buildings. The implication is that there is a definable threshold, and that it is mainly related to building form (Brown & deKay 2001; Lechner 2001; ASHRAE 2004). If the threshold between "skin" and "internal-load" domination is fixed, then this series of tests should reveal it. If the threshold is moveable, then these tests should begin to point to those parameters that determine its position.

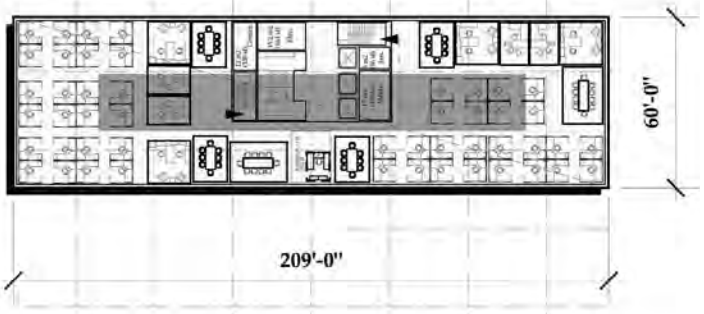
As soon as these questions are asked, others follow, concerning the power of form, relative to other design parameters, such as:

- Does a building with an exemplary enclosure (i.e. a very high level of thermal resistance) always out-perform a building that is of compact shape or favourably oriented to the sun?
- Does a building with a lot of glass always under-perform a building with less glazing, no matter how favourable the orientation or how well-specified the solid portions of the enclosure?
- Are the answers to these questions consistent - from the smallest to the largest building scales, as defined for this test?

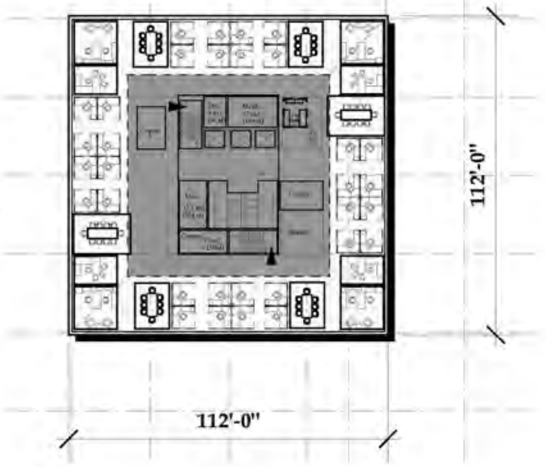
Figure 5.1.2
Sample floor plans of medium-sized office building, showing three variations in form



MDHE**
footprint 12,537 sf
x 4 storeys
gfa 50,148 sf



MDEW**
footprint 12,540 sf
x 4 storeys
gfa 50,160 sf



MDSQ**
footprint 12,544 sf
x 4 storeys
gfa 50,176 sf

The design of the formal types

The schematic designs of the building types take “everyday” technical requirements into consideration. For instance, the floor plates are arranged around a realistic service core, with elevators, fire exits, and equipment rooms. Every type has a flat roof and employs a 20’ structural bay - typical in North American office buildings, of the 1980-2010 era. Any mechanical equipment that is not in the core is located in a rooftop penthouse, which is not included in the gross floor area. Floor plans of three of the eight formal types are illustrated in Figure 5.1.2.

The interior layouts prove the realism of each of these formal types. Within each size class, the allocation of space to all of the various uses is consistent; for instance, each variation accommodates the same number of private offices and conference rooms. On each floor, washrooms and stairs comply with Ontario Building Code 2009 minimums. In the Medium and Large buildings, the core and floor plate dimensions allow two alternative arrangements of private offices and open-plan workspace: one with private offices at the perimeter, and another that favours the open-plan workspaces (e.g. compare the top and bottom of MD**HE, or the left and right of MD**EW). Detailed plans of all SM, MD, and LG types are presented in Appendix 5.

The ratio of Facade Area: Gross Floor Area (GFA) and overall Surface Area (including the roof): GFA - for each of the building forms - is listed in Figure 5.1.3. (The very slight variations in footprint area result from rounding the overall exterior dimensions.)

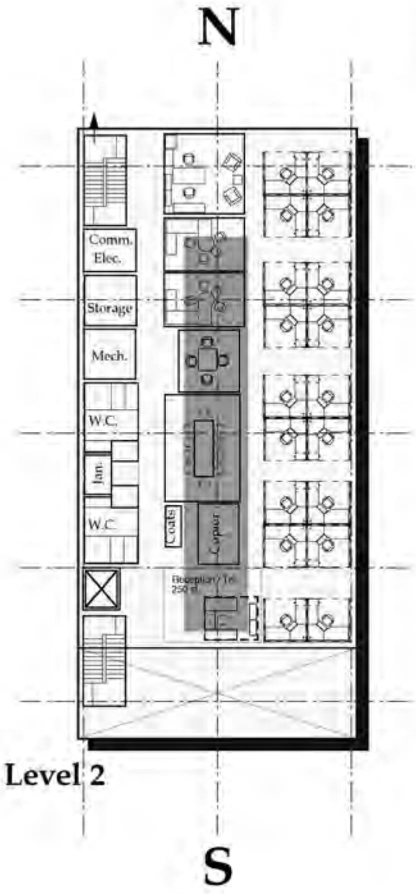
Figure 5.1.3
Overall proportions of the building types tested in the Study of Design Parameters

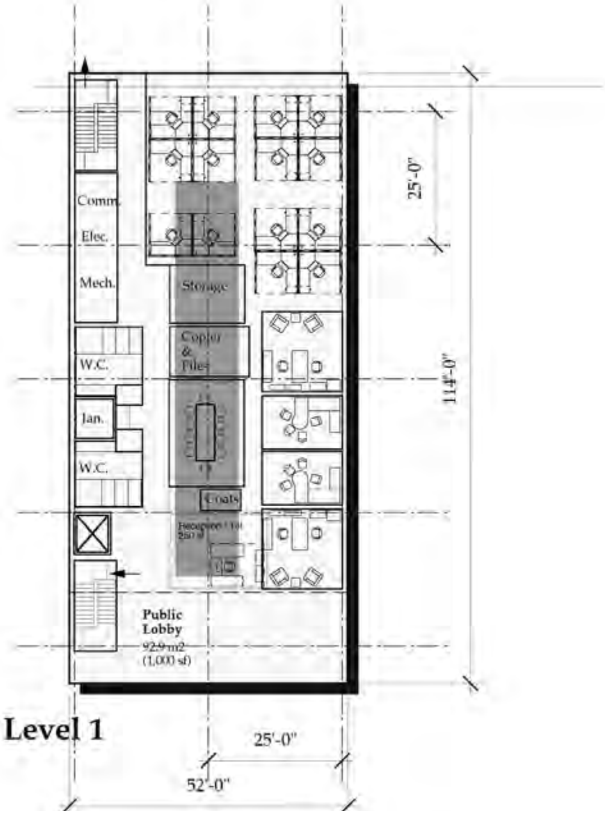
	Plan		**Building**		**Enclosure**		**Proportions**		
	Dimension (feet) ew x ns	Plan shape is 1:	Ftprint (sf)	GFA (sf)	Facades (sf)	Surface (sf)	Fac: GFA is 1:	Surf: GFA is 1:	***Most similar Case Study:***
SM**NS	52 x 114	2.19	5,928	11,856	8,632	14,560	1.4	0.8	*PAAM 66 x 114, 19,500 sf*
SM**EW	114 x 52	2.19	5,928	11,856	8,632	14,560	1.4	0.8	*AJLC Oberlin 144 x 44, 13,600 sf*
SM**SQ	77 x 77	1.00	5,929	11,858	8,008	13,937	1.5	0.9	*Gil. Ordway 160 x 54, 19,200 sf*
MD**HN	123 x 123	less	12,537	50,148	30,576	43,113	1.6	1.2	
MD**HE	123 x 123	less	12,537	50,148	30,576	43,113	1.6	1.2	
MD**NS	60 x 209	3.48	12,540	50,160	27,976	40,516	1.8	1.2	*Artists 63 x 113, 23,500 sf*
MD**EW	209 x 60	3.48	12,540	50,160	27,976	40,516	1.8	1.2	
MD**SQ	112 x 112	1.00	12,544	50,176	23,296	35,840	2.2	1.4	*St. Gabriel’s 119 x 155, 25,000 sf*
LG**HN	150 x 150	less	20,000	160,000	72,800	92,800	2.2	1.7	
LG**HE	150 x 150	less	20,000	160,000	72,800	92,800	2.2	1.7	
LG**NS	90 x 222	2.47	19,980	159,840	64,896	84,876	2.5	1.9	
LG**EW	222 x 90	2.47	19,980	159,840	64,896	84,876	2.5	1.9	*Wind NRG 245 x 120, 46,500 sf*
LG**SQ	142 x 142	1.00	20,164	161,312	59,072	79,236	2.7	2.0	*SAS 139 x 109, 120,000 sf*

Figure 5.1.4
Sample floor plans: small office building, north-south shape (SM**NS)

for plans of all shapes and sizes,
see Appendix 5

Space Allocation	sf		11,856	% of GFA	OBC occ. load
Open Office			5,478	0.462	54.8
Private Office	1,275	1	1,275	0.108	12.8
Conference	280	2	560	0.047	5.6
Copy	150	2	300	0.025	3.0
Corr/Stair/Elev	1,703	1	1,703	0.144	17.0
WC	740	1	740	0.062	7.4
Mech/Elec/Comm	400	2	800	0.067	2.7
Lobby	1,000	1	1,000	0.084	50.2
Total					153

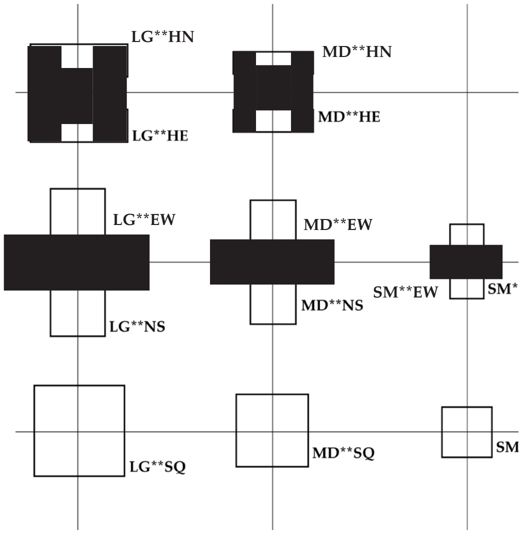




Building orientation

To probe into the impact of building orientation, the forms so far described also are rotated in relation to the sun. Figure 5.1.4 shows the small building, with its long axis aligned north-south (SM**NS). When this long, slender plan form is rotated 90°, a new type is named SM**EW. In the MD and LG sizes, the H-shaped plan forms likewise will be tested in two orientations. Spinning the plan form 90 degrees, while keeping all other parameters consistent, will show whether there is any significant advantage, in Toronto, to re-orienting an entire building toward the sun.

The literature suggests that careful siting of a large building can take advantage of "passive solar effects" and that building orientation is crucial to managing loads. The disposition of a building spine ostensibly improves the energy performance in summer, reducing the high solar gains from the east and west, and therefore reducing the cooling load. It is questionable, in northerly latitudes, whether the reduction in cooling load is significant. In the type with the east-west spine, the significance of solar gains in winter may be cast in some doubt, if considered in relation to Olgyay's observation that thermal effects dominate over solar effects the further away from the equator that one goes. The question then is, where does Toronto sit, along the continuum? (see Sections 2.3, 3.5 and 4.5).



In the first series of simulations, the window-to-wall ratio (WWR) is kept consistent on all four sides, as the forms are rotated. Later, in Section 5.4, supplemental runs test the value of passive solar effects even further.

The toned area at the core of the floor plans in Figures 5.1.2 and 5.1.4 indicates the areas into which natural daylight can never penetrate, given a window height of 8-9' above the floor. All other areas of the plan have the potential to receive daylight from nearby windows and to afford views out, given a favourable layout of interior partitions. The plan studies show that the slender and H-shaped plans offer the potential for much greater access to daylight and views than the square plan forms - particularly in the LG types.

Figure 5.1.5
East-west and H-shaped plans are "spun" on their axes to create 5 more types

Figure 5.1.6
Summary of parameters used as eQuest inputs

see also "Space Allocation inputs" (Fig. 5.1.12) and "Climate Control system inputs" (Fig. 5.1.13)

	Constants	Variables
Use:	Office Building	
Location:	Toronto	
Occupied:	M-F 8-6, 90%; S-S-H 1-5, 15%	
Building shape		
Storey heights:	13' floor-to-floor; 9' ceilings	
Basement:	no basement	
Gross Floor Area:	varies, see right (rounded)	Small (SM)-12,000 sf
		Medium (MD)-50,000sf
		Large(LG)- 160,000 sf
# floors/Footprint:	varies, see right (rounded)	SM 2 @ 6,000 sf
		MD 4 @ 12,500 sf
		LG 8 @ 20,000 sf
Orientation:	varies	see Figure 5.1.5
Enclosure:		
Thermal perform.:	varies, see Figures 5.1.7 - 5.1.9	A - Exemplary
		B - High Performance
		C - Institutional
		D - Market
Ground Floor:	6" slab-on-grade, insul. varies	see Fig. 5.1.7 & 5.1.8
Win-to-wall ratio:	varies, see right	20%, 40%, 60%
Windows:	operable area : fixed area is 1:4	4%/16%; 8/32; 12/48
Ext'r shading:	none	
Skylights:	none	
Interior finishes		
ceilings:	lay-in acous. tile at 9', no insul.	
walls:	frame, no insul.	
floors:	carpet, 6" conc. slab., no insul.	
Occupancy		
Functions:	business suites including open plan and private offices, conference and copier rooms; typical service core; entrance lobby on main floor; no retail	proportions derived from schematic plans, see Appendix 5.*
Schedule:	8am-6pm, M-F; 1-5pm, S-S-H	
Lighting & Equipment		
Ltg power density:	typ. 1.3 W/sf (see Fig 5.1.12)	
Eq. power density:	typ. 1.5 W/sf (see Fig 5.1.12)	
Lighting controls:	n/a in basic runs	*see Section 5.4*
Climate Control (HVAC) systems		
Heating:	electric resistance	
Cooling:	packaged single zone DX coils, with air-cooled condensor (EER 8.5); 1 system for core plus 1 for perimeter	
Domestic water:	electric, size varies	see Figure 5.1.13

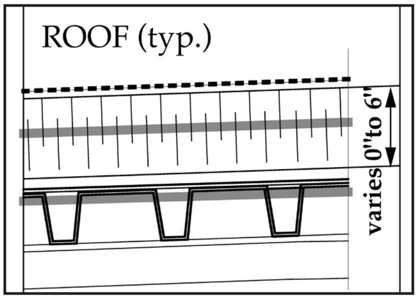
Constants and variables in the Study of Parameters

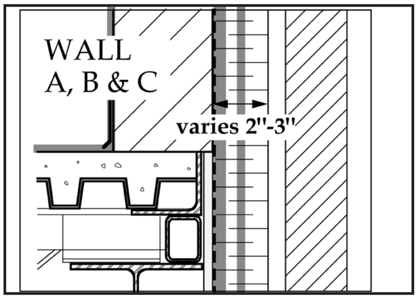
Unlike other energy-use "optimization" studies, this study does not aim to find the ideal specification to suit a particular design scenario. Instead, it aims to isolate the concerns of the architect, and to understand their potential. Therefore, with the exception of facade design, any other contemplated variations are kept to a minimum. A summary of the constants and variables that are input into every "eQuest run" in this study is presented in Figure 5.1.6, and a few general notes follow.

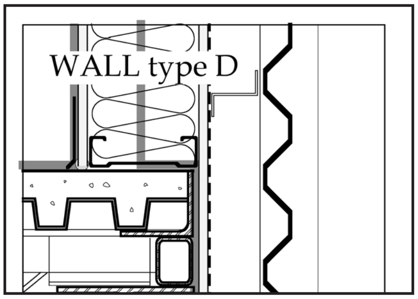
Space allocation is designed to be as close to constant as physically possible in all types. To accomplish this, the building types are abstracted somewhat from reality. For instance, a real building of similar type would have one or more below-grade levels - but a basement would occupy a larger percentage of the overall space in the small building types used here, than it would in the large types. Also, the occupancy of a basement would likely vary with size of the buildings, being dedicated to storage in the small building, and to parking, in the large building - and this would have an impact on energy use. To avoid skewing the results at one building size, in relation to the others, there are no basements in any of the building types tested here.

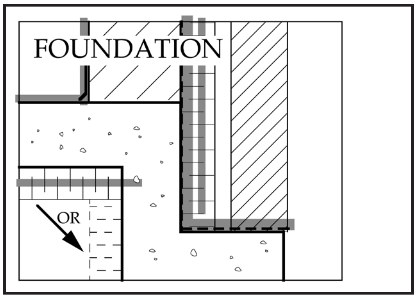
The climate control systems likewise remain constant in all types. The heating system was chosen to neutralize the impact of variations in the size and efficiency of the heating equipment, that would occur from one size of building, to the next. (A detailed list of climate control system inputs is shown in Figure 5.1.13.) Electric resistance heating is used here, although it is not "realistic" for any of the building types. Nevertheless, it operates at near 100% efficiency, independent of fans - thereby closely representing the "heating load" at work in any particular building type. More uncertain outcomes might arise, if more realistic climate control systems were chosen. For instance, heating with a gas-fired system - hydronic or air - ideally would involve right-sizing pumps, fans, and flow temperatures – as closely as possible – for each building size and configuration. It also would involve many more assumptions about the effective operation of the building than are made with electric resistance heating. Had a comparable system been available for cooling the building, it would have been used.

Figure 5.1.7
Skin Variations:
Effective R-values of solid enclosure assemblies, as read by eQuest









	INPUT (from eQ menu)	**EFFECTIVE values** (eQuest READS AS)	
Type D, "Market"			
roof:	BUR no insulation	Uimp 0.215 or R- 4.7	**say R-5**
wall:	alum, blue med. 2 x 6 metal framing @ 16" R-11 batt	Uimp 0.132 or R- 7.6	**say R-8**
foundation:	no insulation		
Type C, "Institutional"			
roof:	BUR 2" polyiso	Uimp 0.053 or R- 18.9	**say R-19**
wall:	brick 2" polyiso 8" CMU (hollow)	Uimp 0.059 or R- 16.9	**say R-17**
foundation:	2' vert. int'r "R-10"		
Type B, "High Performance"			
roof:	BUR 4" polyiso	Uimp 0.030 or R- 33.3	**say R-33**
wall:	brick 3" polyiso 8" CMU (hollow)	Uimp 0.041 or R- 24.4	**say R-24**
foundation:	4' vert. int'r "R-20"		
Type A, "Exemplary"			
roof:	BUR 6" polyiso	Uimp 0.021 or R- 47.6	**say R-48**
wall:	brick 3" polyiso 12" CMU filled w / polyurethane	Uimp 0.028 or R- 35.7	**say R-36**
foundation:	full underslab "R-10"		

"Skin": thermal resistance of the building enclosure

Four complete "packages" of enclosure elements were designed, to mimic approaches that are taken in real-life practice, by designers with varying ambitions. The "Market" type is slightly below the current OBC 2009 minimum.* The "Institutional" type is similar to good practice in civic buildings in the GTA, since the mid-1980s. The "High Performance" type is similar to the majority of the "new normal" cases, and the "Exemplary" type is similar to the least energy-intense cases (see Strategies 2.1 and 2.2 in Section 4.5). Figure 5.1.8 presents an overview of the "skin" performance levels used in this study.

Effective, rather than nominal values, for the thermal resistance of the enclosure elements, are calculated automatically in eQuest. This was verified in the "Construction properties" tab in the eQuest "Component Tree", ***after*** the initial few simulations were run. Figure 5.1.7 shows the "calculated U value" that eQuest interprets, and the corresponding "effective R-values" for each assembly.

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*The "Market" wall and roof do not comply with OBC 2009, which requires that a lightweight wall have a resistance of R-13, and that a roof have a resistance of R-21. However, the "Market" window does comply with OBC 2009, and the wall and roof in this study this represent common construction practice in the GTA, during the 1980-2000 era.

Figure 5.1.8
Summary of variations in performance level of all enclosure elements

		EFFECTIVE Rimp			**WINDOW**	**Air changes/hour**	
		WALL	**ROOF**	**FNDTN.**	**Uimp**	**(ACH)**	***Best match to Case Studies:***
"Market"	**D**	R-8	R-5	none	0.55	0.90	
"Institutional"	**C**	R-17	R-19	vert. int'r 2'	0.34	0.50	*PAAM* *SAS* *GTA Police Sta.*
"High Performance"	**B**	R-24	R-33	vert. int'r 4'	0.35	0.30	*AJLC Oberlin* *Artists* *St. Gabriel's*
"Exemplary"	**A**	R-36	R-48	full u/s	0.21	0.1	*Wind NRG* *Gil. Ordway*

Figure 5.1.9
Variations in window type
& performance level

	A	B	C	D
	Exemplary	**"High Performance"**	**"Institutional"**	**"Market"**
frame:				
material	alum/wood	alum	alum	alum
thermal break	yes	yes	yes	no
insul spacer	yes	yes	no	no
fixed/operable	80%/20%	80%/20%	80%/20%	80%/20%
glass:				
layers	triple	double	double	double
space	argon	argon	argon	air
colour	tinted	tinted	clear	clear
LowE (0.1<e<0.2)	yes, e<0.1	yes, 0.1<e<0.2	yes, 0.1<e<0.2	no
performance (fixed):				
U (BTU/h-sf-°F)	0.21	0.35	0.34	0.55
SHGC (design)	(0.30)	(0.46)	(0.63)	(0.72)
SC input req'd	0.35	0.53	0.72	0.84
VLT	0.60	0.62	0.73	0.81
performance (oper):				
U	0.26	0.40	0.39	0.60
SC	0.31	0.49	0.68	0.83
VLT	0.58	0.60	0.71	0.79
			(windows meet current OBC)	
			U_{met} WINDOW	2.84
			OBC max.	(1.87-3.41 req'd)
glass doors	Triple LowE	Double LowE	Double LowE	Double Clr/Tint
	Al w/th. brk.	Al w/th. brk.	Al w/th. brk.	Al w/o brk.
	1/8"Clr,1/2"Arg	1/4"Tnt,1/2"Arg	1/8"Clr,1/2"Arg	U 0.55
		e2=.1	e3=.4	
	(3603)	(2638)	(2602)	(6000)

Glazing properties

The glazing specifications to suit each enclosure performance level are described in detail in Figure 5.1.9 (in which all values are in Imperial measure).

The “market” window meets the OBC 2009 minimum. The “exemplary” window is similar to the units seen in the most energy-efficient case studies - such as the AJLC at Oberlin (0.17), Wind NRG (0.17), and Gilman Ordway (0.19), and is at the highest performance level that eQuest can simulate. The “institutional” window is similar to the specification used for a typical high school or other civic building, in the researcher’s former practice. The “high performance” window is midway between the “institutional” and the “exemplary” window (see also Strategy 2.3 in Section 4.5).

The values for U, SC, VLT were entered manually in eQuest, via the “specify properties” option. Although Solar Heat Gain Co-efficient (SHGC) would have been the preferred unit, eQuest would not accept it as an input for the scenarios simulated here; therefore equivalent Shading co-efficients (SC) were used.[*]

The commercial availability of all glazing materials was verified by checking current product data sheets of AFG. [†]

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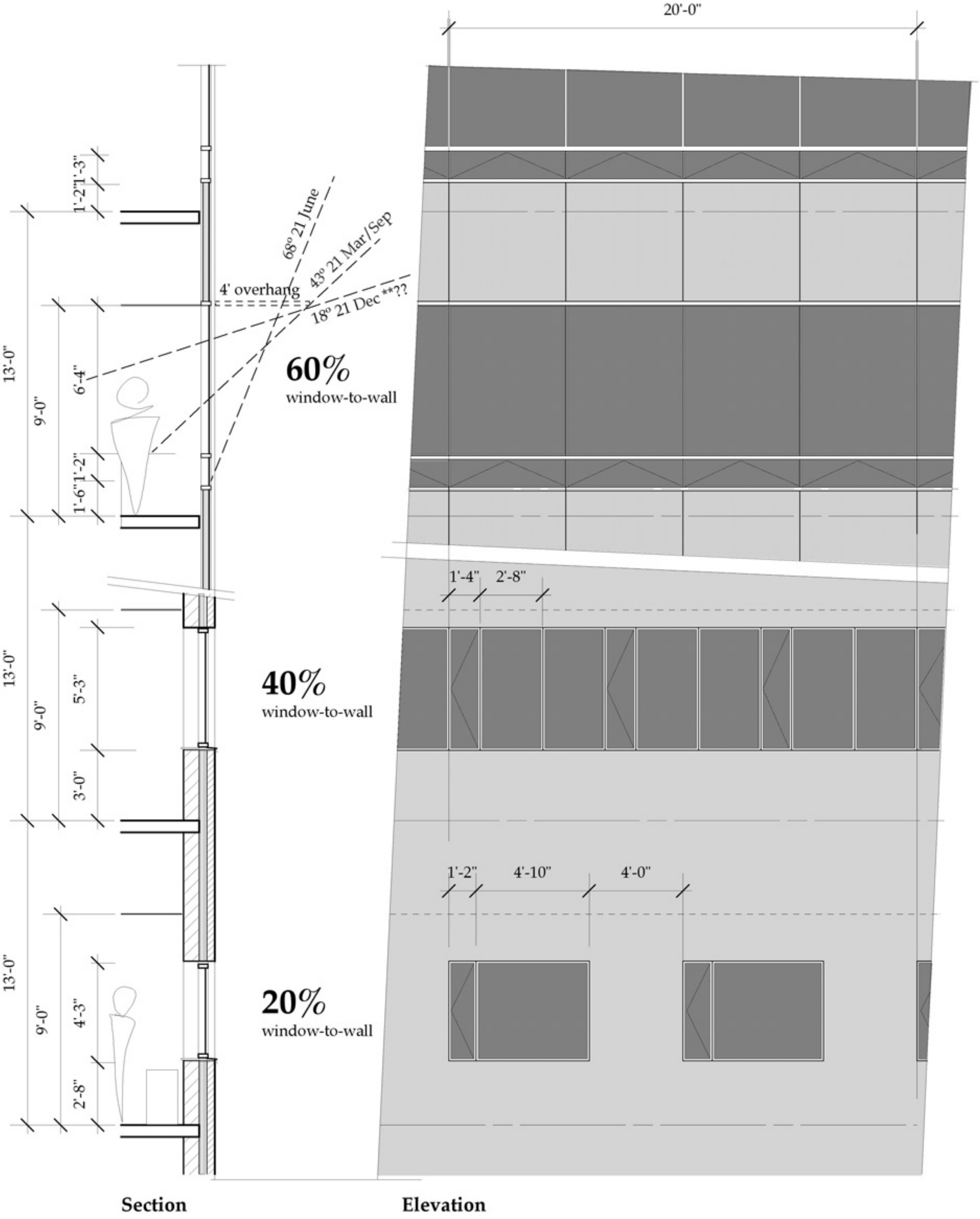
[*] Using the conversion SC = SHGC/0.86

[†] Available online at http://www.afg.com

Figure 5.1.10
Variations in window-to-wall ratio (WWR)



Window proportions

A typical version of each window-to-wall ratio (WWR) is illustrated in Figure 5.1.10. This is one of many possible designs - in which the window area would be consistent over the entire surface of each facade of a building.

In the drawing, the 20% and 40% WWR types are shown with windows "punched" through a brick-on-block cavity wall, and the 60% WWR example is shown as part of a curtain wall system. However, various combinations of WWR and solid enclosure material can be designed; a few examples are shown in Figure 5.1.11. In the simulations in this study, any of the three window proportions may be combined with any of the four wall types.

By design, the proportion of operable units to fixed units is held consistently at 1:4. Thus, in the 20% WWR, operable window units comprise 4% of the total wall area, and fixed window units make up the remaining 16%. The proportions of operable/fixed are 8%/32% the 40% WWR and 12%/48% in the 60% WWR.

In the initial runs, no exterior solar shading devices were included; these results are presented in Section 5.3. In a series of supplemental runs, the impact of exterior sunshades on one building type is studied, and the results are presented in Section 5.4.

The number within the "building type" tag indicates the window-to-wall-ratio. Thus, SM40SQ is a small building with a 40% WWR and a square floor plate; LG60NS is a large building with a 60% WWR and a north-south floor plate.

Figure 5.1.11
Various combinations of WWR and solid enclosure material

a (top) - approx. 60% WWR with masonry
b (bottom) - 40% WWR with metal siding

Figure 5.1.12
Space allocation inputs, including lighting & plug loads

Constants	Variables

Percent of floor area allocated to each use (from schematic plan)

	SM	MD	LG
Open Office	42.0	57.9	58.5
Private Office	11.6	12.0	14.9
Conference	5.1	10.8	9.5
Copy	2.7	2.4	1.5
Corrid&Elev	15.5	6.6	8.4
WC	6.7	3.3	2.3
M/E/C	7.3	4.5	3.7
Lobby	9.1	2.5	1.2

Allocation of space to activity areas

(all eQ defaults)	*Max. sf/pers.*	*Ventil'n cfm/pers.*	*assign first to*	in SM
Open Office	150.0	20.0	perim	
Private Office	225.0	20.0	perim	
Conference	22.5	20.0	core	
Copy	187.5	93.8	core	
Corrid&Elev	150.0	7.5	core	
WC	52.5	50.0	core	perim
M/E/C	450.0	22.5	core	perim
Lobby	10.5	20.0	L1 peri	

Loads when activity areas are occupied

(all eQ defaults)	*Lights W/sf*	*Task Lt W/sf*	*Plugs W/sf*	*Sched*
Open Office	1.3	0.4	1.5	main
Private Office	1.3	0.0	1.5	main
Conference	1.6	0.0	1.0	main
Copy	1.5	0.0	3.0	main
Corrid&Elev	0.6	0.0	0.2	main
WC	0.6	0.0	0.2	main
M/E/C	0.7	0.0	0.2	main
Lobby	1.5	0.0	0.5	main

Loads when activity areas are unoccupied (%)

(all eQ defaults)	*Occup'y*	*Lights*	*Task Lt*	*Plugs*
Open Office	0.0	2.0	0.0	20.0
Private Office	0.0	0.0	0.0	20.0
Conference	0.0	0.0	0.0	0.0
Copy	0.0	0.0	0.0	20.0
Corrid&Elev	0.0	10.0	0.0	0.0
WC	0.0	0.0	0.0	0.0
M/E/C	0.0	0.0	0.0	20.0
Lobby	0.0	10.0	0.0	0.0

Space allocation and related loads

A realistic proportioning of program areas is established in the plan studies. The percentage of floor area allocated to each use must vary somewhat, as the size of the floor plate varies. The percentages are similar in the MD and LG buildings. The small building differs significantly because it has the least efficient net-to-gross floor area ratio - that is, more floor area is taken up with corridor in the small building type than in the larger types. Figure 5.1.12 shows the inputs related to the pattern of occupancy, most of which are kept constant.

Occupant density, within each activity area, must be specified. The defaults offered by eQuest, for the maximum sf/person, are accepted and kept consistent in all building types. Ventilation (cfm/person) defaults also are accepted. The assignment of activity areas (to core, perimeter, or ground floor) is entered, corresponding to the schematic floor plans.

Also, the lighting and power densities, offered as defaults by eQuest are accepted here. These are reasonably conserving - higher than the most stringent current standard but lower than has been common practice in Ontario to date. * One example of what this range looks like, in a real building, is presented in Section 4.5, in the discussion of Design Strategies 2.8 and 4.14.

In the initial runs, no specialized lighting controls were used. Occupancy sensors cannot be specified in the eQuest Schematic Design Wizard; daylight sensors are the subject of supplemental runs, discussed in Section 5.4.

---

* The default for the "reference" building in NRCan's Screening Tool for New Building Design is 18 W/m^2.

Figure 5.1.13
Climate control system inputs

Constants		Variables		
Temperature and Air Flows (wizard screens 3, 19, 20)				
perimeter zone depth 15 ft (set in screen 3)				
return air path "direct"				
T'stat set points				
cooling	74 °F occupied; 82 °F unocc.			
heating	70 °F occupied; 64 °F unocc.			
Design temps				
cooling	75 °F indoor; 55 °F supply			
heating	72 °F indoor; 95 °F supply			
Min. design air flow	0.5 cfm/sf			
Packaged Cooling Equipment (wizard screen 21)				
overall size	auto-sized	SM	MD	LG
typical unit	135-240 kBtuh (11.25-20 T)			
condensor type	air cooled			
efficiency	EER 8.5			
crankcase heating	yes			
Packaged Heating Equipment				
overall size	auto-sized			
HVAC System Fans (wizard screen 24)				
power	1.25 in. WG			
motor efficiency	high			
fan flow	auto-size flow (with 1.15 safety factor)			
HVAC System #1 and #2 Fan Schedules (wizard screens 25 and 26)				
operate fans	1 hr bef. open & after close			
day 1	M-F 7 am - 7 pm			
day 2	S-S noon to 6 pm			
HVAC Zone Heating, Vent and Economizers (wizard screen 27)				
Zone heat sources	none			
Economizer type	drybulb temperature			
High limit	65°F			
Compressor	cannot run with economizer			
Domestic water heating equipment (wizard screen 36)				
heater type	electric	SM	MD	LG
storage cap'y (gal)	varies see right	150	400	800
usage	1 gal//person/day;			
supply temp.	135 degF;			
inlet water temp	equals ground temp			
recirculation %	0.00%			
input rating	51.6 kW			
tank insulation	R-12			

Climate control (HVAC) systems

In all runs, all inputs for heating, cooling and ventilation equipment are kept constant, as far as possible. Only the size of the water heater and the overall size of the packaged cooling equipment varies - both in direct proportion to occupant load. The detailed inputs are shown in Figure 5.1.13.

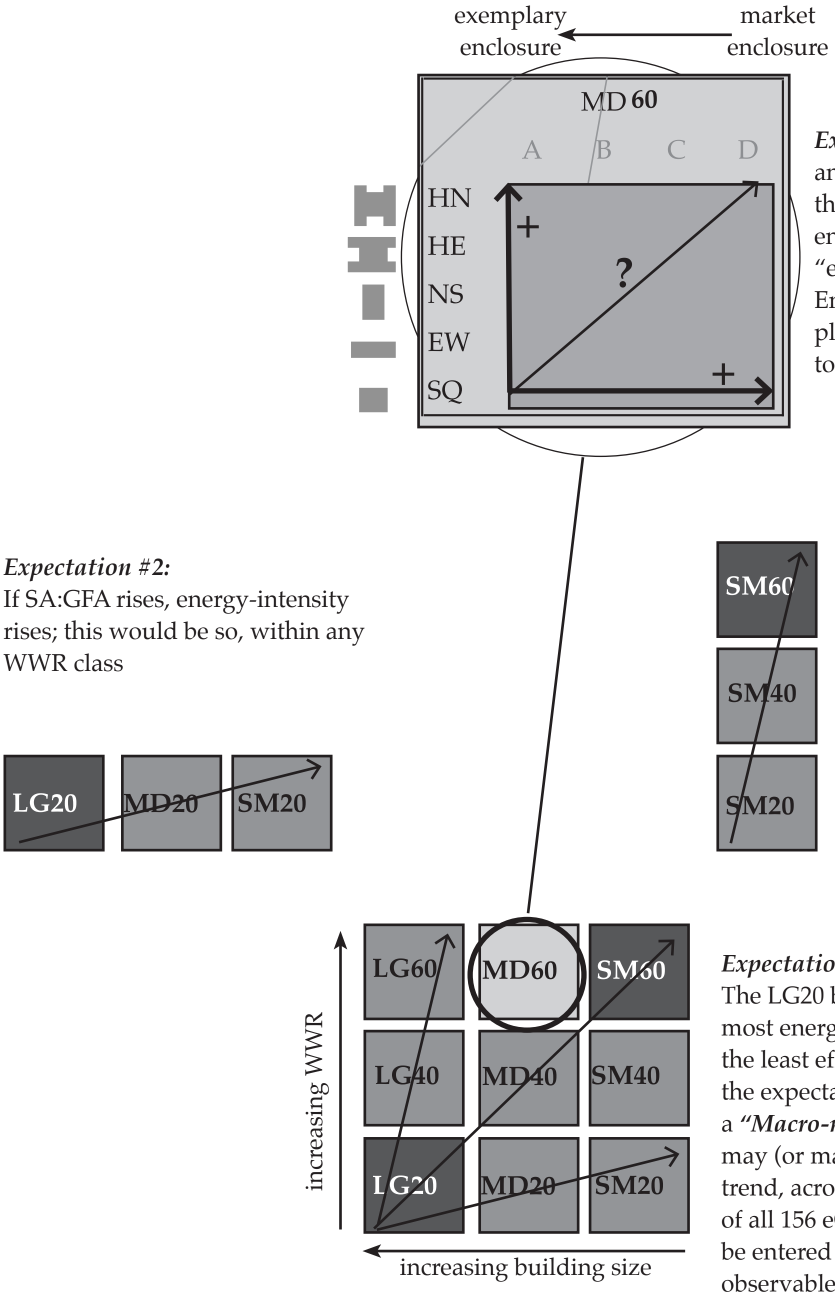
The input for the size of the packaged cooling equipment is “auto-sized”; after all other inputs were entered, the value suggested by eQuest was accepted, even though efficiency level of EER 8.5 is relatively poor, with respect to current standards for large buildings. Fan efficiency in the HVAC systems is, however, entered as better than average current practice.

Water heaters were sized by making a calculation by hand, in the manner recommended by Stein et. al. (1986). A sample calculation is included in Appendix 6.

No heat recovery equipment is specified in the basic building types; given the systems chosen here, heat recovery must be left outside the scope of this study.

Figure 5.1.14
Packaged cooling equipment - approx. 7 tons *(Photo H. Gifford 2009)*

Figure 5.1.15
Expected trends in the simulations of the 156 types



Expectation #1: If building size and WWR are kept consistent, the energy-intensity rises, as the enclosure is changed from an "exemplary" to a "market" level. Energy intensity also rises, as the plan form is changed from SQuare to an H-shape.

Expectation #2:
If SA:GFA rises, energy-intensity rises; this would be so, within any WWR class

Expectation #3:
If WWR rises, energy-intensity rises; this would be so, within any size class.

Expectation #4:
The LG20 buildings should be the most energy-efficient, and the SM60 the least efficient. Putting all of the expectations together creates a ***"Macro-matrix",*** in which there may (or may not) be a straight-line trend, across all fields. The results of all 156 eQuest simulations will be entered in this form, so that any observable patterns may be noted.

Macro-matrix #1

Expected trends

The first two parameters to be tested in this study are building form, of which 8 basic shapes are identified in Figure 5.1.1, and building orientation, of which 5 additional variations are shown in Figure 5.1.5. The others are enclosure performance level, of which 4 levels are described in Figure 5.1.8, and window-to-wall ratio, of which 3 proportions are illustrated in Figure 5.1.10. The complete series of building types comprising Macro-matrix #1 is made up of all possible combinations of these variables. An eQuest simulation will be made for each building type, yielding an energy-use profile pertaining to a particular combination of parameters. The number of simulations required is:

13 plan forms **x** **4** enclosure types **x** **3** WWRs = **156** runs.

A plan for organizing the results was developed, based upon a few general expectations, as described in Figure 5.1.15. "Macro-matrix #1" will either prove, or disprove, the researcher's expectations about the relative power of the design parameters. The lowest energy-intensity results appear toward the lower left, and the highest energy-intensity results will be toward the upper right.

Thus, the large, square building, with an exemplary enclosure and relatively little glazing (LG20SQ-A) is expected to be the least energy-intense of all building types tested. Entering the results from the eQuest simulation of LG20SQ-A low at the lower left of the matrix places that building in a position – relative to others – that is similar to where it would appear on the Intensometer. The small building, with a slender plan, that has much more surface area for its volume, a "market" enclosure specification, and a relatively large expanse of glass (SM60NS-D) is expected to be the most energy-intense type. The parameters in SM60NS-D differ from LG20SQ-A more than any other type, and therefore, the result of its simulation will be entered at the extreme upper right of the matrix. The simulations will determine whether there is a straight-line trend, along a diagonal line across all fields, and whether the trends, within each size of building, are similar.

From reading the literature, visiting the case studies, and reflecting on past experience, the researcher expected to find that the following observations would be made, looking at the first set of simulations:

- Plan form would have a significant impact on energy use, and this would be most significant in small buildings.
- A building with a narrow plan form would be more energy-intense than a building of the same size, with a square plan form, because of its higher surface area per GFA.
- A building oriented with its spine along an east-west axis would be less energy-intense than a square building of the same size (that is, positive solar orientation would outweigh the negative impact of high surface area per GFA).
- The orientation of glazed openings also would have an impact - whether this impact is stronger or weaker than overall building form would be observed in the tests.
- WWR would be powerful enough to nullify choices of shape and orientation that were otherwise helpful in lowering energy intensity. That is, a high WWR in a compact building form would be more energy-intense design than a low WWR in a more slender form.
- A poor enclosure specification also would nullify the helpful effects of form and orientation. For instance, a compact form with an Institutional (-C) enclosure (like the “GTA default” buildings) would be more energy-intense than a slender form with a High-Performance (-B) enclosure.
- Enclosure specification would matter more in Toronto than building orientation, but the power of these two parameters would be reversed in Miami or Phoenix.

The results of the 156 runs comprising the “Macro-matrix #1” would likely confirm some of these expectations, negate others, and shed new light on the overall question of how much an architect’s early decisions can influence the environmental load of a cool-humid climate civic building. The results are presented in Section 5.3. But first, a comparison of the behaviour of one of the buildings in Toronto, to the behaviour in other climates, puts the results in context.

5.2 CLIMATE IMPACTS

In a few preliminary runs, the differences between the energy flow through a medium-sized office building, in cool-humid Toronto, were compared to the flow through the same building, located in colder Regina, more temperate Seattle, hot-arid Phoenix, and hot-humid Miami. The locations were chosen to represent the gamut of climatic conditions in the more built-up regions of North America (see Figure 4.5.2). Representing the "GTA default" approach, and drawn from the middle of the matrix of types, MD40SQ-C is used for this comparison. With a 40% WWR on all four elevations, and an "institutional" enclosure performance level, MD40SQ-C is very close to the design of GTA-Police and GTA-School. (Other types, from elsewhere in the Macro-matrix could be tested in a future study.)

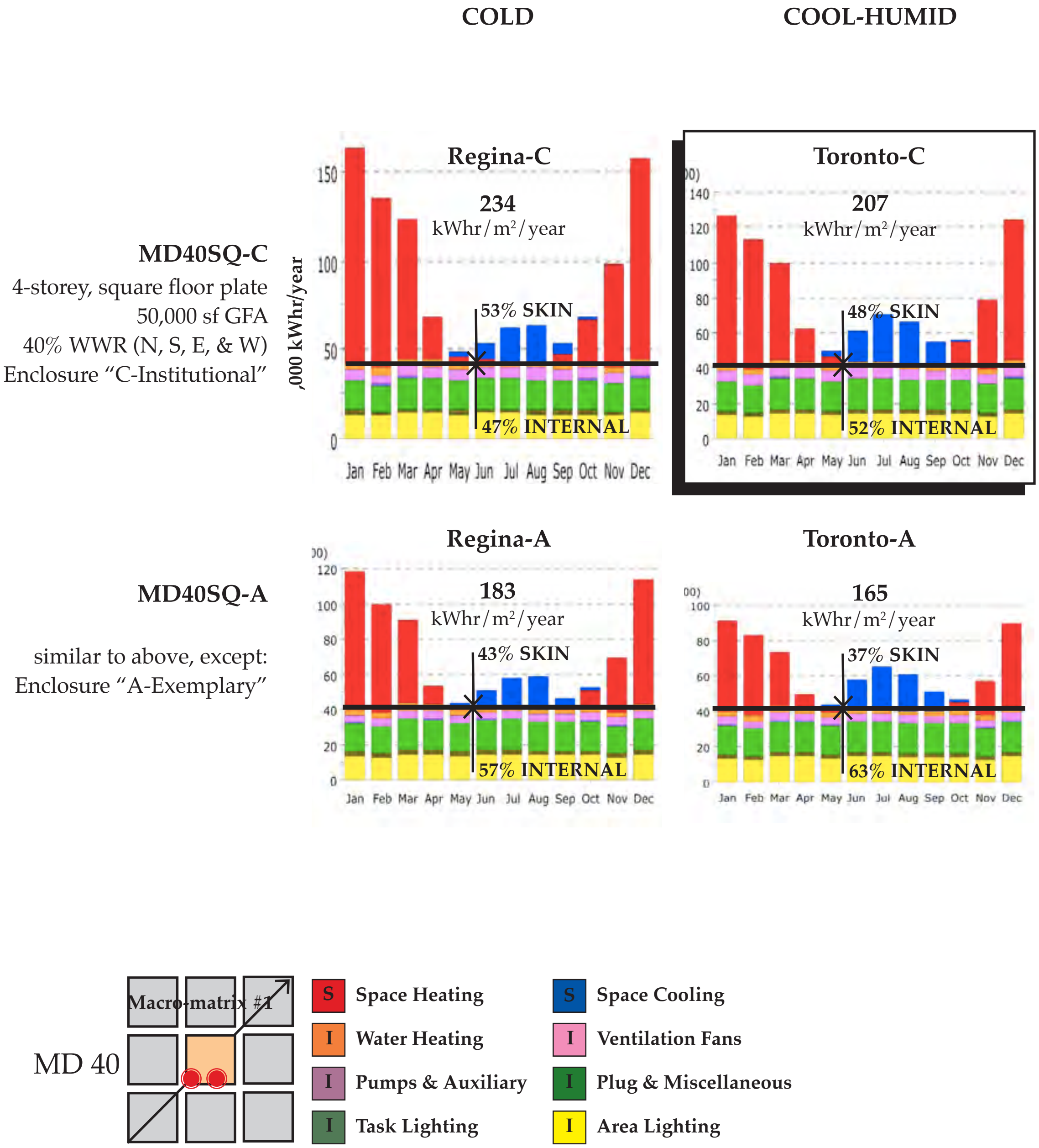
When MD40SQ-C, and a variant with an -A enclosure, are simulated in Toronto, Phoenix and Miami, the overall energy-intensity is comparable, in all three locations (192 to 207 kWhr/m^2/yr). In Regina, the design uses roughly 10% more energy, and in Seattle it use roughly 25% less energy. However, the purposes for which energy is consumed vary greatly with location: year-round, the building in Regina must be heated, while the building in Miami must be cooled. The energy-use profiles, shown in Figure 5.2.1 (overleaf), illustrate how heating and cooling vary with climate, while plug and lighting loads remain constant. In Toronto, energy is needed not only for heating, but also for a significant amount of cooling, over a 4-5 month period.

The energy-use profiles also show the shifts in balance between energy used to meet internal needs (tagged "I" on the legend) and energy needed to help the "skin" of the building maintain comfortable conditions indoors (tagged "S"). The design may be "internal-load dominated" or "skin-dominated", depending on the enclosure and on climate. The examples selected here show that a building that is strongly dominated by internal loads in Seattle, is less so in Phoenix and Miami. The same building in Toronto shows 48% of the energy used to balance loads occurring across the skin and 52% spent internally (see MD40SQ-C in Figure 5.2.1). In Regina, this -C building is "skin-dominated" - but when the enclosure is upgraded from "institutional" (-C) to "exemplary" (-A), the design once again becomes internal-load dominated. In Seattle, no such shift is possible.

This shows that "load-dominance" is not a product of form alone. As the thermal resistance of the enclosure increases, "skin-dominance" diminishes, and "internal-load dominance" takes over. This issue is explored further in Section 5.4.

Figure 5.2.1
Energy-use profiles of MD40SQ building in five different North American climates

(detailed data from simulations of each type is in Appendix 5)



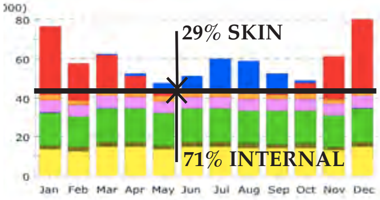
TEMPERATE

HOT-ARID

HOT-HUMID

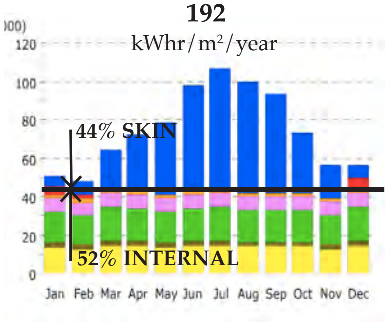
Seattle-C

152
kWhr/m^2/year



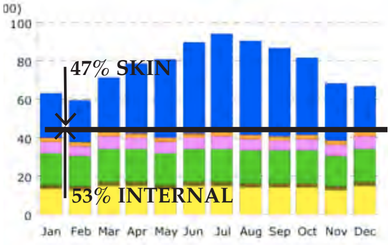
Phoenix-C

192
kWhr/m^2/year



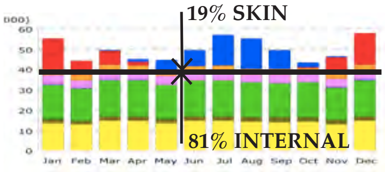
Miami-C

200
kWhr/m^2/year



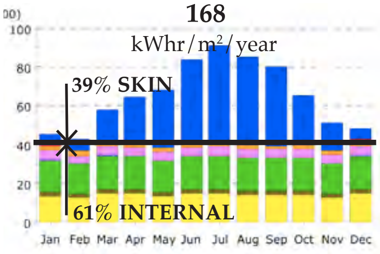
Seattle-A

128
kWhr/m^2/year



Phoenix-A

168
kWhr/m^2/year



Miami-A

176
kWhr/m^2/year

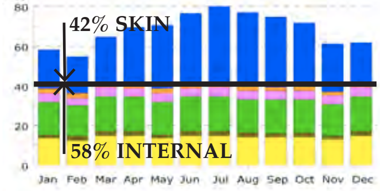
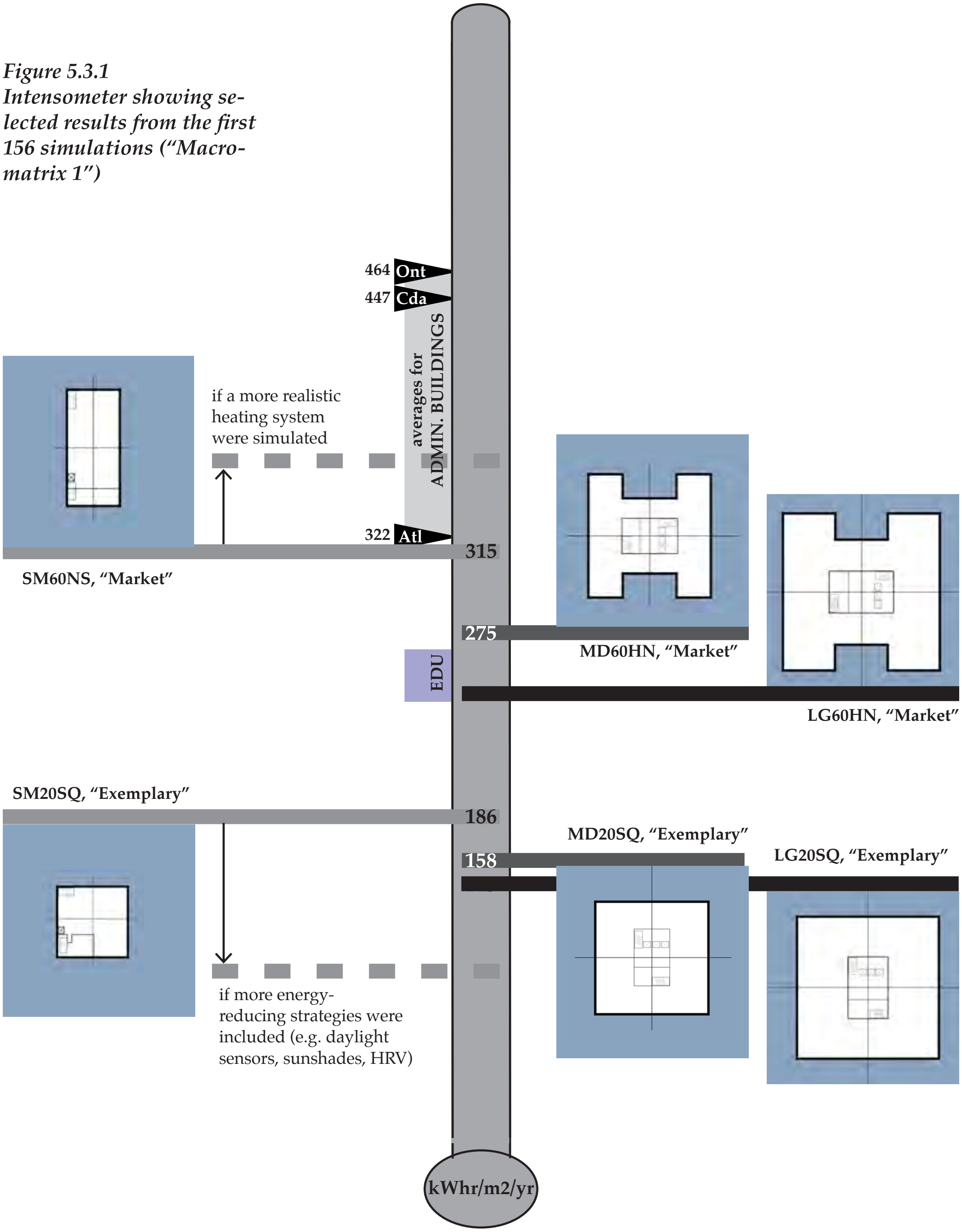


Figure 5.3.1
Intensometer showing selected results from the first 156 simulations ("Macro-matrix 1")



5.3 MACRO-MATRIX #1: RESULTS OF THE FIRST 156 SIMULATIONS

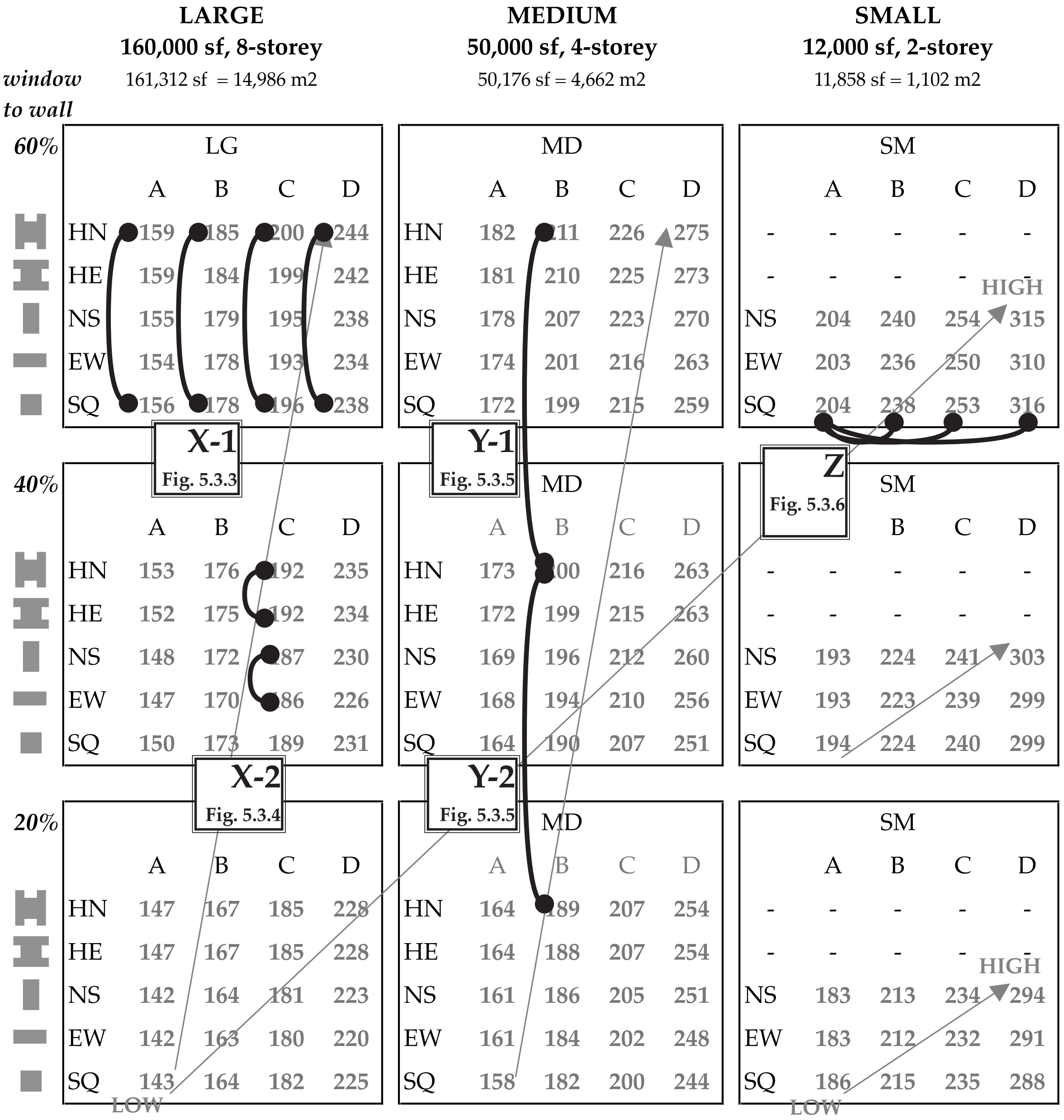
The Intensometer (Figure 5.3.1) shows how the gamut of results from the simulations of Small, Medium, and Large buildings in Toronto compare to the averages for "Administration" buildings, in Ontario and Canada, according to the CIBEUS (NRCan OEE 2002). It appears that an architect can make a significant contribution to the lowering of the annual energy use of an office building in the Great Lakes Basin. However, form and building orientation may not be the primary factors. When choices of shape were combined with choices in enclosure specification and window-to-wall ratio, the energy-intensity of "exemplary" building types dropped to 60% of the energy-intensity of the "market" types. ("Exemplary" types use from 70-78% of the energy-intensity of the "institutional" types.)

These results do not predict the actual performance of a real building, no matter how closely its form might match one of the "types" tested here. Because certain constants that were chosen for this exercise are not entirely realistic (e.g. a flat site, no basement, all four elevations perfectly consistent, and 100% efficient heating), it would be unreasonable to use these results to predict the energy-use in any real case.

All of the results fall below the Canadian and Ontario averages, because of this abstraction, and because the simulations are incomplete. A real-life "market" building would have a higher level of energy-intensity than the "market" building, simulated here - because its heating system would be less efficient, and the lighting might be more densely applied. Also, the simulations do not account for exterior and parking lot lighting, energy used to run elevators and servers, and humidification and de-humidification. The age of the building stock and the wide variation in the attentiveness of building operators account, in part, for the height of the existing average in Ontario.

On the other hand, a real-life "exemplary" building ***might*** have an even lower level of energy-intensity, particularly if some of the strategies seen in the "new normal" cases, studied in Chapter 4, were used in its design. On the basis of the information so far observed, one may imagine that applying exterior sunshades, placing windows more strategically, designing for even lower lighting power density, or recapturing waste heat from the ventilation stream would help.

Figure 5.3.2
"Macro-matrix 1":
Annual energy-intensity
(KWhr/m²/yr) of 156 building types



60% — LG

	A	B	C	D
HN	159	185	200	244
HE	159	184	199	242
NS	155	179	195	238
EW	154	178	193	234
SQ	156	178	196	238

60% — MD

	A	B	C	D
HN	182	211	226	275
HE	181	210	225	273
NS	178	207	223	270
EW	174	201	216	263
SQ	172	199	215	259

60% — SM

	A	B	C	D
-	-	-	-	-
-	-	-	-	-
NS	204	240	254	315
EW	203	236	250	310
SQ	204	238	253	316

40% — LG

	A	B	C	D
HN	153	176	192	235
HE	152	175	192	234
NS	148	172	187	230
EW	147	170	186	226
SQ	150	173	189	231

40% — MD

	A	B	C	D
HN	173	200	216	263
HE	172	199	215	263
NS	169	196	212	260
EW	168	194	210	256
SQ	164	190	207	251

40% — SM

		B	C	D
-	-	-	-	-
-	-	-	-	-
NS	193	224	241	303
EW	193	223	239	299
SQ	194	224	240	299

20% — LG

	A	B	C	D
HN	147	167	185	228
HE	147	167	185	228
NS	142	164	181	223
EW	142	163	180	220
SQ	143	164	182	225

20% — MD

	A	B	C	D
HN	164	189	207	254
HE	164	188	207	254
NS	161	186	205	251
EW	161	184	202	248
SQ	158	182	200	244

20% — SM

	A	B	C	D
-	-	-	-	-
-	-	-	-	-
NS	183	213	234	294
EW	183	212	232	291
SQ	186	215	235	288

Trends observed in Macro-matrix 1

Figure 5.3.2 shows the results of the first round of 156 simulations, comprising Macro-matrix 1. In general, this exercise has confirmed the expectations expressed earlier (see Figure 5.1.15). For instance, the large square building with an exemplary enclosure and relatively few openings is the least energy-intense (LG20SQ-A, lower left). Also, the result for the small slender building with a market enclosure (SM60NS-D, upper right) differs more from the result for LG20SQ-A than any other result.

These tests show that the architectural parameters can make a significant difference at all scales. In each size class, the least energy-intense type uses between 57% and 59% of the energy used by the most energy-intense type. For instance, the LG20SQ-A type uses roughly 59% of the energy needed by a building with the same gross floor area, footprint, and overall height, with a market-level enclosure, a different plan shape and three times as many openings (LG60HN-D).

The simulations suggest that building size has a significant impact on energy-intensity. Comparing any MD building to a SM building with identical parameters shows the MD building using approximately 85% of the energy of the SM building. The LG building uses approximately 77% of the energy of the SM building.

While the simulations have confirmed the overall expectations, they negate some of the ideas previously held about the relative power of the individual parameters. The two concepts in the literature that contributed to these expectations were that form and orientation are crucial, and that the first step to minimizing heating and cooling loads is to determine the orientation and massing of a building (see Section 3.5). To the contrary, the results in Macro-matrix 1 suggest that neither a formal variation of a type, nor a re-orientation are crucial, and that WWR and enclosure performance are far more important. Figure 5.3.3 through 5.3.6 present analyses of the power of: building form, building orientation, window-to-wall ratio, and the thermal resistance of the enclosure.

Figure 5.3.3
The power of building form

compares all pairs in similar positions to mark X-1 on Figure 5.3.2

	LG				**MD**				**SM**			
	A	B	C	D	A	B	C	D	A	B	C	D
WWR												
60%												
HN/SQ	**1.02**	**1.04**	**1.02**	**1.03**	**1.06**	**1.06**	**1.05**	**1.06**	-	-	-	-
HE/SQ	**0.96**	**1.03**	**1.02**	**1.02**	**1.05**	**1.06**	**1.05**	**1.05**	-	-	-	-
NS/SQ	0.99	1.01	0.99	1.00	**1.03**	**1.04**	**1.04**	**1.04**	1.00	1.01	1.00	1.00
EW/SQ	0.99	1.00	**0.98**	**0.98**	1.01	1.01	1.00	**1.02**	1.00	0.99	0.99	0.98
40%												
HN/SQ	**1.02**	**1.02**	**1.02**	**1.02**	**1.05**	**1.05**	**1.04**	**1.05**	-	-	-	-
HE/SQ	1.01	1.01	**1.02**	1.01	**1.05**	**1.05**	**1.04**	**1.05**	-	-	-	-
NS/SQ	0.99	0.99	0.99	1.00	**1.03**	**1.03**	**1.02**	**1.04**	0.99	1.00	1.00	1.01
EW/SQ	**0.98**	**0.98**	**0.98**	**0.98**	**1.02**	**1.02**	1.01	**1.02**	0.99	1.00	1.00	1.00
20%												
HN/SQ	**1.03**	**1.02**	**1.02**	1.01	**1.04**	**1.04**	**1.04**	**1.04**	-	-	-	-
HE/SQ	**1.03**	**1.02**	**1.02**	1.01	**1.04**	**1.03**	**1.04**	**1.02**	-	-	-	-
NS/SQ	0.99	1.00	0.99	0.99	**1.02**	**1.02**	**1.03**	**1.03**	**0.98**	0.99	1.00	**1.02**
EW/SQ	0.99	0.99	0.99	**0.98**	**1.02**	1.01	1.01	**1.02**	**0.98**	0.99	0.99	1.01

Figure 5.3.4
The power of building orientation

compares all pairs in similar positions to mark X-2 on Figure 5.3.2

	LG				**MD**				**SM**			
	A	B	C	D	A	B	C	D	A	B	C	D
WWR												
60%												
HE/HN	1.00	0.99	1.00	0.99	0.99	1.00	1.00	0.99	-	-	-	-
EW/NS	0.99	0.99	0.99	**0.98**	**0.98**	**0.97**	**0.97**	**0.97**	1.00	**0.98**	**0.98**	**0.98**
40%												
HE/HN	0.99	0.99	1.00	1.00	0.99	1.00	1.00	1.00	-	-	-	-
EW/NS	0.99	0.99	0.99	**0.98**	0.99	0.99	0.99	0.98	1.00	1.00	0.99	0.99
20%												
HE/HN	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	-	-	-	-
EW/NS	1.00	0.99	0.99	0.99	1.00	0.99	**0.98**	0.99	1.00	1.00	0.99	0.99

1.00 = the energy intensity is equal in the two types that are being compared

First, form alone, with all other factors being identical, has very little influence on the energy-intensity of the building types tested here. This can be seen by comparing any of the plan variations to the SQ plan having the same other parameters (marks “X-1” on Figure 5.3.2). The ratios, “other shape : SQ”, which are shown in Figure 5.3.3, range from 0.98 to 1.06, and they do not correlate to the level of enclosure performance.

The medium-sized buildings are the most sensitive to plan form change; there is a cluster of results that suggest that changing a MD-sized building from a SQ plan to a slender or H-shape may result in an increase in energy-intensity of approximately 4-6%, regardless of WWR. With respect to this ratio, the difference between the SQ type and the other shapes is greatest in the MD building (see Figure 5.1.3).

Figure 5.3.4 shows the impact of building orientation. Alone, with all other factors being equal, it has very little influence on the energy-intensity of the building types tested here. Perhaps this is because the windows are distributed consistently on all four facades. The influence can be seen by comparing the NS to the EW plan variation, or the HN to the HE (marks “X-2” on Figure 5.3.2). The ratios “EW/NS”, and “HE/HN”, which are shown in Figure 5.3.4, range from 0.97 to 1.00. The difference in energy-intensity between the HN and HE types is nearly “nil” in all cases. The only types in which the EW building seems to be consistently less energy-intense that the NS building are MD-sized, with a high (60%) window-to-wall ratio.

The very limited power of building orientation is an important concept for an architect working with a site where an EW building orientation is undesirable for urban design reasons. It is also crucial to remember that this conclusion relates to a building in Toronto. If a series of simulations were conducted in another climate zone, the results would be different.

Figure 5.3.5
The power of window-to-wall ratio

compares all pairs in similar positions to marks Y-1 and Y-2 on Figure 5.3.2

	LG				**MD**				**SM**			
	A	B	C	D	A	B	C	D	A	B	C	D
reduce from 60% to 40% WWR ("Y-1" and sim.)												
HN40/HN60	**0.96**	**0.95**	**0.96**	**0.96**	**0.95**	**0.95**	**0.96**	**0.96**	-	-	-	-
HE40/HE60	**0.96**	**0.95**	**0.96**	**0.97**	**0.95**	**0.95**	**0.96**	**0.96**	-	-	-	-
NS40/NS60	**0.95**	**0.96**	**0.96**	**0.97**	**0.95**	**0.95**	**0.95**	**0.96**	**0.95**	**0.93**	**0.95**	**0.96**
EW40/EW60	**0.95**	**0.96**	**0.96**	**0.97**	**0.97**	**0.97**	**0.97**	**0.97**	**0.95**	**0.94**	**0.96**	**0.96**
SQ40/SQ60	**0.96**	**0.97**	**0.96**	**0.97**	**0.95**	**0.95**	**0.96**	**0.97**	**0.95**	**0.94**	**0.95**	**0.95**
reduce from 40% to 20% WWR ("Y-2" and sim.)												
HN20/HN40	**0.96**	**0.95**	**0.96**	**0.97**	**0.95**	**0.95**	**0.96**	**0.97**	-	-	-	-
HE20/HE40	**0.95**	**0.95**	**0.96**	**0.97**	**0.95**	**0.94**	**0.96**	**0.97**	-	-	-	-
NS20/NS40	**0.96**	**0.95**	**0.97**	**0.97**	**0.95**	**0.95**	**0.97**	**0.98**	**0.95**	**0.95**	**0.97**	**0.97**
EW20/EW40	**0.97**	**0.96**	**0.97**	**0.97**	**0.96**	**0.95**	**0.96**	**0.97**	**0.95**	**0.95**	**0.97**	**0.97**
SQ20/SQ40	**0.95**	**0.95**	**0.96**	**0.97**	**0.96**	**0.96**	**0.97**	**0.97**	**0.96**	**0.96**	**0.98**	**0.96**

Figure 5.3.6
The power of the thermal resistance of the enclosure

compares all pairs in similar positions to marks Z on Figure 5.3.2

	LG				**MD**				**SM**			
	A/B	B/C	C/D	A/D	A/B	B/C	C/D	A/D	A/B	B/C	C/D	A/D
60% WWR												
HN	**0.86**	**0.93**	**0.82**	**0.65**	**0.86**	**0.93**	**0.82**	**0.66**	-	-	-	-
HE	**0.86**	**0.92**	**0.82**	**0.66**	**0.86**	**0.93**	**0.82**	**0.66**	-	-	-	-
NS	**0.87**	**0.92**	**0.82**	**0.65**	**0.86**	**0.93**	**0.83**	**0.66**	**0.85**	**0.94**	**0.81**	**0.65**
EW	**0.87**	**0.92**	**0.82**	**0.66**	**0.87**	**0.93**	**0.82**	**0.66**	**0.86**	**0.94**	**0.81**	**0.65**
SQ	**0.88**	**0.91**	**0.82**	**0.66**	**0.86**	**0.93**	**0.83**	**0.66**	**0.82**	**0.94**	**0.80**	**0.65**
40% WWR												
HN	**0.87**	**0.92**	**0.82**	**0.65**	**0.87**	**0.93**	**0.82**	**0.66**	-	-	-	-
HE	**0.87**	**0.91**	**0.82**	**0.65**	**0.86**	**0.93**	**0.82**	**0.65**	-	-	-	-
NS	**0.86**	**0.92**	**0.81**	**0.64**	**0.86**	**0.92**	**0.82**	**0.65**	**0.86**	**0.93**	**0.80**	**0.64**
EW	**0.86**	**0.91**	**0.82**	**0.65**	**0.87**	**0.92**	**0.82**	**0.66**	**0.87**	**0.93**	**0.80**	**0.65**
SQ	**0.87**	**0.92**	**0.82**	**0.65**	**0.86**	**0.92**	**0.82**	**0.65**	**0.87**	**0.93**	**0.80**	**0.65**
20% WWR												
HN	**0.88**	**0.90**	**0.81**	**0.64**	**0.87**	**0.91**	**0.81**	**0.65**	-	-	-	-
HE	**0.88**	**0.90**	**0.81**	**0.64**	**0.87**	**0.91**	**0.81**	**0.65**	-	-	-	-
NS	**0.87**	**0.91**	**0.81**	**0.64**	**0.87**	**0.91**	**0.82**	**0.64**	**0.86**	**0.91**	**0.80**	**0.62**
EW	**0.87**	**0.91**	**0.82**	**0.65**	**0.88**	**0.91**	**0.81**	**0.65**	**0.86**	**0.91**	**0.80**	**0.63**
SQ	**0.87**	**0.90**	**0.81**	**0.64**	**0.87**	**0.91**	**0.82**	**0.65**	**0.87**	**0.91**	**0.82**	**0.65**

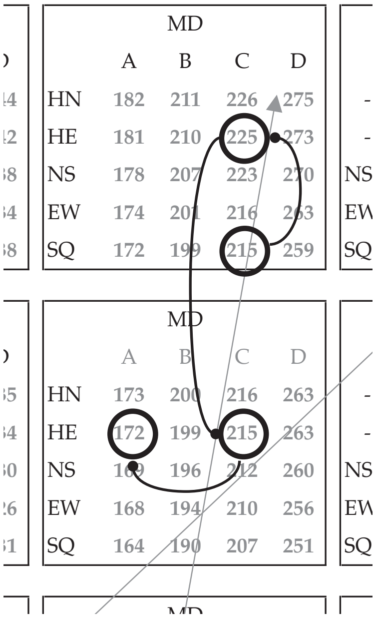
1.00 = the energy intensity is equal in the two types that are being compared

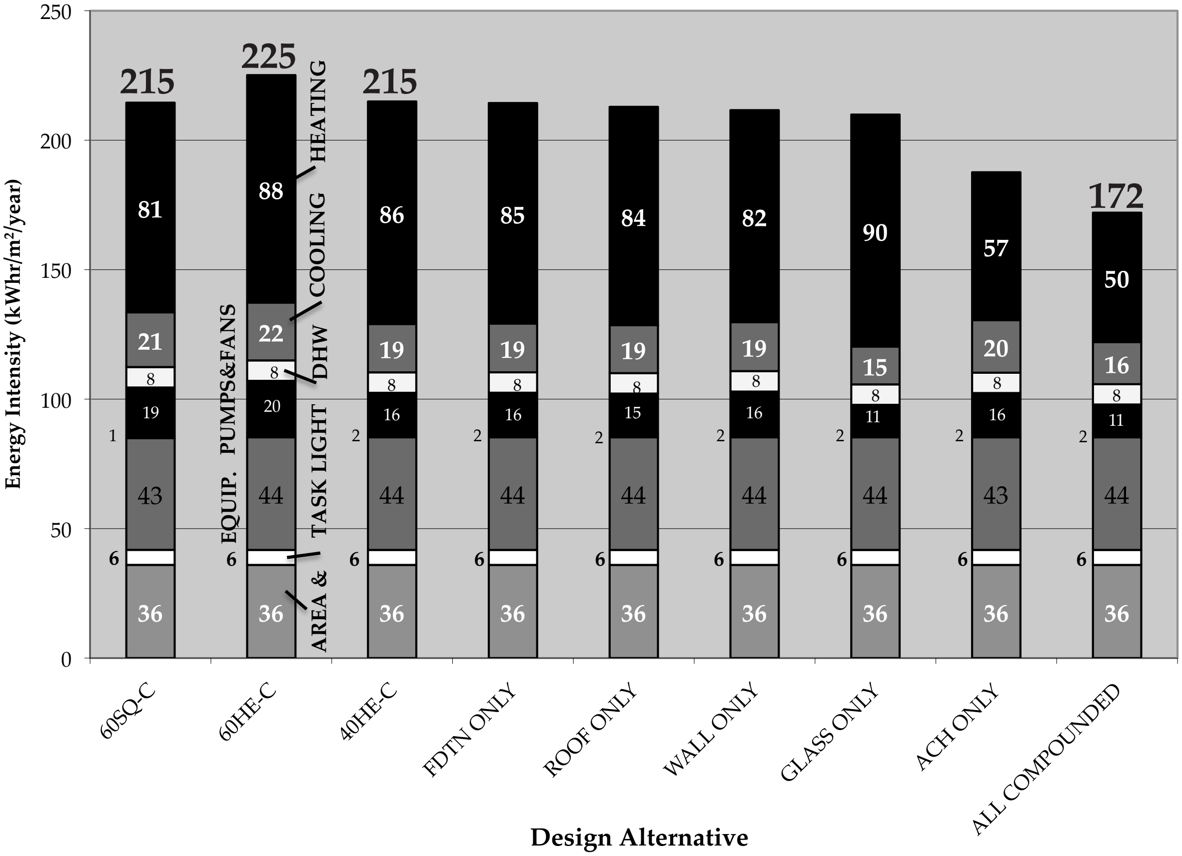
Window-to-wall ratio (WWR) has a slightly stronger impact on the energy-intensity than building form and orientation. This impact is also more consistent across the Macro-matrix. The power of the WWR can be seen by comparing pairs of same-sized buildings having the same enclosure performance level (marks “Y-1” and “Y-2” on Figure 5.3.2). The ratios of all of the pairs are shown in Figure 5.3.5. Changing the WWR on all four facades from 60% to 40%, reduces the energy-intensity to 0.93 to 0.97 of the initial value. Changing the WWR further, to 20%, reduces the energy-intensity a further step to 0.94 to 0.98 of the intensity when the WWR was 40%.

As expected from the preview of loads in the Toronto climate, the thermal resistance of the enclosure is the most powerful parameter of all. The most extreme gap, between “market” and “exemplary” enclosure, can be seen by comparing the “-A” and “-D” results for a given shape, size and WWR (marks “Z” on Figure 5.3.2). The potential reduction in annual energy-intensity, which is shown in Figure 5.3.6 (A/D) ranges from a 0.64 to 0.66 multiplier. The effect of improving the enclosure from an “institutional” type to a “high-performance” type (B/C) ranges from 0.90 to 0.94.

The results of all simulations in Macro-matrix #1 were duplicated on eQuest, by an independent researcher working at a separate location. The trend lines also have been verified, by repeating selected simulations, using other software tools (MIT Design Advisor and NRCan’s Screening Tool for New Building Design). The results of the verification exercises are presented in Appendix 5.

5.3.7
Impact of primary design parameters on one case





The power of parameters in a sample case

The overview provided in Macro-matrix #1 helps form some general statements about the relative power of building form, orientation and enclosure design - a view that has been missing in the literature so far. Nevertheless, many an architect will want to understand these principles, by looking at a specific case. Suppose an architect is designing a medium-sized building. The first scheme has a square floor plate, an "institutional" enclosure and a 60% WWR. The architect wishes to change the shape of the floor plate to an "H", to improve upon the access to daylight and variety of floor spaces, and to create a more interesting exterior shape. To compensate for the extra energy used by the "H-shaped" building, improvements will be made in the enclosure specification, using tactics from step #2 of the Strategy Grid, "Reduce Loads". The architect will then make additional improvement to bring the energy use down as low as possible.

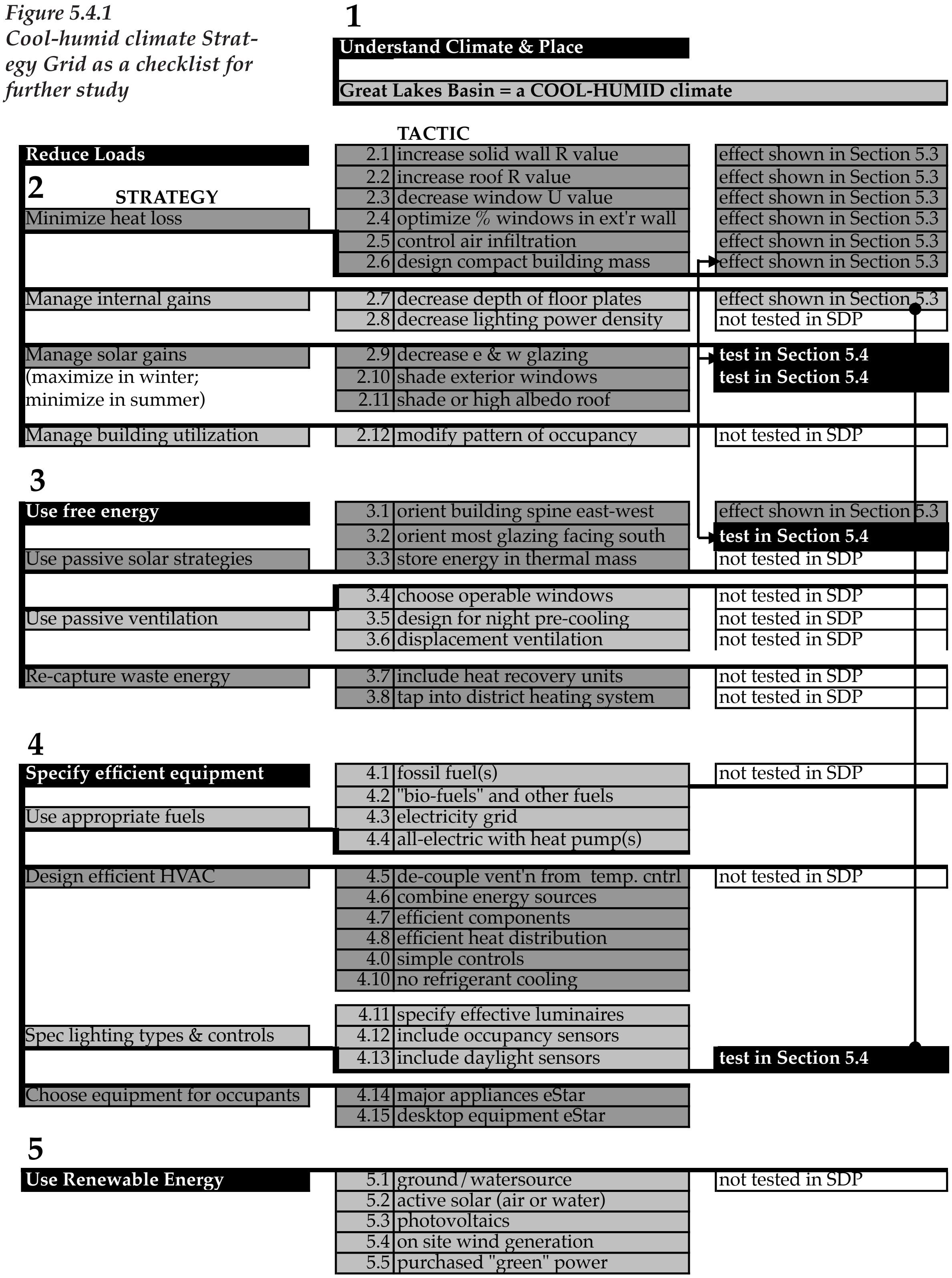
The design changes take a path across Macro-matrix #1, from MD60SQ-C to MD40HE-A (see Figure 5.3.7a). The steps in the path are:

- change shape from SQuare to HE,
- reduce WWR from 60% to 40%,
- change foundation insulation from 2′ vertical to full underslab,
- increase roof insulation from 2″ to 6″ (R-21 to R-48),
- increase exterior wall from R-16 to R-36,
- change from double clear argon to triple tinted argon (U/SC/VT 0.34/0.72/0.73 to 0.21/0.35/0.60), and
- improve the air-tightness of the whole enclosure, by better detailing, more pro-active field review and more thorough testing (reduce air changes per hour from 0.5 to 0.1).

Figure 5.3.7b illustrates the impact of each strategy. With the initial shape change, overall energy-intensity increases slightly, the main difference being in energy needed for heating (second bar from the left). The decrease in WWR compensates for the change in shape - mostly in heating, and in cooling as well (third bar).

The power of each element of the enclosure is shown in the graph, as if it were applied independently to MD40HE-C. Heating energy is reduced slightly by adding insulation to either the walls, roof or foundations. In this particular scenario, improving the glass specification has an effect of similar magnitude, and affects cooling as well. The air-tightness of the enclosure is the most powerful parameter. When all of the improvements to the enclosure are applied together to MD40HE-C, they exert a compound effect (far right bar).

Figure 5.4.1
Cool-humid climate Strategy Grid as a checklist for further study



	STRATEGY		TACTIC	
1	**Understand Climate & Place**		Great Lakes Basin = a COOL-HUMID climate	
2	**Reduce Loads**			
	Minimize heat loss	2.1	increase solid wall R value	effect shown in Section 5.3
		2.2	increase roof R value	effect shown in Section 5.3
		2.3	decrease window U value	effect shown in Section 5.3
		2.4	optimize % windows in ext'r wall	effect shown in Section 5.3
		2.5	control air infiltration	effect shown in Section 5.3
		2.6	design compact building mass	effect shown in Section 5.3
	Manage internal gains	2.7	decrease depth of floor plates	effect shown in Section 5.3
		2.8	decrease lighting power density	not tested in SDP
	Manage solar gains (maximize in winter; minimize in summer)	2.9	decrease e & w glazing	**test in Section 5.4**
		2.10	shade exterior windows	**test in Section 5.4**
		2.11	shade or high albedo roof	
	Manage building utilization	2.12	modify pattern of occupancy	not tested in SDP
3	**Use free energy**			
	Use passive solar strategies	3.1	orient building spine east-west	effect shown in Section 5.3
		3.2	orient most glazing facing south	**test in Section 5.4**
		3.3	store energy in thermal mass	not tested in SDP
	Use passive ventilation	3.4	choose operable windows	not tested in SDP
		3.5	design for night pre-cooling	not tested in SDP
		3.6	displacement ventilation	not tested in SDP
	Re-capture waste energy	3.7	include heat recovery units	not tested in SDP
		3.8	tap into district heating system	not tested in SDP
4	**Specify efficient equipment**			
	Use appropriate fuels	4.1	fossil fuel(s)	not tested in SDP
		4.2	"bio-fuels" and other fuels	
		4.3	electricity grid	
		4.4	all-electric with heat pump(s)	
	Design efficient HVAC	4.5	de-couple vent'n from temp. cntrl	not tested in SDP
		4.6	combine energy sources	
		4.7	efficient components	
		4.8	efficient heat distribution	
		4.0	simple controls	
		4.10	no refrigerant cooling	
	Spec lighting types & controls	4.11	specify effective luminaires	
		4.12	include occupancy sensors	
		4.13	include daylight sensors	**test in Section 5.4**
	Choose equipment for occupants	4.14	major appliances eStar	
		4.15	desktop equipment eStar	
5	**Use Renewable Energy**	5.1	ground/watersource	not tested in SDP
		5.2	active solar (air or water)	
		5.3	photovoltaics	
		5.4	on site wind generation	
		5.5	purchased "green" power	

5.4 "WHAT IF ...?" - MODIFYING or ADDING PARAMETERS

So far, the power of three major design parameters has been explored. Yet there are other strategies often associated in the literature with "green building", and these also may help to lower energy use. In Figure 5.4.1, the Cool-humid Strategy Grid is used to check which operations have, so far, not been simulated.

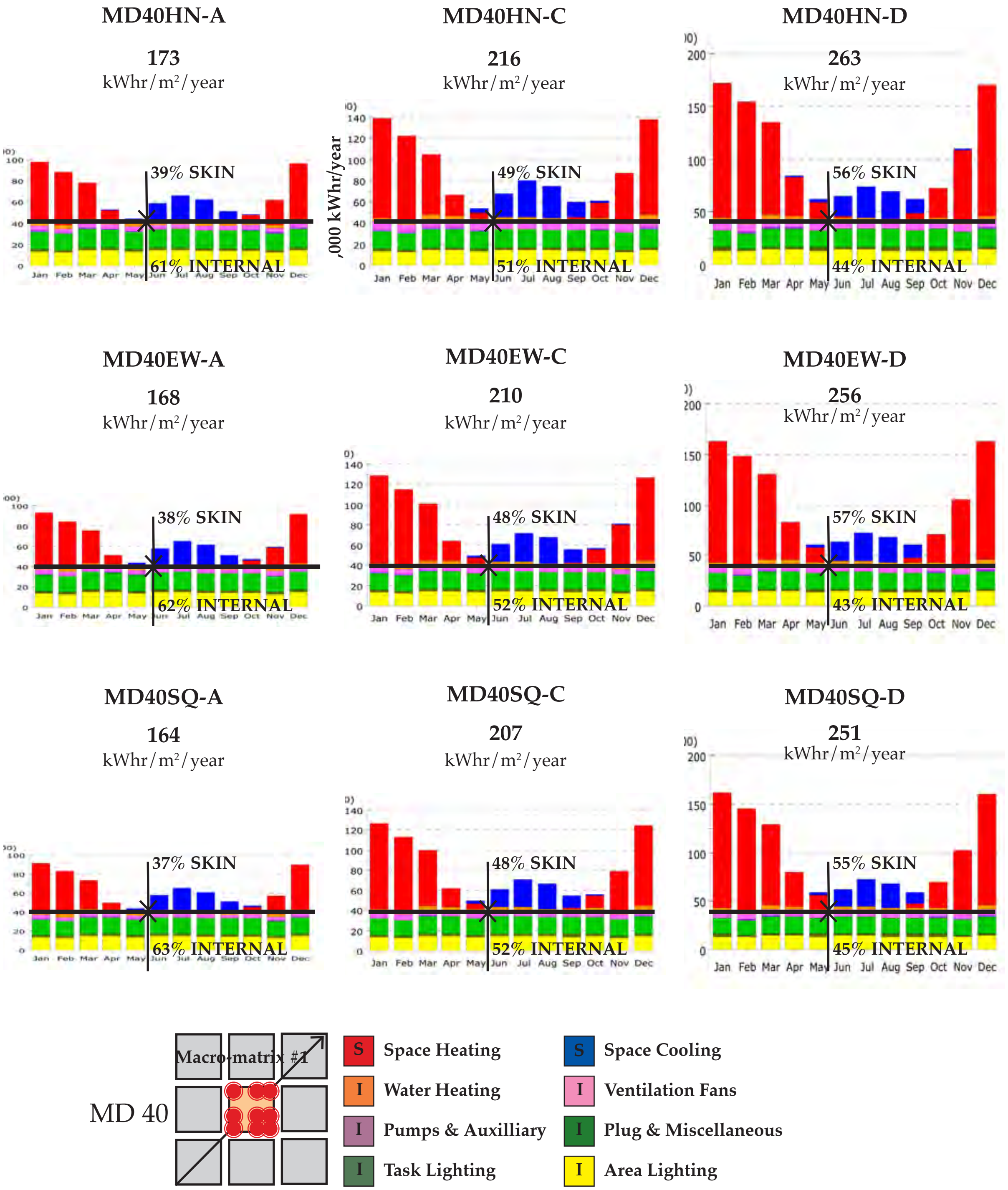
The items in grey, in the right-hand column of Figure 5.4.1, were designed into the simulations in Macro-matrix#1. The items in black are not tested in this study, because they relate to equipment; they are not among an architect's "primary choices". Other items are not easy to simulate, using eQuest. Thermal mass, displacement ventilation, and high albedo exterior surfaces would be interesting subjects for future research, should proper tools for investigation become available.

If the only goal were to lower energy intensity, then one might choose to design all buildings with a 20% WWR and an exemplary enclosure, and not be distracted by other strategies. However, this may not be desirable - or possible - in all projects.

There are a few strategies that have not yet been tested that may help balance a less-than-ideal circumstance. A slender floor plate, or a particular window orientation may be desirable for reasons of urban design, outward architectural expression, or amenity for the occupants. The items in white, which were not tested in Macro-matrix #1, will be studied further in this section, using the original building types, with modified inputs.

This also leads to the question whether changes in building shape or building orientation would be more powerful, if used in combination with strategies such as daylight sensors, exterior shading devices, or window orientation. Changes in building shape may or may not increase comfort and enjoyability, depending on the scenario. It is critical for an architect to understand the trade-offs or synergies between energy benefits (if there are any) and other, more qualitative benefits. The red arrows in Figure 5.4.1 indicate combinations of strategies that may have a synergistic effect.

Figure 5.4.2
Energy-use profiles of selected buildings in Toronto, from Macro-matrix 1



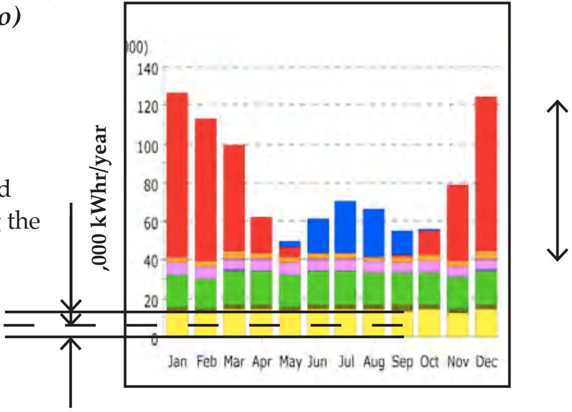
Base loads for lighting and equipment

Before designing the next set of simulations, the energy-use profile of a building in Toronto is considered. Figure 5.4.2 shows what happens to energy use in the MD building with 40% WWR, as shape and enclosure specification is varied. A comparison of the graphs within any of the nine panels of the Macro-matrix would look similar, with the overall figures adjusted.

The simulations reflect the dominance of heating in the Great Lakes Basin, and the high levels of "base loads", in non-residential buildings like these - that is, energy demands for lighting and users' equipment. Making effective design choices requires an understanding of where the balance lies, between skin loads and internal loads - in these building type and location where the designer is working.

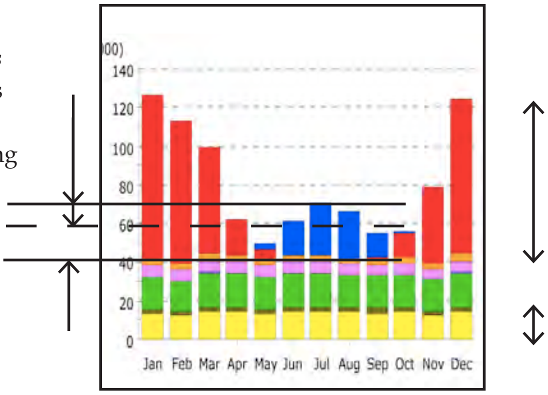
Figure 5.4.3
Expected impacts of energy-saving design features upon MD40SQ-C (Toronto) (,000 kWhr/yr)

Daylight sensors will reduce the energy used for lighting (shrinking the yellow bars)



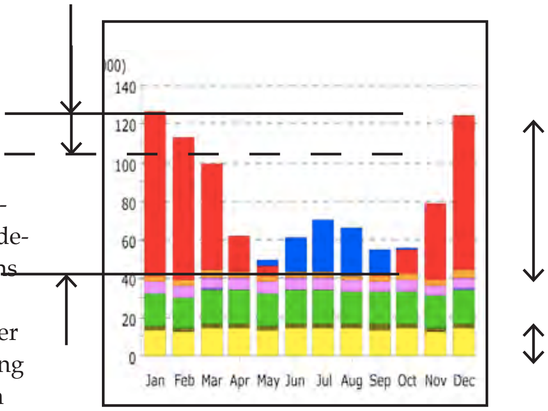
Then, with less heat produced internally by lights, will less energy be needed for cooling, and more energy be needed for heating? If so, how much?

Exterior shading devices may lower cooling loads somewhat, as they do in lower latitudes (shrinking the blue bars)



But, will the benefit gained in summer be significant, in comparison to the heating loads the rest of the year? And will there be any impact on lighting needs?

Increasing south-facing glazing and decreasing east- and west- facing glazing MAY lower heating loads (by capturing desirable passive solar gains on winter days). These strategies MAY also lower cooling loads (by avoiding unwanted solar gains on summer afternoons)



In an office building, in the Great Lakes Basin, how extreme must the approach be, to realize significant impacts on heating and cooling needs? Is there any impact on lighting needs?

Balancing internal loads and skin loads

In Figure 5.4.3, the energy-use profile of MD40SQ-C is used to predict the impact of three additional design strategies. The Energy-Efficiency Measure Wizard in the eQuest software permits simulation of their effects. On the right side of Figure 5.4.3, questions are posed towards the eventual analysis of the results.

The effect of each of the additional strategies may vary with building type. For instance, the types EW, NS, HE and HN all allow natural light to penetrate deep into the floor plate (as can be seen in the sample plans in Appendix 5). Perhaps, if daylight sensors were used, there would be a significant drop in energy intensity of these forms in particular.

Exterior shading devices are gaining popularity in "green" buildings, partly because they are appealing to many architects. They offer good potential for an interesting facade design. One might imagine that exterior shading devices could lower - or perhaps eliminate - the need for cooling in northerly latitudes. Such devices were designed into many of the case study buildings, although they were not constructed in every instance. Whether shading devices are particularly effective, when applied to one building form or another is unknown.

Finally, the question about orienting the building spine east-west lingers, because the concept is so energetically proposed in the literature. Orienting the building spine east-west usually creates an opportunity to increase south-facing glazing, and to decrease east and west-facing glazing. * This may be particularly helpful in the EW form, as well as MD**HE (which does not shade itself as much as LG**HE). In the simulations that follow, a few levels of such an approach will be tested - both in Toronto, and at other latitudes. This will show how much the effect of building orientation varies with location.

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*It is important to remember that the latter two operations may be accomplished without re-orienting the whole building.

Figure 5.4.4
Impact of daylight sensors on the MD building types in Toronto (4,662 m^2)

MD		**WITHOUT (Macro-matrix #1)**					***WITH Daylight Sensors (Supplemental simulations)***			
window to wall		kWhr/m^2/yr					kWhr/m^2/yr	***WITH ÷ WITHOUT***	kWhr/m^2/yr	*WITH ÷ WITHOUT*
60%		A	B	C	D		A	***A***	D	***D***
	HN	182	211	226	275	HN	**165**	***0.91***	**259**	***0.942***
	HE	181	210	225	273	HE	**165**	***0.91***	**258**	***0.945***
	NS	178	207	223	270	NS	**163**	***0.92***	**256**	***0.948***
	EW	174	201	216	263	EW	**158**	***0.91***	**249**	***0.947***
	SQ	172	199	215	259	SQ	**159**	***0.92***	**248**	***0.958***
40%		A	B	C	D		A	***A***	D	***D***
	HN	173	200	216	263	HN	**156**	***0.90***	**249**	***0.947***
	HE	172	199	215	263	HE	**156**	***0.91***	**248**	***0.943***
	NS	169	196	212	260	NS	**154**	***0.91***	**246**	***0.946***
	EW	168	194	210	256	EW	**153**	***0.91***	**242**	***0.945***
	SQ	164	190	207	251	SQ	**153**	***0.93***	**240**	***0.956***
20%		A	B	C	D		A	***A***	D	***D***
	HN	164	189	207	254	HN	**149**	***0.91***	**241**	***0.949***
	HE	164	188	207	254	HE	**148**	***0.90***	**240**	***0.945***
	NS	161	186	205	251	NS	**147**	***0.91***	**238**	***0.948***
	EW	161	184	202	248	EW	**147**	***0.91***	**235**	***0.948***
	SQ	158	182	200	244	SQ	**147**	***0.93***	**234**	***0.959***

What if daylight sensors are included?

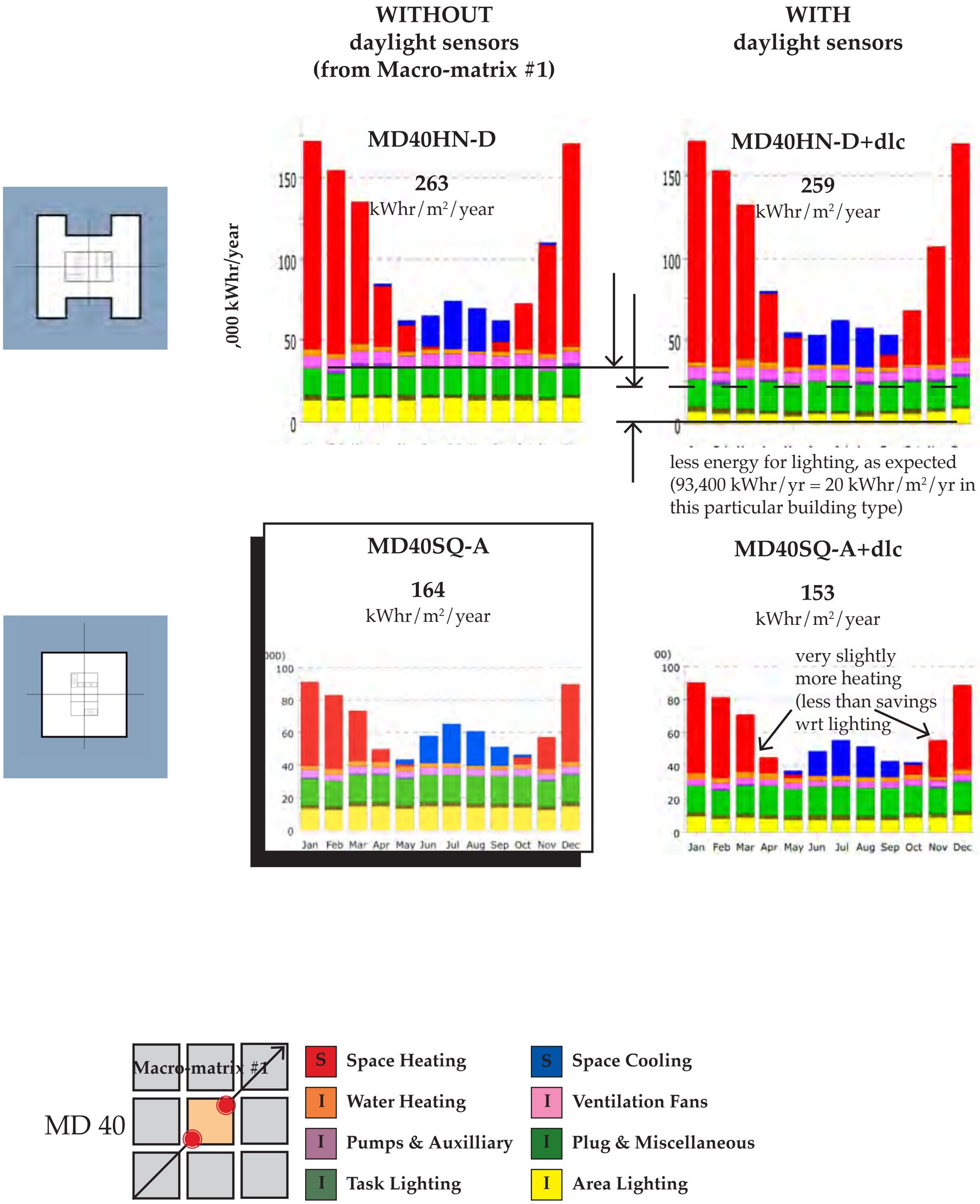
To explore this question, eQuest's "Energy-Efficiency Measure Wizard" was used to modify the original simulations. The Medium building was used, as representative of the others. Each result with daylight sensors is compared to the result for the identical building, without sensors. Inputs were as follows:

- sensors on: ground, top, and middle floors,
- 2 photo sensors each floor (max. eQuest allows; location not specified),
- each sensor controls 50% of the area lights in the building,
- design light level 50 foot candles (eQuest default),
- stepped type controller, with 3 steps, and
- "Light Control Probability": 1.00.

The results for all of the MD-A and MD-D building types are shown in Figure 5.4.4, with the ratios "with sensors: without sensors" indicated to the right of each result, in green type. It appears that a MD-sized office building with daylight sensors, in Toronto, may use roughly 0.90 to 0.96 of the energy of the same building without daylight sensors

The energy-intensity results of a series of simulations also suggest that the effect of daylight sensors is reasonably consistent, regardless of building form or orientation (see Figure 5.4.4). However, their impact is stronger in building in which the thermal resistance of the enclosure is high. Daylight sensors appear to reduce the overall annual energy-intensity of the "medium-sized" building by between 5% (in the "market" building) and 10% (in the "exemplary" building).

Figure 5.4.5
Energy use profiles in two building types - with and without daylight sensors



The energy-use profiles in Figure 5.4.5 show that daylight sensors reduce the energy required for lights, every month, fairly evenly throughout the year (yellow bar).

The figures that accompany the energy-use profiles (Figure 5.4.6) show that energy for heating must go up slightly, to compensate for the heat not generated internally by lights. This effect is more severe in the building with more thermal resistance in the enclosure (10% increase in the A-Exemplary type, vs. 6% increase in the D-Market type). Because the heat from lights is retained more effectively within an -A building, the effect of reducing the generation of that heat is greater than it is in a -D building. In both buildings, energy needed for cooling and fans drops when area lights are on daylight controls.

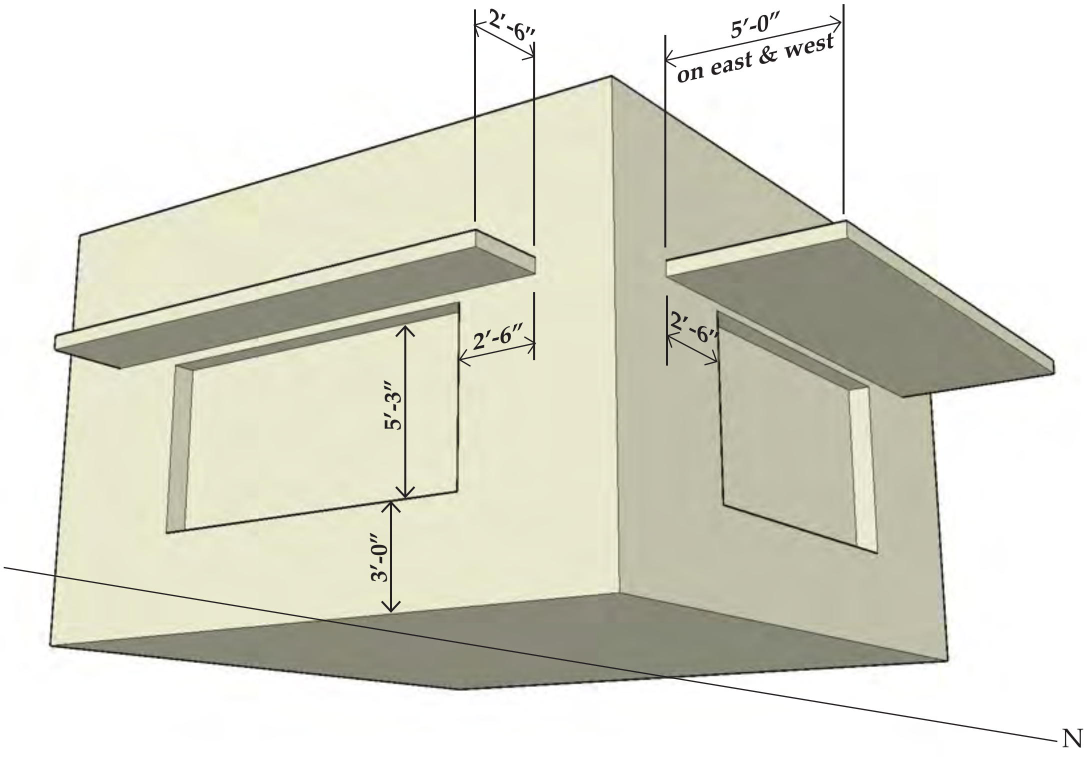
This shows that, in Toronto, daylighting controls can be somewhat more powerful than building form, much more powerful than building orientation, and roughly on a par with the power of window-to-wall ratio. It also suggests that lighting controls are most effective when used together with better-performing enclosures. Further, it suggests that there is no special synergy between plan form and daylight sensors, with respect to energy use.

Figure 5.4.6
Breakdown of loads with and without daylight sensors *(,000 kWhr/yr)*

	MD40HN-D	**MD40HN-D**	
	WITHOUT	**WITH**	**EFFECT**
heating	606.40	643.70	x1.06
cooling	92.00	83.40	x0.91
DHW	37.00	37.00	-
fans	87.80	83.30	x0.95
pumps	7.00	7.00	-
equip.	202.80	202.80	-
task lts.	27.00	27.00	-
area lts.	167.70	74.30	x0.44
	1,227.60	1,158.40	

	MD40SQ-A	**MD40SQ-A**	
	WITHOUT	**WITH**	**EFFECT**
heating	206.03	228.33	x1.11
cooling	76.03	68.18	x0.90
DHW	36.60	36.61	-
fans	49.77	45.25	x0.91
pumps	3.90	3.90	-
equip.	201.05	201.50	-
task lts.	27.05	27.05	-
area lts.	167.77	100.63	x0.60
	768.20	711.00	

5.4.7
Design of sunshades



What if well-designed exterior sunshades are included?

In Chapter 4, exterior sunshades were observed in roughly half of the "new-normal" cases; this is a significant departure from practice in the "GTA default" designs. However, the least energy-intense designs achieved their performance with limited or no use of sunshades. This prompted the question whether the value of sunshades, with respect to annual energy use, may be overstated in the literature - and whether this causes designers everywhere to imagine that they are an important element in a "green" building, regardless of locale.

Perhaps sunshades are useful for another purpose (such as managing light quality), or perhaps they are more useful in southern latituudes than in the Great Lakes Basin. To try to answer the latter question, several supplemental simulations were conducted on the Medium-sized building type, with 40% WWR, in all of its variations (shape, building orientation, and enclosure performance level).

Before doing the eQuest simulations, the design of the sunshades was checked, very carefully. Using the window sill and head heights that were originally designed for the 40% WWR type (shown in Figure 5.1.10), a 3-D model was constructed in SketchUp, including one window and a small section of exterior wall, facing each of the cardinal directions. Horizontal awnings were designed to suit this 40% WWR type, according to the advice in the "how-to" manuals (Brown & deKay 2001; Lechner 2001). The design is shown in Figure 5.4.7. Snapshots of the shadows cast, throughout the day, at the summer and winter solstice, and at the fall equinox are shown for Toronto (in Figure 5.4.8) and Miami (Appendix 5). *

After determining that the awnings were providing adequate shading, eQuest's "Energy-Efficiency Measure Wizard" was used to modify the original simulations of the Medium building (without lighting controls). The new inputs were as follows:

- exterior horizontal sunshades on all windows except those facing north,
- sunshade dimensions as shown in Figure 5.4.7, and
- no vertical "fins" were used.

The results of the eQuest runs are discussed, starting on page 426.

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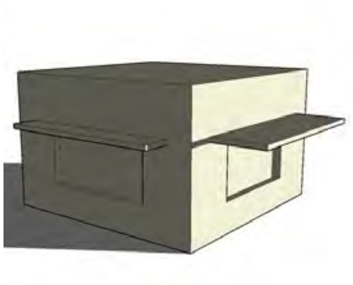
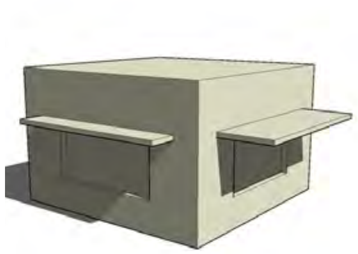
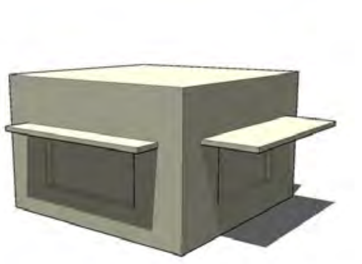
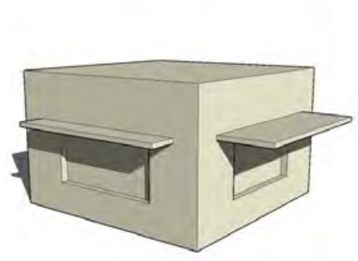
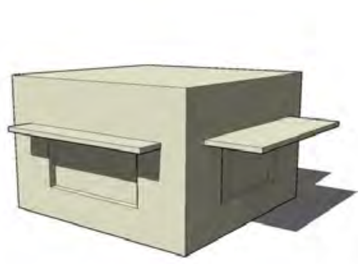
*According to the advice in the manuals, in Miami, the awning on the south facade could have been half as deep, while the awnings on the east and west had to be similar in both locations. Nevertheless, the awnings tested in the SketchUp models are the same for both locations.

5.4.8
Effect of sunshades in TORONTO

SUNRISE **9:00 AM** **NOON**

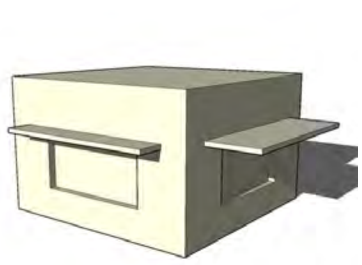




04:45 a.m.

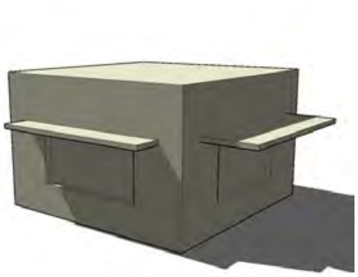
06:15 a.m.

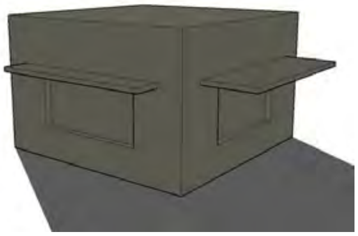




07:55 a.m.

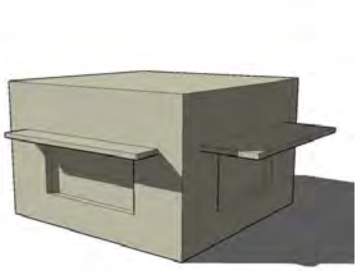
3:00 PM **SUNSET**





07:45 p.m.

summer solstice
21 June



06:05 p.m.

autumn equinox
21 September

04:35 p.m.

winter solstice
21 December

5.4.9
Energy-use profiles of MD-40SQ types in TORONTO, with and without exterior sunshades

TORONTO

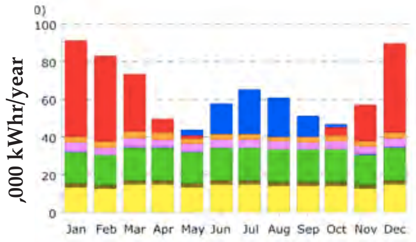
MD40SQ-A

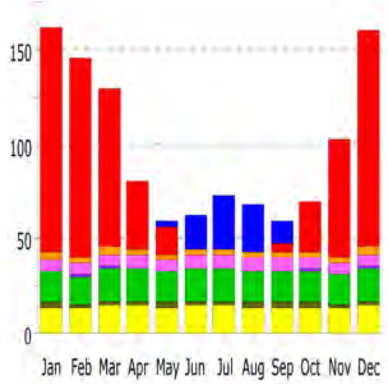
164
kWhr/m^2/year

MD40SQ-D

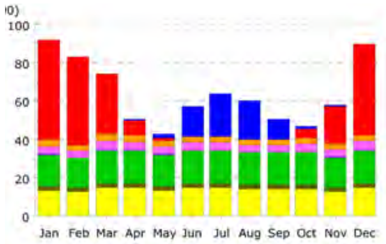
251
kWhr/m^2/year

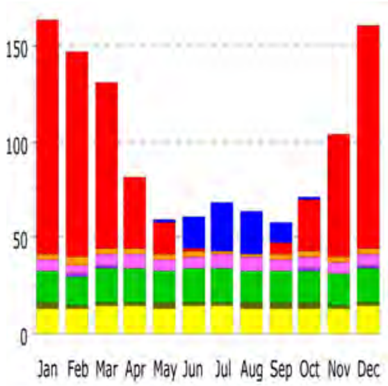
WITHOUT
exterior sunshades
(Macro-matrix #1 run)





WITH
exterior sunshades



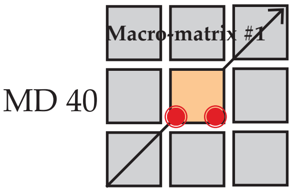


MD40SQ-Ashaded

165
kWhr/m^2/year

MD40SW-Dshaded

251
kWhr/m^2/year



S **Space Heating**
I **Water Heating**
I **Pumps & Auxilliary**
I **Task Lighting**
S **Space Cooling**
I **Ventilation Fans**
I **Plug & Miscellaneous**
I **Area Lighting**

Effect of sunshades in Toronto

Figure 5.4.10 shows the impact of exterior awnings on the LG, MD, and SM buildings with 40% WWR in Toronto. Contrary to expectations raised in the literature, there is rarely a reduction in overall annual energy intensity (LG40SQ-A, MD40HN-A, and SM40SQ-A being the exceptions). When there is an impact, it is slight (a factor of .96 to .99). In one case (MD40SQ-A), the simulation showed an increase in energy-intensity, when awnings were added to the design.

Figure 5.4.9 shows the impact in graphic form. As expected, there is some reduction in cooling energy. In the -D type, in which cooling used 7.4% of all energy expended in the building, sunshades reduced the draw to 6.6%. In the -A building, cooling and fan energy are reduced, but heating energy is increased by slightly greater amount (these amounts are both small in the overall picture). Additional heating is needed in January and February, perhaps because the awnings shade the south windows partially, during mid-day, at that time.

These results suggest that, in Toronto, exterior awnings are not useful for reducing the overall energy-use in an office building. They may be useful in reducing the discomfort of occupants, particularly those sitting next to a south facing window, where even winter sun can cause over-heating in a localized area.

5.4.10
Energy-intensity of 40% WWR types in Toronto, with and without exterior sunshades

TORONTO - NO sunshades
(results from Macro-matrix #1)

	LARGE 160,000 sf 8-storey		**MEDIUM 50,000 sf 4-storey**		**SMALL 12,000 sf 2-storey**	
	A	D	A	D	A	D
HN	153	235	173	263	-	-
HE	152	234	172	263	-	-
NS	148	230	169	260	193	303
EW	147	226	168	256	193	299
SQ	150	231	164	251	194	299

TORONTO - WITH sunshades

	LARGE		**MEDIUM**		**SMALL**	
	A	D	A	D	A	D
HN	**153**	**234**	**172**	**263**	**-**	**-**
	1.00	*1.00*	*0.99*	*1.00*		
HE	**152**	**234**	**172**	**262**	**-**	**-**
	1.00	*1.00*	*1.00*	*1.00*		
NS	**148**	**229**	**169**	**260**	**193**	**305**
	1.00	*1.00*	*1.00*	*1.00*	*1.00*	*1.01*
EW	**147**	**226**	**168**	**255**	**193**	**299**
	1.00	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*
SQ	**149**	**230**	**168**	**251**	**187**	**299**
	0.99	*1.00*	*1.02*	*1.00*	*0.96*	*1.00*

5.4.11 Energy-use profiles of MD40SQ types in MIAMI, with and without exterior sunshades

MIAMI

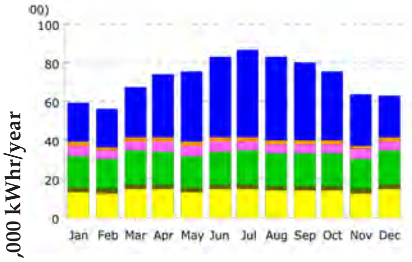
MD40NS-A

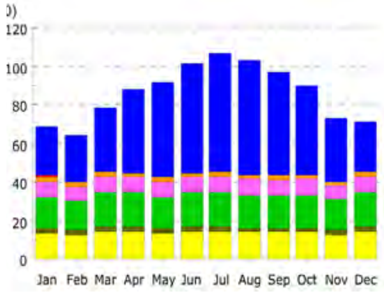
186
kWhr/m^2/year

MD40NS-D

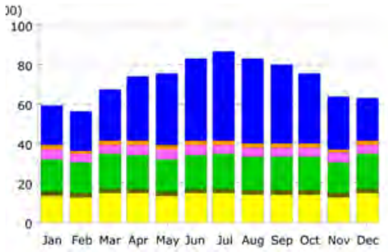
221
kWhr/m^2/year

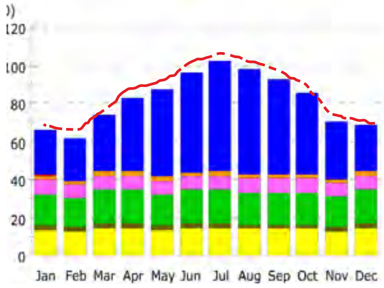
WITHOUT
exterior sunshades
(Macro-matrix #1 run)





WITH
exterior sunshades



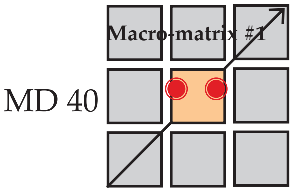


MD40NS-A

179
kWhr/m^2/year

MD40NS-D

211
kWhr/m^2/year



S Space Heating
I Water Heating
I Pumps & Auxilliary
I Task Lighting
S Space Cooling
I Ventilation Fans
I Plug & Miscellaneous
I Area Lighting

Effect of sunshades in Miami

Figure 5.4.12 shows the impact of exterior awnings on the LG, MD and SM buildings with 40% WWR in Miami. There is more effect in Miami than in Toronto. In only 4 of these 26 simulations was there no impact; in the remaining 22 simulations, the impact range from a factor of 0.95 to 0.98. The MD building types were twice as likely as the LG types to show a reduction by a factor of 0.95 to 0.96.

The upper panel in Figure 5.4.12 shows the Miami version of the "Macro-matrix #1" baseline simulations. These results show that building form and orientation matter a bit more in Miami than in Toronto. There is a greater difference between the SQ type and the slender type EW or NS, and this is consistent across the matrix. Also, comparing HN to HE or NS to EW shows a consistent difference. Nevertheless, the thermal resistance of the enclosure still is more powerful, in Miami, than building form or orientation.

Figure 5.4.11 shows the impacts of exterior awnings in graphic form. They are not as dramatic as one might have expected. The base internal loads (area lighting and users' equipment) are as significant in proportion to skin loads in Miami as they are in Toronto. Therefore, the addition of awnings is not powerful enough to tip the balance; cooling loads are at 48% of the overall in the -D type and 42% of the overall in the -A type, whether sunshades are present or not. The reduction of cooling energy in both cases is small, and consistent throughout the year (see lower right, Figure 5.4.11).

5.4.12
Energy-intensity of 40% WWR types in Miami, with and without exterior sunshades

MIAMI - NO sunshades
(results from Macro-matrix #1)

	LARGE **160,000 sf** **8-storey**		**MEDIUM** **50,000 sf** **4-storey**		**SMALL** **12,000 sf** **2-storey**	
	A	D	A	D	A	D
HN	173	202	185	219	-	-
HE	168	198	175	217	-	-
NS	171	198	186	221	188	229
EW	162	186	174	204	175	213
SQ	168	231	176	210	181	213

MIAMI - WITH sunshades

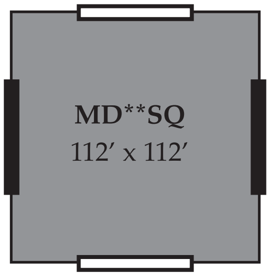
	A	D	A	D	A	D
HN	**170**	**194**	**180**	**209**	**-**	**-**
	0.98	*0.96*	*0.97*	*0.95*	*###*	*####*
HE	**164**	**193**	**174**	**209**	**-**	**-**
	0.98	*0.97*	*0.99*	*0.96*		
NS	**168**	**190**	**179**	**211**	**182**	**218**
	0.98	*0.96*	*0.96*	*0.95*	*0.97*	*0.95*
EW	**162**	**181**	**171**	**198**	**172**	**206**
	1.00	*0.97*	*0.98*	*0.97*	*0.98*	*0.97*
SQ	**165**	**230**	**172**	**203**	**181**	**205**
	0.98	*1.00*	*0.98*	*0.97*	*1.00*	*0.96*

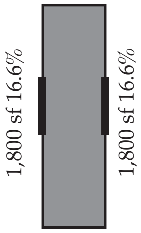
5.4.13
Medium-sized -C building, configured to test the power of window orientation

1,800 sf window area (black)
on East or West facade
wall is 60′ x 52′ = 3,120 sf
WWR is 57.7 %

1,800 sf window area (white)
on North or South facade
wall is 209′ x 52′ = 10,868 sf
WWR is 16.6%

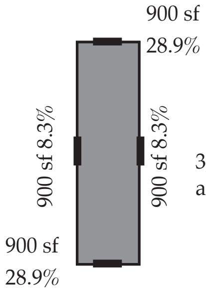
1,800 sf window area
on any facade
wall is 112′ x 52′ = 5,824 sf
WWR is 32.1 %





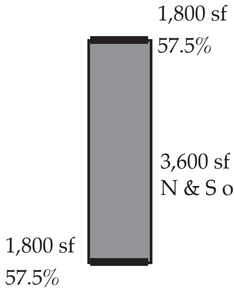
3,600 sf glass
E & W only

MDNS-gl EW**



3,600 sf glass
all 4 sides

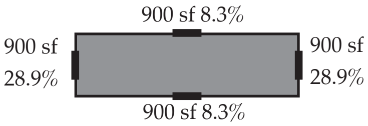
MDNS-gl NSEW**



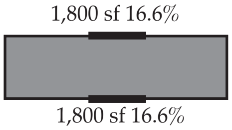
3,600 sf glass
N & S only

MDNS-gl NS**

MDEW-gl EW**

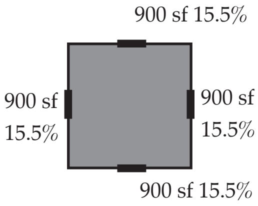


MDEW-gl NESW**

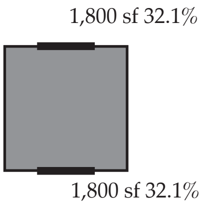


MDEW-gl NS**

MDSQ-gl EW**



MDSQ-gl NS**



MDSQ-gl NS**

What if windows are oriented differently?

The results of Macro-matrix #1 showed that neither the shape nor the orientation of a building has much impact on the energy-intensity - of an office building in Toronto. Yet the literature advises architects to maximize south-facing glass and minimize east- and west-facing glass. Also, the "new normal" cases in Chapter 4 showed a preference for south-facing glass, and some curtailment of east- and west- facing glass. Therefore, the assumption in this test is that window orientation may be more powerful than either form or building orientation, in some scenarios. The intention is to discover when and how much.

To test the power of window orientation, variations on the Medium-sized building were developed. A fixed amount of glazing (3,600 sf) was allocated to the facades of the square and slender building types, to create a series of new types. Inputs were as shown in Figure 5.4.13. *

A building with south-facing glass is expected to perform better than a building with east- and west-facing glass, regardless of building shape (square or slender) or building orientation. The energy-intensity of a building with glass evenly distributed on all four sides may perform at the median between the buildings with glass placed on two favourable, or two unfavourable facades. The matrix of results in Figure 5.4.14 was set up to reflect this expectation.

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* The sill and window heights shown in Figure 5.1.10, were used where appropriate, to suit the WWRs specified in Figure 5.4.14. In these tests, unlike the prior set, all windows were fixed units.

5.4.14
Annual energy intensity (kWhr/m^2/yr) of variants described in Figure 5.4.13

Building Type	**Glass area (sf) on each façade**				**Energy Intensity (kWhr/m2/yr) by Enclosure Performance Type**			
	N	E	S	W	A	B	C	D
(from Macro-matrix #1) 4,660 sf of glass equally distributed on ALL FOUR facades:								
MD20NS-glNESW	1,165	1,165	1,165	1,165	161	186	205	251
% of wall area:	20.0%	20.0%	20.0%	20.0%				
MD20EW-glNESW	1,165	1,165	1,165	1,165	161	184	202	248
% of wall area:	20.0%	20.0%	20.0%	20.0%				
MD20SW-glNESW	1,165	1,165	1,165	1,165	158	182	200	244
% of wall area:	20.0%	20.0%	20.0%	20.0%				
3,600 sf of glass on E&W facades, various building forms:					**Z -1**			
MDspNS-glEW	0	1,800	0	1,800	157	182	202	248
% of wall area:		16.6%		16.6%				
MDspEW-glEW	0	1,800	0	1,800	158	182	203	248
% of wall area:		57.5%		57.5%				
MDspSQ-glEW	0	1,800	0	1,800	157	181	200	244
% of wall area:		32.1%		32.1%				
3,600 sf of glass equally distributed on ALL FOUR facades, various building forms:								
MD15NS-glNESW	900	900	900	900	159	183	202	249
% of wall area:	15.5%	15.5%	15.5%	15.5%				
MD15EW-glNESW	900	900	900	900	158	182	200	246
% of wall area:	15.5%	15.5%	15.5%	15.5%				
MD15SQ-glNESW	900	900	900	900	156	180	198	242
% of wall area:	15.5%	15.5%	15.5%	15.5%				
3,600 sf of glass on N&S facades, various building forms:					**Z -2**			
MDspNS-glNS	1,800	0	1,800	0	158	182	202	247
% of wall area:	57.5%		57.5%					
MDspEW-glNS	1,800	0	1,800	0	157	180	199	245
% of wall area:	16.6%		16.6%					
MDspSQ-glNS	1,800	0	1,800	0	157	179	198	242
% of wall area:	32.1%		32.1%					

Also, the importance of glazing orientation is expected to vary, as the level of enclosure performance is changed. South-facing glass, by attracting solar gains in the winter, helps offset the need for heating from a combustion source, it is said. In a building with an exemplary enclosure, heating energy is less significant than in a building with a market-level enclosure. If glass orientation matters, and if it can reduce heating energy, then it will matter more in the market (-D) type than in the exemplary (-A) type.

The results, shown in Figure 5.4.14, suggest otherwise. To present the baseline, the 3,600 sf of glass was distributed evenly on all 4 sides, the pattern followed that in Macro-matrix #1 closely, even though the whole-building WWR had dropped from 20% to 13%.

When glass is concentrated on only two facades - either all north & south, or all east & west, the variance in energy-intensity is shown to be next to nil (Z-1 on Figure 5.4.14). Energy-intensity did not vary significantly whether the glass was on the north and south facades or on the east and west facades (Z-2 on Figure 5.4.14).

These results could be a function of the very small whole-building WWR in the types developed here. So, another series of types was developed, with more glass overall. These are shown in Figure 5.4.15 (on the following page).

Figure 5.4.15
ASHRAE's advice to architects regarding the orientation of buildings and glazing
(ASHRAE 2004)

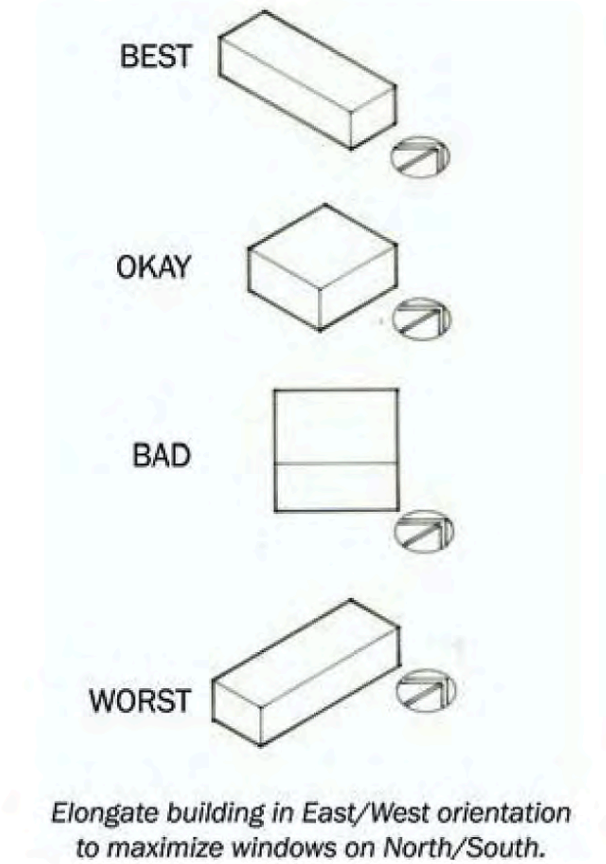
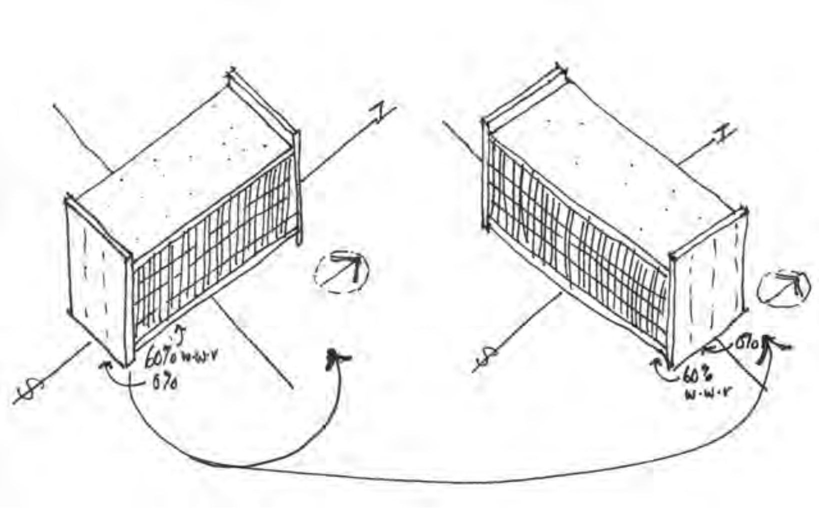


Figure 5.4.16
Variants tested in different North American climates



The question about the power of window orientation is provoked by urgings in the literature - like the illustration in Figure 5.4.15, which is taken from the *Advanced Energy Design Guide for Small Office Buildings* (ASHRAE 2004). The advice that a building with an east-west spine is "bad" appears under the banner "Warm climates", although the text suggests it pertains to the Great Lakes States and northern New England (Zones 5 and 6) as well as it does to the southern states, from Florida to southern California (Zones 1 and 2). This advice is asserted as a rule, and is gaining traction in the literature. It assumes windows are distributed evenly on all facades, or concentrated on the long flanks of the building.

To test the validity of this assertion in Toronto, two new variations on the 4-storey, 50,000 sf, Medium-sized building were envisioned; these are shown in Figure 5.4.16. In the first variant, the WWR on the east & west facades is 65% - the "worst" alternative, according to the ASHRAE Guide. In the second variant, the building is spun on its axis, allowing the facades with 65% WWR to face north and south - the "best" alternative, according to the advice in Figure 5.4.15. The enclosure performance level -C was used, to represent the common current practice, to which the ASHRAE Guide is directed.

The results, shown in Figure 5.4.17, suggest, again, that re-orienting an entire building - even if it is designed with large amounts of glass on its long facades - would have very little effect on the annual energy-intensity, at the latitudes surrounding the Great Lakes Basin (see Figure 2.7.3). As these results show, such a design operation would have a significant effect closer to the equator - where, as Olgyay stated, solar radiation effects dominate over temperature effects (1963).

		Energy Intensity (kWhr/m2/yr)		
	latitude	**spine NS glass E&W**	**spine EW glass N&S**	**difference (% of high)**
Regina	50°N	250	241	**-3.7%**
Seattle	47°N	164	157	**-4.5%**
Toronto	44°N	219	213	**-2.8%**
Phoenix	33°N	219	193	**-13.5%**
Miami	26°N	221	199	**-11.1%**

Figure 5.4.17
The effect of rotating a MD-C building with glass on the long sides, in various climates

Figure 5.5.1
The effect of architectural parameters on the annual energy-intensity of an office building in Toronto

2.1 through 2.4 Which is most powerful, enclosure design, or some other element?

Increase the thermal resistance of the enclosure elements from “Market” (-D) to “Exemplary”(-A) type	0.64 - 0.66
Increase the thermal resistance of the enclosure elements from “Institutional” (-C) to “High-Performance” (-B) type	0.90 - 0.94

2.5 How much would 20%, 40%, or 60% WWR matter?

Reduce the window-to-wall ratio from 60% to 40%	0.93 - 0.97
Reduce the window-to-wall ratio from 40% to 20%	0.94 - 0.98

2.7 & 2.8
How much does plan form drive energy-intensity?

Change the Building Form from SQ to EW/NS or HE/HN	0.98 - 1.06
Change the Building Form of the MD60 building from SQ to EW/NS or HE/HN	1.04 - 1.06

2.9 How much does WWR on the east & west drive energy-intensity? and 3.3 How much impact from WWR on the south facade, in the Great Lakes Basin, vs. elsewhere?

Orient windows N&S only, in Phoenix & Miami	0.87 - 0.90
Orient windows N&S only, in Toronto	0.96 - 0.97

2.10 How much impact from exterior sunshades in the GLB vs. elsewhere?

Add exterior awnings to 40% WWR bldge in Toronto	0.96 - 1.02
Add exterior awnings to 40% WWR bldge in Miami	0.95 - 1.00

3.1 How much impact does rotating a building, form north-south to east-west, have in the Great Lakes Basin, vs. elsewhere?

Re-orient the building from spine aligning with NS axis to spine aligning with EW axis	0.97 - 1.00

4.13 What is the impact of daylight sensors, when combined with 2.7, slender floor plate?

Add daylight sensors to any building type (effect increases as enclosure performance increases)	0.90 - 0.96

5.5 SUMMARY OF FINDINGS IN THE STUDY OF DESIGN PARAMETERS

The purpose of this phase of the study was to isolate the parameters that fall primarily in the architect's purview, and to understand their relative power - not to determine the ideal design components to suit one particular circumstance. The more general understanding should help an architect to quickly select the design strategies that are most likely to have a real effect on energy use, in order to test them further within the constraints of a particular project. This should also help the whole design team understand which strategies have the highest priority, and why - as any future design goes through development.

The unique challenges presented by the climate in the Great Lakes Basin have been compared to conditions in warmer and colder locations. In the Analysis of Case Studies, in Chapter 4, a quantification of HDD and CDD showed this area as a very challenging climate - not always purely cold, and sometimes hot and humid enough that powerful design strategies are required to maintain a comfortable environment for work.

The impact of the Great Lakes climate on a designer is expressed, in Section 5.2, in the energy-use profile for a simulated office building in Toronto, compared to the profiles for the same building in Regina, Seattle, Phoenix and Miami. This comparison shows the degree to which the "cool-humid" region truly does offer "the worst of both worlds". As in the colder climates of the Canadian Prairies and American midwest, the largest use of energy in the Great Lakes Basin is for heating. Unlike the more temperate zone on the Pacific coast, there also is a significant, and sustained need for cooling. Toronto lies on the threshold of the northerly latitudes, in which it is difficult to predict, purely on the basis of building form and size, whether a design may be called "skin-dominated" or "internal-load dominated". An office building has large internal loads, compared to a single-family house, but the skin-vs.-internal load proportion shifts, according to the thermal performance of the enclosure and the climate in which the building is situated.

At the end of Chapter 4, the Analysis of Case Studies left several questions to be answered here, in the Study of Design Parameters. A summary of the answers to these questions is presented in Figure 5.5.1.

In Section 5.1, seven general expectations were expressed, relative to the trends that the Macro-matrix would show. Of these, two expectations were negated, two were cast in serious doubt, and one was confirmed, although somewhat weakly. Only two were confirmed clearly.

The two expectations that were negated emphatically, by the results of the simulations, have to do with form and climate. First, form has a very weak influence on the energy use of an office building in Toronto, and it exerts no more significant influence in the small building than in the medium or large building. Second, building orientation has a small influence in Miami, and no influence in Toronto, while enclosure performance has strong influence in both climates.

The two expectations that were cast in doubt also have to do with building form and orientation. One expectation was that a building with a narrow plan form would be more energy-intense than a building with a square plan, because of its increased surface area. The results suggest that this is not always the case. Among the 72 pairs that tested this hypothesis, only 25 narrow buildings were more energy-intense than their square counterparts, and only 9 showed at least a 3% deviation. Another expectation was that an east-west building would naturally be less energy-intense that a square building, due to "passive solar" effects. Among the 36 pairs that tested this hypothesis, only 18 east-west buildings were less energy-intense than their square counterparts, and again by margins that are within 2%. The evidence of these tests suggests that there is some effect sometimes, but does not support the contention that a slender plan form, oriented east-west is beneficial, universally, in lowering energy use.

The results confirm that the lowering of window-to-wall ratio contributes to the lowering of energy intensity. They suggest that this strategy outweighs the power of building orientation - which, as noted above, is not very significant.

The two expectations strongly confirmed have to do with the power of the overall enclosure specification, and the orientation of windows. The thermal resistance of the enclosure is by far the most powerful parameter, at all building sizes (see Figure 5.5.1). Window orientation matters a great deal more in Miami than in Toronto (11% difference between two extremes in Miami, vs. 2.8% in Toronto, as shown in Figure 5.4.17). Since overall building form is not a strong driver of energy use, it can be said that window orientation matters more, even in Toronto, than building form.

Three additional design strategies were tested: daylight sensors, exterior sunshades, and window orientation. Daylight sensors lowered energy-intensity significantly, and were most effective in the building types with “exemplary” enclosures. However, they did not make the slender EW building any more effective, relative to their SQ counterparts. Exterior awnings were shown to have no positive effect on the energy intensity of an office building in Toronto; in a building with an exemplary enclosure, they may have a slightly negative effect, increasing heating loads. In Miami, awnings are more useful - reducing the need for cooling, slightly, throughout the year. Likewise, even an extreme bias of window orientation likewise toward the south proved nearly inconsequential in Toronto, and much more important in more southerly latitudes.

These conclusions highlight the problematic nature of vaguely-delimited “blanket” statements about the power of a particular design parameter. For instance, when one reads that “the form of a building is crucial to its environmental performance, as are its orientation and materials” (Hagan, 2003), it is easy to assume that a “new normal” design approach begins - as so many other “new” approaches in the history of architecture have begun - with a new approach to form. The results here suggest that the “new normal” - in non-residential civic buildings in the Great Lakes Basin, at least - has nothing whatsoever to do with form.

Other types of statements are more precisely framed, such as “the orientation of a building has considerable influence on its behaviour in summer”. The results here suggest that this may be so, although “considerable” is debatable, and ought to be quantified. “Behaviour” in this statement may refer more to comfort than to overall energy-intensity. If one hears such statements often enough, one may begin to believe that they apply, with consistent force, to any design problem at hand - and that is a misconception. Architects must continue to question the assumptions behind every such generalization.

Recommendations

After conducting both the Analysis of Case Studies and the Study of Design Parameters, a few generalized recommendations may be made to designers of non-residential civic buildings within the Great Lakes Basin, and similar cool-humid climates, as follows.

- Provide the building with a weather-resistant, thermally resistant enclosure. In this region, heating is the largest load that can be affected by architectural design. Deal with load reduction by making “keep the heat in” the highest priority, knowing that the design of the enclosure has - by far - the strongest influence upon the annual energy use of the building, of all parameters tested here.

- If the design process begins with an assumption that the window-to-wall ratio ought to be more than 40%, reconsider this carefully. If large expanses of glass are highly desirable, locate them strategically, to obtain maximum qualitative advantage for the minimum energy expenditure.

- Resist the encouragement, which is rampant in the literature, to re-orient the building in relation to the sun. Passive solar effects are very weak in buildings of this size and type in this area. Urban design considerations are still important.

- Also resist the entreaties to re-shape a building purely in the interest of energy-use reduction. Overall shape and energy use relate very weakly. However, shape and daylight penetration relate strongly; the presence of daylight deep within an office building is an asset in terms of enjoyability and beauty, regardless of the energy-use impact. After heating, energy for lighting is the second-largest load in an administration building in Toronto. Daylight sensors are an easier - and far more effective - strategy than re-shaping or re-orienting an entire building, if lowering energy-use is the objective.

- Whichever way the building faces, consider the orientation of large swaths of glass carefully, but do not over-stress about it. Use east- and west-facing glass with a purpose (such as view and quality of light), and understand that there is a price to pay for it, but it is small. Specify the glass very carefully, with low SHGC. Plant a deciduous tree outside.

- Question the relevance of statements that relate to cooling. Architects often are concerned about major cooling equipment, because it represents a considerable portion of the mechanical systems budget, and it occupies space in the building. However, cooling represented from 5% to 11% of the total annual energy use of the types in the Macro-matrix #1 for Toronto (consistent with the observation in the "new-normal" cases). Cooling presents a much less significant opportunity for energy-use reduction than heating, lighting, and users' equipment.

- Resist entreaties to adopt a "carbon neutral" goal for a single building. Neighbourhood synergies are possible, practical and

> may be important. In the course of this study, no freestanding, fully off-the-grid, non-residential building was discovered. Even when all of the most effective design strategies were simulated together, the office building types were shown to be far from "carbon-neutral"; only a few approached the level of energy-intensity at which on-site generation of renewable energy would be likely to be practical. Consider introducing on-site devices for generating renewable energy only if the building energy intensity is 120-150 kWhr/m^2/yr or less. (In the future, this range may be adjusted, as it is driven by both available space and affordability - the latter being partly dependent upon the prevailing cost of electricity from the grid.)

Reflections

The Study of Design Parameters answered the researcher's questions about the relative power of the architect's primary choices. The methods employed in this study could be used to study other building types in the Great Lakes Basin, and beyond. In practice, an exercise such as this might help train the designer's intuition about the consequences of typical early-stage design decisions.

The eQuest tool proved effective. It accepted inputs in sufficient detail to define the building types accurately, and also allowed alternate tests - of the types in other locations, with modified design strategies - to be done swiftly. However, the Schematic Design Wizard did not easily accept inputs regarding: elevator power, skylights in an atrium, part of building dug into a hill, occupancy sensors, stack losses, thermal mass, displacement ventilation, or energy for heating outside air, in this all-electric scenario. Also the determination of internal thermal zones is a nuance left for future study.

Because of the abstraction used to do the study and so many things left out of the simulations, the specific energy-intensity figures shown here must not be applied to a real-world problem, no matter how closely it resembles one of the building types designed for Macro-matrix #1. In future research, it would be useful for studies to confirm that the effects observed here also are observable in other building types and locations. Nevertheless, the comparison of these results has clarified several misconceptions running rampant in the "green building" literature. Now it is possible to synthesize the lessons learned here with those from Chapters 3 and 4, and to consider how they may be deployed in architectural consulting practice.

6

PLACES TO INTERVENE IN PRACTICE

6.0 APPLYING THE LESSONS LEARNED

At the outset of this study, the practitioner-turned researcher had a hunch that the old familiar approach was due for an upgrade. This was accompanied by the admission that there were large gaps in earlier training. During the next twenty years of practice, the first aim would be to “get the beat” about energy flow in buildings.

Also, there was a great deal of hype about “green building”, coupled with a sense that an “easy recipe” would not necessarily lead to sure success. The cost and process impacts of “going green” were unclear. Poor-quality information, coupled with “wanting to believe” created a risky situation for an architect in consulting practice. More than simply “getting the beat”, during the next twenty years of practice, the aim would be to avoid designing a project that acquires a "green" rating that actually is an "energy hog", and to "set the beat" at an appropriate level for each future project.

An architect who works with civic clients is in a milieu in which more than mere "efficiency" is expected, yet prejudices linger about whether a "low-load" building can also be "high-satisfaction", and what such a building looks and feels like. Overspecialization in the professions exacerbates the prejudices. During the next twenty years, the aim would be to realize designs that are not only exemplary as "low load" but also very satisfying – that is meaningful, enjoyable, beautiful and clever. Having the ability to ask effective questions of the engineering consultants was seen as one key to more effective integration of human and technical concerns.

The design process may be described as a complex system. Particularly in the early stages, an architect must take in information from an array of sources, and synthesize all that is heard, into a design proposal. As the process continues, the engineers on the design team are consulted and re-consulted, with each decision adding a layer of complexity to the entire architecture.

Complex systems were the objects of analysis in the life work of Donella Meadows, who argued that there are ten points in any complex system, at which change is leveraged. Meadows presented these points as lying along a continuum with ten levels - from a point where a stimulus is likely to have relatively little effect (number 9), to more sensitive points, where leverage is powerful, and may effect change that is both profound and wide-reaching (numbers 1 and 0).

Meadows tells of the moment when her model crystallized, during a workshop about global economics, but she acknowledges that what "bubbled up" was the result of decades of rigorous analysis of complex systems, done by many smart people. She describes each leverage point, giving examples of how specific interventions at each level initiated change in economic, and political systems, during the late 20th century. Meadows did not apply her model to the construction industry, or to architectural practice; the application is part of the exercise here.

The complex system to be considered here is the practice of a consulting architectural designer – particularly in the early stages of a project. Section 6.1 begins by summarizing Meadows' model, as written. In Section 6.2, initiatives inspired by the research are classified according to Meadows' model, and presented in relation to each of the roles that an consulting architect assumes - including strategic advisor to the client, imaginative designer with technical know-how, co-ordinator of the design team and public advocate. In Section 6.3, general reflections on the proposed list of interventions are made, along with a few suggestions for further thought.

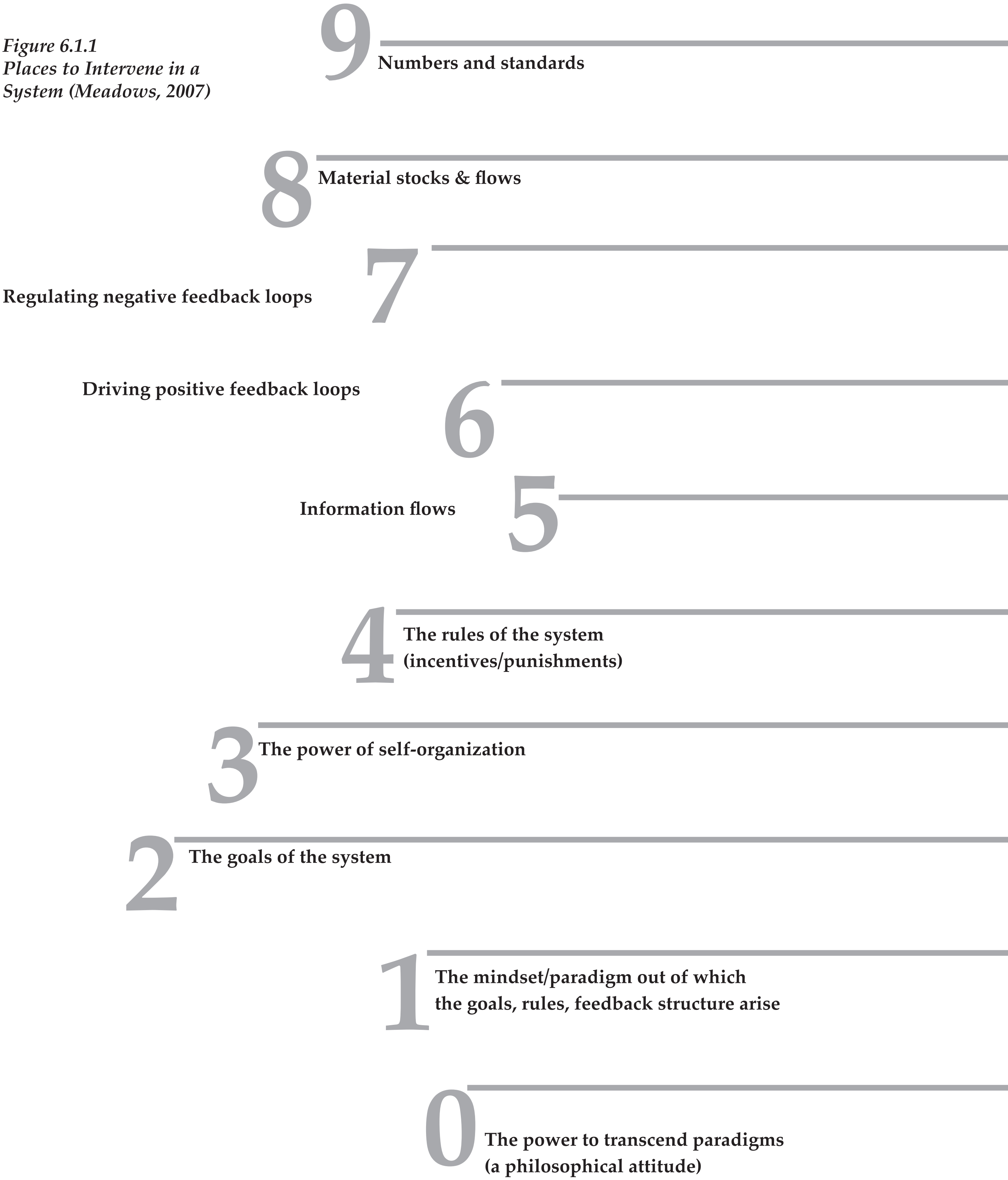
6.1 "PLACES TO INTERVENE" IN A COMPLEX SYSTEM

On first reading, the "Places to Intervene" framework seemed both wise and practical. The entire model, along with the shorter taxonomy "mindset, process, tools, stuff", had been cited extensively in the "green building" literature. However, the "leverage points" in architectural practice were not discussed by Meadows, nor have they been fully elaborated by those who make reference to her work (e.g. Reed 2004).

The model provides a structure through which the findings of this study may be launched into application – in future research studies, and in the early stages of real projects. Through the "Places to Intervene" lens, this discussion aims to highlight the lessons learned in the study that may be most useful in consulting practice, and to suggest when and how to place them near the nexus of decision-making, during the schematic design stages.

The list of leverage points, proposed by Meadows in Places to Intervene in a System (2007) is illustrated in Figure 6.1.1 (overleaf).

Figure 6.1.1
Places to Intervene in a System (Meadows, 2007)



stuff

tools

process

mindset

Meadows' Definition	**Meadows' Examples:**
9 Parameters that regulate flows in a system rarely change behaviour. Diddling with details = re-arranging deck chairs on the Titanic, except when a number kicks off a levge. point higher on the list, or when it relates to the length of the delay in a feedback loop.	9 water faucet; caps on campaign contribs don't clean up politics; fiddle w/interest rates doesn't dissolve business cycle
8 The principal leverage of material stocks is in proper design in the first place. Once constructed, levge. is in not exceeding limits. Yet, a big stabilizing stock (e.g. a lake or a bank balance) acts as a buffer.	8 the parts of a plumbing structure; the car fleet that takes 20 years to turn over
7 A neg. feedback loop (NFL) keeps system states within safe bounds. It needs a goal, a monitoring device, & a response mechanism. The effectiveness of the NFL depends on the accuracy in monitoring + the swiftness & power of response. Complex systems have numerous NFLs, many of which are inactive most of the time.	7 thermostat loops; strengthening a NFL: preventative medicine, healthy diet, exercise, rest & recreation, and the protection of whistle-blowers
6 "Any place where the more you have of something, the more you have the possibility of having more." If unchecked, PFLs spin out into chaos. Reducing the gain around a PFL is usually more powerful than strengthening NFLs.	6 the more money you have in the bank, the more interest you earn; the more soil erodes, the more it is vulnerable to erosion
5 New information loops put reports where they can be acted upon appropriately. Missing information loops are common causes of system malfunction. Rerouting info usually is easier and cheaper than rebuilding infrastructure.	5 the electric meter in the front hall that led to 30% reduction in energy use; the public reporting of pollution emissions
4 Rules define the scope of a system, and the degrees of freedom within it. "Rules change behaviour. Power over rules is real power." To understand systems, pay attention to rules, and who has power over them.	4 constitutions, laws of thermodynamics, incentives/punishments, informal social agreements (progressively weaker)
3 Self-organization means adding or deleting any aspect lower on the list. To survive change by changing, a system needs a stock of info, a source of variety (e.g. creativity), and a means of testing. Any system that scorns experiment is doomed over the long term.	3 human brain takes in new info and emits new results; biological and cultural diversity = stock.
2 There is a hierarchy of goals in a system. "People within systems don't often recognize what whole-system goal they are serving." A leader at the top may change the goals of the whole system, by "articulating, repeating, standing for, and insisting upon new goals".	2 the "goodness" of technologies depends on who using, to what end; R. Reagan insisting on "getting gov't off our backs"
1 The "great unstated assumptions" in society yield goals, info flows & stocks. Change can be instantaneous, when you point at anomalies in old paradigm, come confidently from the new one, don't waste time with reactionaries, and work with "the vast middle ground" of people who are open-minded.	1 assumptions in our culture: "growth is good"; one can "own" land; nature is a stock of resources to be converted to human purposes
0 The highest leverage is to accept that NO paradigm is "true", no matter how comfortably it fits one's worldview. "Leverage has less to do with pushing levers than it does with disciplined thinking combined with strategically, profoundly, madly letting go."	0 through mastery over paradigms, people throw off addictions, live in constant joy, have impacts that last for millennia

6.2 "PLACES TO INTERVENE" IN ARCHITECTURAL CONSULTING PRACTICE

What if an imaginary design team, operating within a mid-sized architectural practice that serves civic non-residential clients, sets out to design a "low-load and high-satisfaction" civic centre. Suppose the client, with the help of the team, has decided that the target for energy-use within the new building is to be half of today's average.

The client may have said "yes" to the "low-load" goal, in order to please a constituency (e.g. customers or tenants who value "environmental" action), in order to be seen to be "doing the right thing", or "moving with the times", to save money every year, to comply with a regulation, or to express its core values. The architectural team may have said "let's do it", because achieving the goal has the potential to give the consulting firm a new "niche", or because it expresses the members' values, it is an interesting designs challenge, or simply because the client wants energy-efficiency to be a part of the project - therefore it has become necessary to work towards this low-load goal.

Either way, the team is in a condition similar to the researcher's experience, as described in Chapter 1. The members' intention is to effect a real reduction in energy use, that is measurable in the utility bills, while providing a high-quality design, that can be appraised using traditional qualitative criteria, such as those in the QDQ. The team recognizes that there is hype about "green building" abounding, but they know an "easy recipe" is not likely to be the most effective. Also, they acknowledge that there are gaps in the training of all of the team members, regarding "environmental design".

The team has access to the research in Chapters 3, 4 and 5, and will use Meadows' "Places to Intervene in a System" to understand what sort of results may be leveraged by changes in routine practice.

It is assumed that the mindset of every member of the team is reasonably disposed toward the development of a truly "low-load" proposal, and this assumption is crucial. In the original model, Meadows places "the goals of the system" at leverage point #2, and mindset at the near-strongest level #1. In the early stages of the design of a civic building, architect and client work closely together, to establish the goals of a project, and to select the principal approaches to meet those goals. Both clients and architects have the power to select one another based on a "good match", with respect to shared values and ways of working – and this power still is exercised often, in the arena of public projects. Architects, when performing at their best, sometimes are able to influence their clients' attitudes. And clients sometimes can influence their architects' attitudes. This scenario, therefore, involves an architect-client team, working in a spirit of collaboration, toward a common, over-riding, whole-system goal - to design a building that provides the maximum human satisfaction at the minimum environmental expense.

With Meadows' most powerful leverage points (2-Goals, 1-Mindset, and 0-Let Go) already assumed, the team draws upon the research findings in Chapters 3, 4 and 5, and identifies several specific initiatives to take. They relate each initiative to one of Meadows' leverage points, and group each action according to the role to which it most closely relates. Then, they speculate as to the possible outcomes, and the limitations, of each initiative.

Meadows uses the term "sources of variety", at leverage point number 3. Applied to architecture, in the pre-design process, these "sources" are the members of real-world design teams, working to select their paths amid the "stock of information" about green buildings. These "sources of variety" will remain powerful and effective as long as they retain their nimble characteristic of continuous evolution. In the "new normal", many processes, components and systems, that have been assumed, in the past, as automatic defaults, may be re-considered; every one of the usual "default" design decisions may be re-visited.

These initiatives are proposed, because every one of them is worth pursuing; other initiatives were considered, but omitted from the discussion. Each one may be started independently of the others, but no single intervention is expected to overpower all of the others – nor do any of them purport to take the place of normal project management duties. The initiatives may not be entirely discrete – some may be exercised from within more than one professional role and some may address more than one of the challenges identified at the outset. The "Places to Intervene" are organized here in the position where they seem to be most relevant.

Figure 6.2.1 Interventions, in the role of strategic Advisor to the client

INTERVENTION	SAW ITS EFFECT IN ...
1. Analyze utility bills from clients, especially repeat clients - *and ask questions of the Operations & Maintenance representatives of client agencies*	**... the exercise of calculating utility data -** *e.g. for the GTA Police, GTA School, and GTA SAC, which helped build a frame of reference, and open a dialogue with owners' representatives (Section 2.5, App. 3).* **... periodic queries of other architects** - *confirm that analysis of fuel bills rarely is done, and that energy-intensity figures are only meaningful in a broad context, as depicted in the Intensometer (Section 4.3).*
2. Request (or conduct) comprehensive Post Occupancy Evaluations (POEs) of projects designed in the office - *i.e. compare to, or develop a "baseline" of measurable expectations*	**... results rarely made public -** *and not in the green building rating systems (Section 3.4)* **... post occupancy studies discussed during visits to some of the case studies -** *e.g. AJLC, Wind NRG, Artists, Gilman Ordway, PAAM (Sect. 4.2)*
3. Use the Questions of Design Quality to discuss project priorities with the client - *i.e. help clients participate in good-quality discourse about design*	**... poor registry of quality in existing rating systems -** *e.g. SBTool (Section 3.4)* **... appraisals of "satisfactoriness" in the "new normal" and "GTA default" cases -** *(Section 4.2)*

In Section 3.3, the discussion showed that an architect, when acting in the role of strategic advisor to the client would be well-advised to be impeccable with his or her words, and to continue to demand better-quality information.

The three interventions suggested here all aim to open and deepen the dialogue between architect and client - to help both “get the beat” regarding energy flow in buildings, and to prepare to realize designs that are strong in relation to both quantitative and qualitative criteria.

These initiatives are most likely to be taken by the more experienced members of an architectural team, who have the most contact with the client.

Advisor

“PLACE”	**POTENTIAL LEVERAGE**
7 **NEG’VE FEED-BACK**	**Analyzing utility bills** *may identify aspects of a design that are less than successful, and this might inform the next design, should a building owner and a particular design team embark on a second project together.* *Meadows argues that humans invent negative feedback loops to keep system states within safe bounds, and says that, to strengthen a negative feedback loop, one must improve the accuracy of monitoring (ask effective questions & listen well), and the quickness and power of the response (apply the feedback appropriately).*
5 **INFO. FLOW**	**A POE** *may help an architect identify specific areas for improvement, and this probably will include issues for the engineers on the design team. This process will reveal surprises, and some may be disappointing, so it* ***requires an open mindset and “letting go”.*** *It is helpful if the results of a POE can be compared to “typical” results, drawn from a large numbers of evaluations of similar buildings, as was the case at Wind NRG (Baird 2006). In particular, it should indicate the degree of “enjoyability”, relative to other buildings of similar type. A third-party evaluator, who specializes in POE may ask the questions. Some large architectural firms are developing internal divisions for this purpose (Gonchar 2008).*
2 **GOALS**	**The QDQ comprises 21 questions** *that were developed to help an architect lead a discussion about an emerging design, in clear, plain terms that may be understood by non-architects. Meadows observes that people within systems don’t often recognize what whole-system goal is begin served by a particular initiative. If stakeholders are helped to appreciate the issues, then they may be able to form their own good-quality responses to the questions in the QDQ, and to contribute to a productive discourse about an emerging “low-load + high-satisfaction” design. Meadows further suggests that “articulating, repeating, standing for, and insisting upon” new system goals has very powerful leverage over the behaviour of all actors within a system. Through this leverage point, stakeholders may even become substantive contributors to solutions - during the design - or operations - phases.*

Figure 6.2.2
Interventions, in the role Designer

INTERVENTION	SAW ITS EFFECT IN ...
4. Understand the local climate quantitatively - *i.e. compare HDD & CDD in this region to data in other regions*	**... energy use in global regions -** *(Sect. 3.1)* **... climate data for best practices** *(Sect. 4.5)* **... comparison of climate impacts on a typical building in four zones -** *(Sect. 5.2)*
5. Construct a large Intensometer in the front hall of the office - *i.e. run an in-house challenge, comparing the energy-intensity of all designs*	**... not routine in rating systems -** *(Sect. 3.4)* **... compiling and presenting the Intensometer -** *learning the overall range is huge, and that the gap between model and actual is huge - plus the keen interest expressed by architects and owners in the graphic frame of reference (Sect. 4.3).* **... proving some statements re power of parameters to be inaccurate -** *when results were viewed in a frame of reference (Section 5.3)*
6. Train the intuition about energy-effects of design decisions - *e.g. in ascending order of difficulty: 1-learn to read simulations, or 2-learn to do simple simulations, to see where the largest loads are, and to test variations, or 3-calculate the heat loads in a few designs, by hand.*	**... gaps in optimization study lit.** *(Sec. 2.3)* **... urgings in IDP lit.** *(Sect. 3.3)* ... **studying the results of simulations,** *which only became meaningful in context - i.e. relative to other results, to climate, and to buildings designed in past practice (Sects. 4.2 & 4.3).* **... learning to read the results of an energy simulation -** *and viewing the "where energy is used" proportions in relation to other results (Chapter 5, App. 5)*
7. Refer frequently to the Strategy Grid during the schematic design phase - *i.e. post a list, on every desktop, that distinguishes between high-level design approaches and detailed tactics*	**... its genesis is the literature -** *e.g. Olgyay, Lloyd-Jones, McLennan, Yeang (Section 2.6)* **... analysis of best practices -** *(Section 4.5)* **... Order of Ops what-ifs? -** *(Section 5.4)*

Designer

When acting in the role of imaginative designer, an architect needs to acquire more technical know-how, and greater interest in using it. The four interventions suggested here all aim to help architects to identify and take advantage of opportunities to lower energy use, while increasing satisfactoriness. They all have to do with new kinds of information, although the last two fit better with leverage points lower on the list than point number 5. All can be taken by design principles, project managers or more junior members of the design team.

"PLACE"	**POTENTIAL LEVERAGE**
5 **INFO. FLOW**	**Quantifying local climatic conditions** *should help set priorities (e.g. "keep the heat in") and it may help discern the more useful tactics from the less useful tactics in green building precedents.*
5 **INFO. FLOW**	**An Intensometer in the office lobby** *would be a "new loop", placing both predicted and actual energy-use data from recent projects where it is seen daily by all designers. Just as the power meter in the front hall reminded building occupants to turn off the lights before leaving the building, and Intensometer in the office lobby may motivate designers, and help remind them of projects that have achieved exemplary results* *However, this will work only if the office* ***mindset*** *supports continuous improvement by all participants (e.g. no "designers vs. "greens").*
3 **ORG'ZE SELF**	**Reading an energy simulation** *could form a "new loop, delivering feedback to a place where it wasn't going before". Rerouting information in this way could be powerful. If an architect questions the results of an energy model, she may take greater care in verifying the inputs to the next one - getting higher-fidelity feedback with each report. However, simply reading an energy simulation may NOT modify the direction of a project, if the reading occurs long after the crucial design decisions are fixed.* **Doing simple simulations** *helps analyze large buildings quickly. If the inputs are selected appropriately, and if the results are analyzed well, then an architect may avoid spending unproductive time on "non-starters" and, over time, may improve one's intuition. However, a "ghetto" of simulators may form within the team, and this could negate the benefits. Also, an architect may NOT be able to explore a full range of design options, without the help of a simulation specialist.* **Calculating heat loads by hand** *may help the designer, to understand the largest loads. Some argue the architect is equipped better than anyone else to do this, knowing the design options best (Gifford 2009).*
2 **GOALS**	**The Strategy Grid** *is a hierarchy of design approaches, that may help remind a designer what goal must be served - e.g. locating an appealing technology on the Grid will remind one of the approach it purports to serve, and of alternative technologies that may serve the same purpose.*

Figure 6.2.3
Interventions, in the role of facilitator or co-ordinator of the design team

INTERVENTION	SAW ITS EFFECT IN ...
8. Include energy specialist(s) and building science consultants on the design team.	**... ideas in Integrated Design Process (IDP) literature re roles -** *(Section 3.3)* **... 6 of 7 case studies -** *i.e. all except SAS (Chap. 4, App. 5)* **... researcher's need for help in setting up Study of Parameters -** *(Section 5.1)*
9. Check the engineers' work (drawings and outline specification) for specifics - *e.g. size of a/c (run time), lighting power density, inputs to simulations re space allocation and occupant density*	**... rarely noted in case study lit. -** *(Sect. 2.3)* **... cases where building operators do extensive monitoring -** *e.g. SAS, AJLC, Wind NRG, Gilman Ordway (Sect. 4.2 & 4.5)*
10. Think about the things the energy simulation programs don't show - *e.g. equipment and plug loads, exterior loads, standby losses, etc.*	**... gap between simulations and actual in new-normal cases -** *e.g. AJLC (Sect. 4.2)* **... items on the Strategy Grid that are not reported in eQuest -** *e.g. (Sect. 5.4)*
11. Involve intern architects in the process of making decisions about design strategies to lower energy use	**... articles in content review -** *(Section 3.2, App. 1)* **... occupants at AJLC Artists and GTA-SAC -** *(Section 4.2)* **... "shadow team" student helping to verify simulations -** *(Sect. 5.3 & App. 5)*

An architect, as co-ordinator of the design team, is responsible to make meetings more productive, not just more frequent. Integrating the design inputs of all members of the consulting team is a complex process, that requires advanced communication skills.

The four interventions suggested here aim mainly to help members of the architectural team ask effective questions of the members of the engineering team - so that the maximum potential of both the architecture and the engineering, working together, may be realized. Integrative thinking within the architect's imagination is also the aim.

These initiatives may be taken by the architectural project manager, as well as others on the architectural team who have contact with specialists in the team at large.

Coordinator

"PLACE"	**POTENTIAL LEVERAGE**
5 **INFO. FLOW**	**Specialists on the team** *form another "new loop". They may improve two-way communication between the architects and engineers, and they may help the architect & client articulate specific technical goals.* *However, decision-making may NOT be integrated, if the architect merely "off-loads" responsibility for particular components onto each specialist.*
3 **ORG'ZE SELF**	**Checking the engineers' work -** *or, better, being pro-active in asking particular questions is part of the co-ordination role. For instance, inquiring about the "run-time" of in-service equipment may influence the sizing of equipment in future designs. Right-sizing cooling equipment may increase comfort, and save costs on fuel bills. Insisting that the engineer design a smaller system may save capital cost, and save space. It requires that the architect adopt a confident* ***mindset*** *and that the engineer is prepared to* ***let go****. It may requires a fee agreement that is not tied to the size (and cost) of the mechanical equipment.*
3 **ORG'ZE SELF**	**Thinking about things the energy simulations don't show** *is a way of "self-organizing" which, Meadows says is "systems lingo" for evolution. The process involves raw material, a source of variety, and a means for selecting the products of creativity. Meadows acknowledges that this intervention point is obvious but unpopular, because encouraging diversity may mean losing control.*
3 **ORG'ZE SELF**	**Involving junior members in the decision-making process** *also may mean losing control, but Meadows observes that to scorn experimentation or to wipe out raw material of innovation is to be doomed. Interns are a potential source of variety; collaboration of this kind is intended to establish a culture in which new ideas are taken seriously by the older generation, while timeless principles are taken on board by the younger generation.*

Figure 6.2.4
Interventions, in the role of public Advocate for "sustainable design"

INTERVENTION	SAW ITS EFFECT IN ...
12. Participate in "green and gorgeous" design awards programs that celebrate both low-load and high design quality **-** *e.g. AIA TopTen, SABMag (Cda)*	**... internat'l programs. -** *e.g. Holcim, AIA COTE (Sect. 3.4)* **... local programs. -** *e.g. NESEA* **-** *(Ch 4)* ... **awards outside normal arch'l realm,** *e.g. APA award to Wind NRG (Sect. 4.2)*
13. Help develop appropriate legislation or other incentives to govern performance of future projects in the region where one's practice is located **-** *i.e. depending upon building function, size, and whether it is new construction or renovation, establish hard targets for energy-intensity*	**... the ten-year track record of the Canadian Commercial Building Incentive Program (CBIP)** *(Section 3.4)* **... the clarity of the targets expressed in the 2030 Challenge** *(3.4)*

An architect, who chooses to act in the role of a public advocate, ought to speak from relevant experience and real evidence.

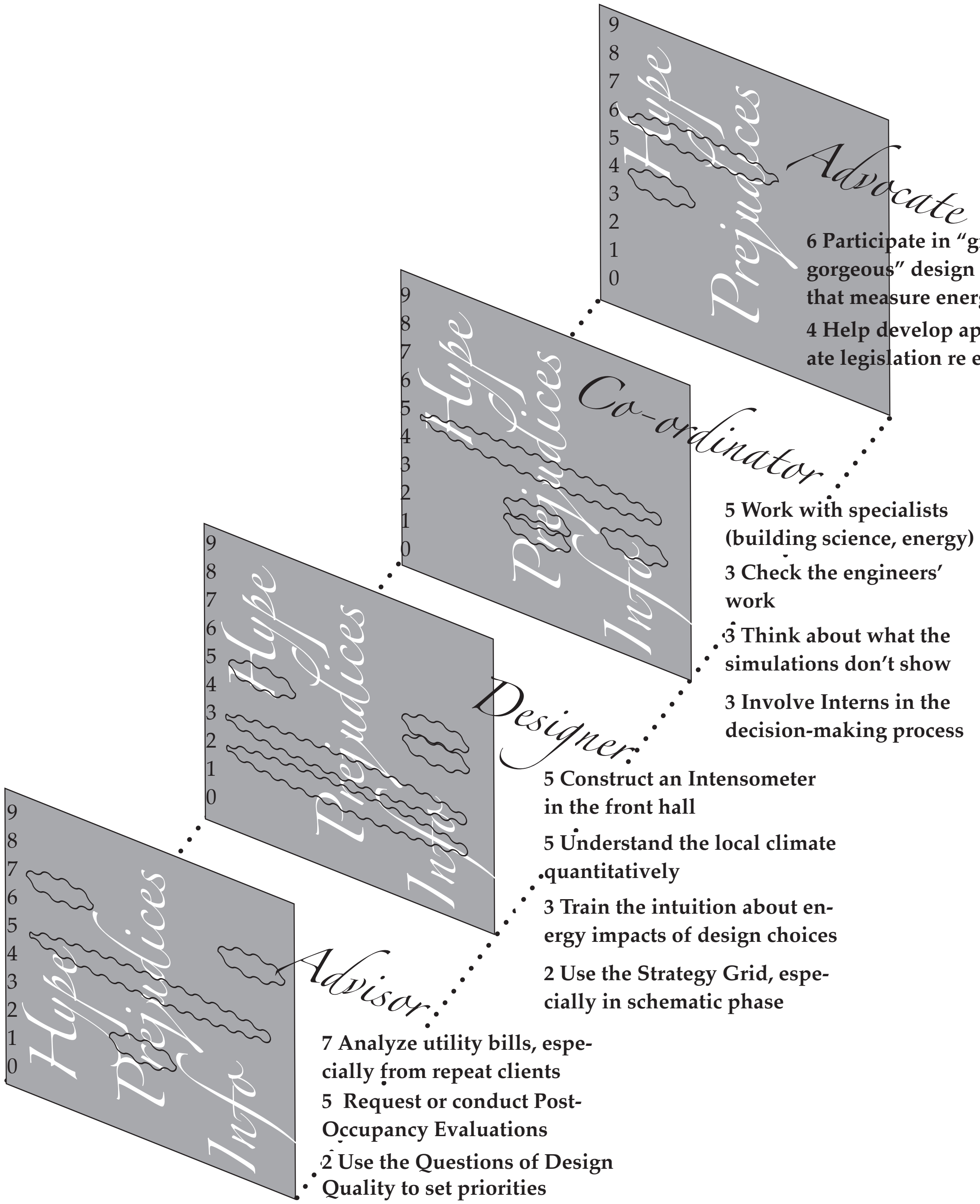
The two interventions suggested here aim to avoid celebrating "green" energy-guzzlers, and to ensure that public perceptions of what architects are doing, or can do, are accurate.

Number 13 is most likely to be taken by the more experienced members of the profession, while number 12 may involve members of any level of experience - as long as actual data is involved.

Advocate

"PLACE"	POTENTIAL LEVERAGE
6 **+ FEEDBACK**	**Design awards programs** *may show creative ways of "realizing green". This might be considered a positive feedback loop, or a new information loop. These programs must demand energy-use data (as the AIA Top Ten Green program does) - otherwise, it is difficult to argue that the so-called "green" projects are in fact "low-load".*
4 **RULES & INCENTV**	**Laws and monetary incentives** *are intended to change behaviour. They apply to all participants in a system, not only to a small group, and articulate constraints upon a design. Meadows suggests paying close attention to who has power over the rules. How this power is shared with respect to building projects - by architects, developers, legislators, and neighbours - is a key area for future study.* *Laws and incentives may NOT show an a/e team how to achieve the target, nor to combine it with other targets (such as comfort). To follow through, this system intervention* ***requires a "source of variety" (system place #3) -*** *that is, a designer's imagination.*

Figure 6.3.1
Summary of suggested places to intervene in consulting practice



6 Participate in "green + gorgeous" design awards that measure energy use

4 Help develop appropriate legislation re energy

5 Work with specialists (building science, energy)

3 Check the engineers' work

3 Think about what the simulations don't show

3 Involve Interns in the decision-making process

5 Construct an Intensometer in the front hall

5 Understand the local climate quantitatively

3 Train the intuition about energy impacts of design choices

2 Use the Strategy Grid, especially in schematic phase

7 Analyze utility bills, especially from repeat clients

5 Request or conduct Post-Occupancy Evaluations

2 Use the Questions of Design Quality to set priorities

6.3 ABOUT LEVERAGE POTENTIAL

This research was initiated in response to three challenges: hype about what a "green" building is and how to design one, prejudices about the relationship between green and high-quality design, and an abundance of poor-quality information. An architect in consulting practice plays at least three roles (or four, if he or she chooses to be an active advocate for the profession). It may be that some of the initiatives proposed here can address more than one of the challenges, and be exercised from within more than one role. Figure 6.3.1 illustrates the thirteen proposed interventions, in relation to the professional roles and the existing challenges.

Some initiatives that are touted, in the literature, as particularly valuable in moving to a "new normal" design approach were not adopted by the imaginary design team; and are intentionally omitted from this list. For instance, learning to estimate financial paybacks was considered, and it appears to fit well at leverage point number 9, "numbers". Such calculations seek to prove, to a building owner or developer, that paying a premium first cost for a green design will realize a financial return, over time. This type of argument often is presented to developers of commercial and multiple-residential buildings, and is seen to have merit in some circles.

However, Meadows argues that numbers rarely change behaviour in a complex system. That is, numbers don't re-balance a system that is stagnant, wildly variable, or growing out of control. Payback calculations may not, as Meadows says, "be worth the sweat put into them”. The built-in assumptions often are all too easy to discredit. With respect to “low-load” design, combining several uncertainties, such as inflation rates and fuel prices, may raise even more doubt. As Ellingham and Fawcett show, the numbers may not, in the end, appeal to the “gut feel” of experienced decision-makers in the development industry (2006).

The “green building” rating systems, such as LEED, seem to fit Meadows’ phrase: “the more you have of something, the more you have the possibility of having more” – leverage point number 6, positive feedback loops. Meadows says these “drive growth, and collapse in systems. ... Reducing the gain - slowing the growth - is usually more powerful ... than strengthening negative loops, and much preferable to letting the positive loop run.” Within a schematic design process, where the goal is to realize a “low-load + high-satisfaction” building, slowing the growth around “rating systems” – that is, just not participating - frees up the time & energy required to do more effective work on the initiatives proposed here. In the realm of advocacy, however, architects may be called upon to be part of one of the “negative feedback loops” that, as Meadows says, “usually kicks in sooner or later.”

The “Places to Intervene” model is not proven by scholarly research – rather it is the product of the imagination of one (albeit, highly experienced) systems analyst. Meadows says her model “is tentative and its order is slippery”. Nevertheless, it has proven to be an interesting way to organize an otherwise disparate list of strategies.

As “new normal” practice matures, no doubt more initiatives will surface. This list captures, for now, a number of tasks that were seen in the “new normal” cases (like conducting a Post-Occupancy Evaluation, working with building science specialists, and participating in green design awards programs) or tried in the course of the research (like the climate analysis, the QDQ, and thinking about things the energy simulations don't show).

The initiatives are simple and discrete enough that they could be undertaken singly – though, as Meadows says, in a messy real-life scenario, it is more likely that one would run up and down the list, trying out leverage points wherever they can be found. The likelihood of any of them being taken is high, only in an organization that espouses "great unstated assumptions" (i.e. paradigms) that permit innovation. Meadows argues:

> *"So how do you change paradigms? Thomas Kuhn, who wrote the seminal book about the great paradigm shifts of science, has a lot to say about that. In a nutshell, you keep pointing at the anomalies and failures in the old paradigm, you come yourself, loudly, with assurance, from the new one, you insert people with the new paradigm in places of public visibility and power. You don't waste time with reactionaries; rather you work with active change agents and with the vast middle ground of people who are open-minded." (2007)*

Power in an initiative may relate to the breadth of its coverage – that it addresses multiple challenges or can be exercised from within multiple roles - or to the depth of its leverage on the complex process of design synthesis. As to the likelihood of the effects being as predicted in Meadows' model predict, time – that is, active experimentation, and ongoing reflection – will tell.

7

CONCLUSIONS

This research has shown that a new normal in the design of civic buildings is necessary and achievable, and that an architect's "know-how" is critical to success. With the help of its consulting engineering team, an architect can compose a meaningful, enjoyable, and beautiful design that can run at as little as 20% of today's norm. The greenhouse gas emissions of the completed building will follow the rate of energy use closely.

The study has shown that some of the fundamental architectural decisions – particularly façade design and enclosure specification – may reduce energy use significantly, but that other initiatives are needed as well. The idea that there is a correct order of operations in the design of a low-load building has been shown to be valuable; particular architectural strategies must be in place, in order for equipment strategies to work well. The tools developed here - the

Intensometer, Strategy Grid, and Questions of Design Quality – now can be proposed for use in consulting practice, because they have proven useful, throughout this research.

In the hope of reaching a new normal expediently, many architects have taken up rather clumsy tools instead. Regrettably, some already are party to claims that their designs are "green", when in fact they are gas-guzzlers. Building operation, currently, is touted as the governing factor, but no building can perform better than it was designer has allowed. As shown in Section 3.3, the lack of "know-how" about low-load design, that pervades the architectural profession, has been noticed.

To begin to improve upon the present situation, this study has highlighted strategies used by design teams, working in the non-residential civic realm, who have made real, not theoretical progress towards an architecture that is both low-load and high-satisfaction. By understanding the local climate, choosing an appropriate overall design approach, and selecting the most powerful architectural strategies, some of the risks associated with heading into new territory may be averted.

In this closing chapter, all remarks address the researcher's own future design approach, and that of interested colleagues, interns and students. In Section 7.2, specific goals for the energy-intensity of civic administration buildings, public assembly buildings and schools are recommended. Thirteen places to intervene in consulting practice are proposed, in Section 7.3. A few caveats about the research as a whole are noted, and eight questions for future study are suggested, in Sections 7.4 and 7.5. But first, there is a brief outline of what the research has revealed, concerning the theory, practice and techniques underlying the move toward a low-load and high-satisfaction civic architecture in the Great Lakes Basin.

7.1 ABOUT SUSTAINABLE DESIGN (REPRISE)

Consulting architects continue – and will continue - to face the challenges that inspired this research. Marketing hype, prejudices within the design professions, and a risky convergence of "poor quality information and wanting to believe" are flourishing still. Moving from the symbolic to the substantial is not easy – but this research has described the major hurdles in such a way that they may be faced more easily.

Hype

As this text is being written, the hype around "green building" continues to escalate. In November 2009, more than 28,000 participants in the construction industry – many of them architects – gathered at the USGBC's annual conference, where 1,800 purveyors of "green products" congregated in the "world's largest expo hall". LEED plaques, in various shades, adorned 3,870 building projects in the United States and 187 projects in Canada. * A few voices, questioning whether "leadership in energy" design was actually happening, were audible – but they rarely were heeded, amid the clamour. † A profound lack of "know-how" among industry professionals had been noted, and the Fourth Report of the Intergovernmental Panel on Climate Change concluded that it was "very hard to find a team competent enough to achieve …" a 50% reduction in energy use (WBCSD 2007, IPCC WG3, Levine 2007). Real progress was being made, towards a "ow-load and high-satisfaction architecture - but in only a handful of projects, and relatively quietly.

The idea that a "new normal" is required should be distinguished from the hype about how to achieve it. The inquiry in Chapter 3 showed that climate change and the global fuel supply were, by 2006, seen as severe challenges - by entities as diverse as the American Association for the Advancement of Science, the International Energy Agency (a body with 28 member countries, within the framework of the Organization for Economic Co-operation and Development), the UN Congress on Sustainable Development, and the petrochemical giant Royal Dutch Shell. In late 2009, public support for urgent action with respect to the environment generally, and climate change in particular, showed no signs of abating, and "greening the economy" was seen as a potential way out of a deep recession. ‡ Architects were being called upon to "go green" and, although the construction industry was never called upon to act alone, all credible models of the needed global reduction of GHG emissions relied on the building sector for a significant contribution.

In practice, the idea that "it's the architects who hold the key to turning down the global thermostat" is as problematic as the notion that they don't know where to find it (Mazria 2003). In Canada, nearly half of today's total GHG emissions emanate from buildings. Yet, the architects who design non-residential civic buildings in Ontario have influence upon only ten percent of new-construction starts annually. It is important for civic buildings to show progress, because

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* http://www.usgbc.org and http://www.cagbc.org, both accessed 17 November, 2009

† See for example, Mireya Navarro, "Some buildings not living up to green label", in the New York Times, 31 August 2009, Jacob Gershman, "Fake Green Labels" in the New York Post, 21 September 2009, and Scofield 2009.

‡ See, for example: Gordon Brown, "Britain's green revolution will power economic recovery" in The Guardian, 12 July 2009, and Liz Galst "Do Green jobs create greener Americans at Greeninc.blogs.nytimes.com, a blog for discussion of "Energy the environment and the bottom line", both accessed 19 November, 2009.

they are conspicuous; yet it is equally important that their potential contribution be understood accurately. If the architectural profession is to continue to be trusted, then "going green" ought to entail achieving a measurable lightening of the burden placed by buildings upon the natural environment. No matter what else the word "sustainable" may be taken to imply, this must mean reducing the actual energy-intensity of a completed building. If performance targets for a project are clear, and if compliance is substantiated, then the architects of civic buildings will have played the role that they are truly able to play – no more, and no less. Practicing architects, who value environmental stewardship, need to engage in less hype and transmit more reliable information, in order to remain credible. Specific, realizable targets are proposed later in this chapter.

The techniques that are available to architects - to get on with the complex job of realizing truly low-load buildings - were illustrated amply in Chapter 4. The search for best practices in exemplary designs proved that an architect must begin by understanding the demands of the climate in which he or she is working. Many design strategies are effective in a cool-humid climate, but there are limitations. In Chapter 5, the thermal resistance of the enclosure design was shown to be the single most powerful design parameter, when it comes to lowering the energy use of a building in the Great Lakes Basin. By continuing to study buildings that truly are low-load, and looking at new design opportunities through the lenses constructed in Chapters 4 and 5, the "know-how" of the architect of average competence can be improved, towards the goal of meeting quite aggressive targets for energy-intensity reduction.

Prejudices about what "green" is

As the hype about how to "go green" escalated, another ongoing challenge began to abate – although, some would argue, not quickly enough. Prejudices about what "green" or "low load" buildings look like, or are like to inhabit, still lingered – perhaps with less force in the public eye than in more expert circles. Environmental design had been seen as a specialty within architecture, for some time, not an issue to take centre stage in every design opportunity, and that traditional view was difficult to dislodge. During the study period, it continued to be the subject of dedicated courses in many architectural curricula, where integrating technical concerns into the design studios is a perennial challenge, and it was relegated to a once-a-year feature issue in most architectural journals.

Beyond the narrow confines of the architectural discourse, interest in the environment was converging with a host of other concerns. In Chapter 3, headlines in the popular press showed a clear public perception - that various crises facing society interlock. From carcinogens in the water supply to plastic bags in trees, the effects of human activity were rebounding towards the front lawns of North America – with increasing frequency and increasingly severe implications for human health. "Triple-Bottom-Line" thinking had appealed to the enlightened self-interest of business-owners, politicians, defense analysts, and others. Business and ecology had found plenty of common ground.

The possible convergence of environmental concerns and design excellence was slowly being accepted in architectural practice, but the view that "compartments were beginning to dissolve", so often expressed in the general public discourse, appeared rarely in the recorded architectural discourse. A few critics were trying to break down the stereotypes when they poked fun at the perception of "green" buildings as crude and ugly and "green" designers as the "self-righteous and the badly dressed", but there was not a strong focus on the energy issue (Guy and Farmer 2001, Hagan 2003, Buchanan 2005). Nevertheless, the magnitude of the reductions in GHG emissions needed in North America meant that tasks formerly relegated to the engineering sub-consultants soon would have to be faced on the architects' desk as well.

There also were plenty of mixed messages in the literature about what "green" would look like, or whether it could be defined by look and feel at all. As shown in Chapter 2, some suggested that a "green" building could be just like a typical office building of the late 20th century, with some "eco-friendly" components added on. Others argued that an "environmental" design must be imbued with a particular sensitivity to place, and that such a design would be recognizable mainly by its relation to the landscape and its use of daylight. The impact of particular climates on the designer's list of priorities was far from a universal concern, in the architectural discourse at this time.

Where prejudices dividing "green design" from "design in general" linger in a consulting practice, qualitative design goals will be perceived as competing with energy-efficiency goals. Elsewhere, many architects take a serious interest in the creative challenges inherent in lowering fuel use while realizing a "locally relevant, culturally rich" design (e.g. Croxton 1997, McDonough 2002, Davey 2003, Buchanan 2005, Beaven 2008). Those who are fully engaged in the effort are drawn by the demands of "technical mastery combined with ... design imagination" (Simon 2000).

The techniques for overcoming prejudices about what "green" buildings are like depend upon the commitment of a future building owner to the dual goal of low-load and high-satisfaction design; they also flow from a mindset, in the architect, that this commitment presents a welcome opportunity. Among the cases studied in Chapter 4, the least energy-intense designs involved a "deep green" client. Social-assistance agencies and clients wanting iconic architecture achieved moderate reductions in energy use, while public service clients seem to be the type that is least-often associated with exemplary performance. Neither a pure "idea" nor a pure "service" architectural consulting firm was a designer of any of the "new normal" cases. Architects whose practices lean toward an "idea-service" emphasis made the most frequent appearances in the "new normal" cases.

Another technique for overcoming prejudices is the Integrated Design Process. In IDP, during the pre-design and project definition phase, an architect has a key role to play, with the help of the whole consulting team, to help the owner to establish appropriate goals. As the design develops, the architect leads by framing and testing hypotheses about how to meet the goals, draws on the advice of the engineering specialists, and reminds the owner as to its role in the operation of the building. Perhaps the most significant aspect of IDP is that the lead architect, as co-ordinator of the overall team, has a chance to establish a tone that invites the other members of the architectural team to get interested in the engineering decisions, and gives the engineers opportunities to get interested in the architectural decisions.

Given the testimonials about IDP, it is easy to imagine that an architect's primary role in "green" design is to organize more IDP processes. However, the simple exhortation that architects ought to adopt a more "holistic approach" is insufficient. During the field visits to the "new-normal" cases, owners, engineers and building occupants attested to the skills of the architect in listening well and integrating human and technical concerns. Also, the results in Chapter 5 show that the architect truly does "deal the cards" to the rest of the team, during schematic design stage, and that greater integration of concerns - within the architect's own head - is sorely needed.

Risks arising from "wanting to believe"

Amid the hype and lingering prejudices, a third factor was challenging to architects, including the researcher. The convergence of poor quality information and "wanting to believe" tempts many into taking unnecessary risks, in the name of a good cause (Hackett 2006, McGarva 2007, Vyas 2007). Poor quality information is rampant, with respect to the real performance of "green" buildings, as well as the quality and cost of “green” design. “Wanting to believe” manifests in architects as a sense of “duty to market green solutions” (Brophy 2003), and an unquestioning support of the claims of third parties, many of whom stand to benefit from a “go-green” initiative.

The real behaviour of buildings should be distinguished from off-hand statements about the “critical importance” of particular design parameters, construction products, or rating systems. Although big buildings behave differently than single-family houses, and energy is used in buildings in Toronto for different purposes than in Miami, statements are made routinely as if all buildings in all climates behave similarly. Much of what was presented to practitioners, at conferences and seminars during the study period, turned out to be too vague to be relied upon; some of the messages from the rating systems were actually misleading. With respect to actual building performance, actual satisfactoriness, the cost of constructing a “green” building in a given marketplace, and the power of early design decisions, practitioners need to draw less on blind faith and more on high-quality data.

Ostensibly, the actual, in-service energy-performance and satisfactoriness of a “green” building is better than in its non-labeled counterpart. Today’s “green-labeled” building, it is claimed, saves energy, and supports all manner of improved conditions – including increased worker productivity, higher retail sales revenues, and better learning than a non-labeled building. However, in Chapter 3, it was discovered that the most popular “green building” rating system in North America is a very poor indicator of real reduction in energy-intensity. The LEED system often celebrates buildings that are not energy-efficient, conceals information about the absolute energy-performance and GHG emissions of the buildings it rates, is a poor indicator of design quality, does not acknowledge climate-specific design challenges, and gives readings that contradict the readings of other yardsticks. In Chapter 4, the range of performance, among LEED-labeled buildings, was shown to be as much as 300%. Also, it was a surprise that many existing collections of “green” building case studies turned up wanting in verifiable data with regard to user satisfaction (see Chapter 2). When applying a checklist from a rating system, an architect may “want to believe” that he or she is lowering environmental loads – but the pursuit of a label, on its own, alone has proven neither a sufficient nor a necessary action toward the goal.

With regard to the cost of a “green” building, many in the industry would like to believe that a simple rule can be framed that would apply no matter when or where a project is to be constructed. Six major cost studies, conducted by different groups between 2002 and 2007, and reviewed in Chapter 3, are testaments to the effort being invested in establishing such a theory. Some expect that the capital cost of a "green" design would be higher than that of a default design, due to the application of unusual construction technologies or processes. Others argue that the cost can be lower, as climate-control equipment is reduced in size and inter-disciplinary co-ordination of the whole design is improved. However, in Chapter 4, among the projects examined in this study, no correlation could be observed between energy-efficiency and capital cost, or between "green" rating and capital cost. It seems that market forces drive the capital cost of construction to a greater degree than any "green" concern.

Often touted as something formidable and mysterious is the power of an architect's initial design decisions. Architects may want to believe that building form is all-powerful, but the evidence suggests otherwise. In Chapter 4, when 19 cases were compared, there was not a strong correlation between overall massing, building orientation or plan aspect ratios and energy-intensity. In Chapter 5, a series of simulations showed that these parameters exert virtually no impact on the energy use of an office building in the Great Lakes Basin.

In consulting design practice, it is still rare for an architect to be aware of how much energy is consumed by any of his or her designs. Actual energy use is sometimes noted by a building operator, rarely fed back to a mechanical engineer, and almost never reaches the ears of an architect. * Also, some misunderstanding seems to have developed, among architects, about the relative magnitude of "embodied" and operating energy. Embodied energy may be associated easily with the marketing claims about a "green" product, but it is very difficult to measure reliably. In one study of a typical North American office building, embodied energy is estimated at a tiny fraction of the rate at which operating energy is expended (see Section 3.2) – however the models that estimate embodied energy are very much works in progress, and further study is warranted to verify their accuracy.

The visits to the very low-load buildings, and their designers clarified many of the dilemmas in the literature, particularly with regard to design quality. In Chapter 4, seven occupied buildings were appraised as more meaningful, beautiful, clever and natural than their GTA default counterparts. Unfortunately, because data is scant for both groups, it is not known for certain whether these buildings are consistently more or less comfortable – thermally, visually, and

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* The evidence of this, presented in Section 3.4, has been supported anecdotally through frequent query of colleagues in consulting practice.

acoustically – than “non-green” buildings. However, evidence presented in Chapter 4 has shown that low load and high satisfaction can be achieved in a single design, and that there are powerful synergies when the two goals meet.

A practitioner might also look at the payback arguments in the existing studies of the cost of “green”, and want to put such an argument forward to a client on an upcoming project. However, the discussion in Chapter 3 showed at least three serious problems with these arguments. First, the valuation of externalities – an effort with noble intentions - is, in the detail, subject to compounding layers of assumptions, each of which would require extensive study to verify. Second, the studies are focused on LEED cases; and, like the LEED energy studies, the data is dominated by predicted, rather than actual figures. Third, the studies tend to treat dissimilar bidding and construction environments (different places and times) as if they were similar – rendering the conclusions highly suspect. Practitioners need to talk about the cost implications of the designs they propose, but “wanting to believe” that the valuation argument in one set of circumstances is transferable to another is not helpful. More study of the actual costs of locally-relevant comparators, conducted with an objective stance, is sorely needed.

Practitioners also have reported discussions about re-orienting their designs, in accord with the urgings in the literature although, so far, no report of such action happening has been collected. At the very least, such a change may negate good urban planning practices. At worst, it could incur added costs with no attendant benefit.

Techniques for obtaining better quality information are proposed throughout this study. First, with respect to the technical performance of “green” – or any – buildings, one ought to insist upon a measure of actual energy use intensity, rather than a prediction of a “percent better than” variety, using the Intensometer as a frame of reference.

Second, with respect to satisfactoriness, one can use the Questions of Design Quality (QDQ) to articulate the myriad ways in which buildings satisfy their occupants and neighbours. Actual first-hand experience of the “green” cases proved invaluable to the research. A structured Post-Occupancy Evaluation (POE) might involve a user survey, built upon the QDQs.

Third, with respect to the cost implications, one ought to stop looking for a one-size-fits-all rule about capital costs, and accept that life-cycle arguments often fail to appeal to the “gut feel” of experienced

Figure 7.2.1
Energy-intensity targets for non-residential civic buildings in the lower Great Lakes Basin

(current averages for Canada from NRCan OEE 2002, for the U.S. from US DOE EIA 2003; goals in the 2030 Challenge from Mazria 2007)

	Canada/U.S. average CEBCS/CIBEUS **kWhr/m2/yr**	**RECOMMENDED TARGETS**		Goals in the 2030 Challenge			
		35%	**25%**	2010	2015	2021	2030
		(to nearest 10 kWhr/m2/yr)		-30%	-50%	-40%	-25%
						-5% every 3 years	
Administrative Office							
ONTARIO	464	**160**	**120**	320	230	190	120
ATLANTIC	322	110	80	230	160	130	80
U.S.A.	302	110	80	210	150	120	80
Public Assembly							
ONTARIO	356	**120**	**90**	250	180	140	90
ATLANTIC	258	90	60	180	130	100	60
U.S.A.	251	90	60	180	130	100	60
Education							
ONTARIO	258	**90**	**60**	180	130	100	60
ATLANTIC	258	90	60	180	130	100	60
U.S.A.	249	90	60	170	120	100	60

developers (Ellingham and Fawcett 2006). An architect can, however, analyze the potential impacts of a "green" design, using traditional market factors in combination with the "Busby factors", as outlined in Chapter 3.

Finally, with regard to the power of form, building orientation, and skin design, Chapter 5 gives general guidance about the degree to which each of these parameters influences energy-intensity in an office building in the Great Lakes Basin. Using the principles highlighted there, an architect can continue to hone the craft of design for "low-load and high-satisfaction".

The hype, prejudices, and poor-quality information surrounding environmental design may continue to proliferate. The underlying theory and the issues in practice have been described, and techniques have been listed to help architects face the challenges. The recommendations that follow should help architects to practice more effectively, amid these ongoing challenges.

7.2 RECOMMENDATIONS

The research supports five key recommendations, with respect to: targets for the energy-intensity of future designs, the share of the responsibility for energy-use reduction that may fall to architects, the level of design quality that may be expected, and the tools to use when taking a "new normal" approach.

Recommendation #1:
Establish a target for the overall annual energy-intensity of a new building, in the range of 25% to 35% of the current average, depending upon occupancy type and location. Targets for administrative offices, public assembly buildings and schools - in Ontario, the Atlantic Provinces, and the U.S. - are proposed in Figure 7.2.1.

Recent scientific and economic studies suggests that the total North American greenhouse gas emissions, from all sectors, ought to be reduced to 40% of 2006 levels by 2050 (Socolow 2007). An equivalent reduction in energy-intensity of new buildings might be appropriate but, if the overall average is to shift, new buildings should be required to meet more stringent targets than renovations. (Also, more efficient technologies can be incorporated into new buildings more easily than into older buildings.) Since emissions depend upon the source of energy in a particular region, and upon the fuel mix in a particular design, aiming a little low with respect to site energy use will allow some wiggle room in reaching the 40% target for GHG emissions. Thus, energy-intensity targets of 25-35% (i.e. a 65-75% reduction) are in an appropriate range, if new building stock is to make a reasonable contribution to climate change mitigation.

This level of reduction in energy-use has been seen only in cases where the building owner is deeply committed to such a result. There is little evidence that attaining a "green building rating" increases the likelihood of reaching such an exemplary level of performance. There is much evidence to suggest that the architect's ingenuity and the design team's coherence – rather than a checklist – is the key.

Also, as the "new normal" cases show, worthwhile achievements are made all along the energy-intensity spectrum, and some circumstances are more conducive to profound energy-reduction than others. The simulations in Chapter 5 show how much impact can be attained, in incremental steps. Most circumstances present opportunities to realize some degree of improvement as compared to the "default" approach. Keeping the heat in and making appropriate use of natural daylight are the approaches with the most leverage, in the Great Lakes Basin.

Recommendation #2:
Make architectural decisions, at the schematic design stage, that lower the energy-intensity of a new building to around 60% - 70% of that of a design using the "GTA default" approach. This is the full extent of the contribution that the architecture alone can make, using today's technologies.

It is difficult to establish this target precisely - because circumstances differ in every case, and one team may draw the line between "architectural" and "engineering" decisions slightly differently than the next (particularly with respect to lighting design). Also, there are myriad combinations of design strategies that may together reach the overall 25-35% target that is recommended above. In the Analysis of Case Studies, the moderately energy-efficient designs leaned heavily on "reduce load" strategies and down-played "free energy" and "efficient equipment" strategies, while the least energy-intense designs employed tactics from all five steps in the "Order of Operations".

The simulations in Chapter 5 showed that, in the Great Lakes Basin, the design of the building enclosure has far more influence over energy use than building form, orientation, or even window orientation. The overall window-to-wall ratio (WWR), the window specification, and the material assemblies in the walls and roof can, all together, achieve the level of reduction in Recommendation #2.

Architectural measures that are not-so-effective include: changing the building form, and re-orienting the building in relation to the sun. In the Great Lakes Basin, these parameters matter very little to non-residential buildings larger that 10,000 sf. Orienting windows toward the south can contribute some energy-savings, although this effect is much less significant in non-residential buildings at this latitude than it is in more southerly zones. Victor Olgyay's observation - that thermal considerations dominate over solar radiation effects, the further one moves away from the equator – can, once again, be made when looking at the results in this research.

Recommendation #3:
Assuming the architectural targets in Recommendations #1 and #2 are adopted, design the mechanical and electrical systems to realize a further 40% - 50% reduction.

As shown in Chapter 4, measures to reach this target may include: heat-recovery ventilation (HRV), actively-managed natural ventilation, efficient components and heat distribution, simple effective controls, efficient lamps and fixtures, occupancy and daylight sensors, and energy-efficient appliances and desktop equipment. Mechanical measures that are not so likely to reduce overall energy-use, in a cool-humid climate, include night pre-cooling and eliminating refrigerant-based cooling.

It may appear as though mechanical and electrical engineers have greater room for improvement than architects. However, the "new normal" cases also show that the engineering works well only when the architecture allows. For instance, down-sizing of mechanical plant can only happen if the thermal resistance of the enclosure is designed at a high-performance or exemplary level, such as St. Gabriel's Church. An HRV may be of unruly size in a GTA default building – but it is compact in a well-insulated, tightly sealed building, such as Artists for Humanity.

The likelihood of such reductions seems to increase when building science and energy-specialists join the design team (in seven out of seven "new normal" cases with very low energy-intensity this was the case). Using equipment to best effect is perhaps the most powerful mark of an effective mechanical-electrical design.

Recommendation #4:
Continue to establish high expectations of quality in new projects, while adopting the energy-use targets recommended above. Conduct thorough post-occupancy evaluation of buildings designed in the of-

fice, and make comparisons to other buildings that are relevant – in order to effect continuous improvement, while making the transition toward a "new normal" design approach.

The new-normal cases in Chapter 4 are architecturally expressive, meaningful to their local communities, and delightful to inhabit – and some operate on as little as 70 kWhr/m^2/yr, which is 15% of comparable, recently constructed buildings. A wide palette of materials and styles may be employed to achieve these results. Incorporating locally relevant façade treatments, atria and functional landscapes increases the potential to achieve both low energy use and high satisfaction. The imaginative introduction of daylight into a building is a device that can be crucial to the satisfaction of users' needs for comfort and beauty and, when combined with lighting controls, as shown in Chapter 5, can help lower energy use considerably.

Recommendation #5:
To select key strategies, and suggest questions that can be put to the engineers, use the tools developed to conduct the analysis – including the Intensometer, the Questions of Design Quality (QDQ), and the Strategy Grid. Be wary of all claims related to today's green building rating systems.

Practicing architects need to hear less hype and acquire more "know-how", to engage in less prejudice and more effective collaboration, to exercise less blind faith and demand higher quality data. The tools that were developed to meet these needs, as the research unfolded, can continue to help in consulting practice.

The Intensometer provides a frame of reference about energy use in buildings, expressed as "absolute energy intensity". It can be tailored to compare buildings of similar use and climate zone to one another, and to statistical averages, and it can compare a "rated" building to a non-rated building, provided energy-use data is available. The Strategy Grid helps to keep track of design tactics that lower energy use. It is a reminder to distinguish a strategic design goal from the myriad ways that exist to approach a goal. In the twenty-one Questions of Design Quality, conditions of "sustainability" mingle with traditionally recognized conditions of design excellence. A "new-normal" design practice should have an Intensometer in the front hall and the QDQs and a Strategy Grid on every desktop. These tools organize core knowledge to which every architect should refer often.

In contrast, none of the rating systems, as currently constituted, consistently represents "low load" designs, and no rating system that uses a purely numeric score can describe the qualities that a "high satisfaction" design provides.

In any event, a consulting architect, who associates his or her name with any claim that a particular project is "green", must aim to realize verifiable reductions in energy-use and GHG emission, and must monitor the real performance of the occupied building. If one is induced to use a rating system on a particular project, then the same policy should be followed. Architects should resist recruitment for the purposes of promoting any system with the flaws described in Chapter 3. To do otherwise is to risk committing a fraud against an unsuspecting public.

7.3 "PLACES TO INTERVENE" IN CONSULTING PRACTICE

In Chapter 6, thirteen specific interventions were proposed, with the intent that they be tested in future real-life projects, where the client is willing. The initiatives on this list were chosen with the help of Meadows' "Places to Intervene in the System" (2007). An open mindset in the architectural team was assumed.

In the role of **"strategic advisor to the client",** an architect must be impeccable with one's words, and demand good-quality information. He or she ought to:

1. **Analyze utility bills from clients, especially repeat clients.** This initiative communicates the architect's pro-active stance about the issue to the owner. It provides an opportunity to ask about any gap between the predicted level of energy use and the actual level. The information gleaned is needed to compile the Intensometer in the front hall, recommended as intervention #5.

2. **Request that a structured Post Occupancy Evaluation (POE) be done** on buildings designed in the office, after 2-3 years of occupancy. (Such a review was initiated, in one case study, by the building science consultant.) The information would help back up claims, or avoid making wrong ones, and lead to fixing problems before they fester. Given a healthy level of humility, an architect could conduct this analysis on his or her own. No matter who asks the questions, the feedback could help design better the next time.

3. **Use the Questions of Design Quality (QDQ) to involve the client, and stakeholder groups, in a productive discussion about what constitutes "satisfactoriness"** in a particular place and time, and how that might relate to a "low-load" objective.

In the role of **"imaginative designer",** an architect ought to acquire technical know-how, and a keen interest in using it. This means to:

4. **Understand the climate quantitatively.** The project brief should show climate data - including heating- and cooling-degree days (HDD, CDD) precipitation and insolation - noted alongside topographic and soils information. The same information should accompany any design precedents that are used for inspiration.

5. **Construct a large Intensometer in the front hall of the office,** that reports the actual energy-use of projects designed in the office, and others. Include periodic updates as the buildings age.

6. **Train the intuition about the energy-effects of early design decisions.** Learn to use simple software to simulate energy-use patterns, and to make heat-loss calculations by hand, during the schematic design phase. Document and seek peer review of all inputs to any simulation.

7. **Refer frequently to the Strategy Grid, to obtain ideas of alternate ways to reach an energy target.**

In the role of **"co-ordinator of the design team",** an architect must integrate concerns within her (or his) own head. This may mean to:

8. **Include energy specialists and building science consultants on the team.** Some clients currently are trying to frame incentives to link fees to building performance, to supplant the disincentive to innovate that exists when consulting fees are tied to construction cost (and hence, to size of equipment). However, this is neither fair to the consultants, nor perhaps the wisest course, because an owner's behaviour during occupancy can overwhelm even the best consultants' design decisions. More pro-active help is available from added expertise, although this ought to augment - not take the place of - an architect's understanding of the issues.

9. **Check the engineer's work.** Check the drawings and the engineers' estimate of lighting power density. Question the size of the cooling equipment, in relation to the benchmarks in Section 4.5. Verify all architectural inputs to simulations, paying particular attention to proportion of space allocation and occupant density.

10. **Think about the things the simulations don't show,** trying not make them use excessive energy, by design. Remind the engineers and client that these are not accounted-for, in any prediction.

11. **Involve intern architects in the process of decision-making** about design strategies that may lower energy use. These people need to be supervised, but they do provide a source of variety of ideas. The purpose is to establish a culture of integration in which new ideas are taken seriously by the older generation, while proven principles are taken on board, by the younger generation.

As **"public advocate",** an architect must speak from real evidence rather than a position based only on hope. She or he might choose to:

12. **Compete for a design award that celebrates "green + gorgeous" projects.** The adjudication criteria should require objective evidence of the energy use of each contender, to support any associated "green" claims.

13. **Help develop appropriate legislation** to govern the performance of future projects in the region where one's practice is located.

Viewed through the structure of Meadows' "Places to Intervene" model, this list consists mainly of ways that an architect might self-organize, and new information loops that would support the shift to a "new normal" design approach. * The model would place financial payback arguments and material specifications, in the categories of "numbers" and "stocks and flows". As such, they may be used to some effect, but they probably have less leverage potential than the strategies recommended here. All of these initiatives will take time, but so would the process of making mistakes and going down dead-end roads. These interventions in practice are intended to help avoid such perils.

7.4 CAVEATS

The recommendations and interventions proposed in Sections 7.2 and 7.3 should be tempered by a realistic appreciation of the role of clients, the fact that every building is part of a larger neighbourhood, and the limitations of the existing energy simulation software.

First, successful reduction in energy-intensity is proportional to the responsibility assumed by a building owner. As shown in the Analysis of Case Studies, the most energy-efficient buildings are occupied by agencies that monitor, analyze, and correct the performance of their

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* Of the initiatives proposed here, #1 and #12 have to do with feedback (some leverage), while #2, 4, 5 and 8 constitute new information loops (more leverage), #13 has to do with rules and incentives (even more leverage), #6, 7, 9, 10 and 11 are ways of self-organizing (very strong leverage), and #3 has to do with goal-setting (the strongest).

buildings. Some of these agencies may be characterized as "deep-greens" - such as the Woods Hole Research Center, and Wind NRG, and the faculty within the Environmental Studies Program at Oberlin College. Others have a more human-centred mission, but nonetheless keep their operations accountable to their employees and directors - such as Artists for Humanity, SAS, and PAAM. While well-informed architects, building scientists and energy specialists can play a role during the early years of occupancy, no amount of attention from consultants can take the place of a committed owner-occupant, to ensure the building realizes the fullest potential of its design.

Second, the focus on the challenges in designing a single building, in this study, should not imply that neighbourhood connections are unimportant. No project truly is "free-standing", and the design of a neighbourhood or region with energy in mind offers opportunities that are not available when one must stop at the property line. It may not be necessary or possible to reach "carbon neutrality" at the level of an individual building. In the course of this research into non-residential civic cases no fully "carbon-neutral" building was discovered.

Third, all energy simulations ought to be viewed as suspect. They are useful in some respects, but give results that differ greatly from actual energy use. They depend on appropriate inputs, but cannot accept all of the inputs needed to describe the real life of a building.

The eQuest software was helpful in the research in Chapter 5, because it presented a full menu of construction components that are commonly used in North American non-residential buildings. Its format was easily accessible to the researcher, with limited coaching. It demanded more inputs than some of the other tools, such as the NRCan Screening Tool or MIT Design Advisor - and thereby instilled confidence in its outputs. The Study of Design Parameters was an experiment in expanding the skill-set (and patience) of an experienced practitioner, and in beginning to re-train the intuition. Engineering assistance was required to establish correct inputs to describe the mechanical and electrical systems, and to verify and analyze trends in the overall results. All things considered, the tool seemed as though it would be an appropriate one, to help an architect see preliminary results of his or her decisions, during the schematic design stage.

However, in many of the cases studied in Chapter 4, actual performance was seen to deviate from the prediction of a computer simulation, by as much as 30%. Real performance varies from year to year, as weather and the patterns of occupancy of a building ebb and flow - even in the most energy-efficient buildings, with the most attentive operators. An engineer with extensive experience in energy simulation recently advised that the following elements are "normally" at issue, in the gap between simulated and actual energy use: exterior lighting, kitchen equipment, servers, elevators, humidification, standards for plug loads, weather, and occupancy schedule (Carpenter 2009). Real-life parameters that could not be reflected in the simulations done in this research included: elevator power, part of a building dug into a hill, occupancy sensors, heat loss up an exhaust stack (standby losses), thermal mass, and shading from nearby trees and buildings.

The greatest use of an energy-simulation lies in the comparison of multiple iterations that show the effects of small variations in a design. If the results are used to tell a client what to expect, they should be multiplied by a large factor of safety, and expressed as a range.

7.5 QUESTIONS FOR FUTURE STUDY

How much satisfaction is there, in real "green" buildings?

A series of structured post-occupancy evaluations of "new normal" buildings, and relevant "default" designs, would build a database to help compare one group to the other. More "green" buildings should be analyzed, using the QDQ as a checklist, with particular focus on thermal, acoustic and visual comfort. A corporate-level commitment would be required, from the building owners, to allow interviews of occupants and the collection of field measurements.

How can we estimate the power of "free energy" strategies?

Advanced simulation tools are required to study the effects of strategies such as: displacement ventilation, passive ventilation, passive solar effects, natural ventilation, night pre-cooling, and thermal storage in massive construction. Ongoing research in the Faculty of Engineering at the University of Waterloo incorporates observations in the field, about some of these issues (Hanam 2010).

Do various building types behave similarly?

The process used in the Study of Design Parameters should be replicated, using typical schools, recreation centres, libraries, courthouses, and other building types as test subjects – to see whether the design strategies associated with the reduction of energy use in office buildings are consistently powerful.

What is the leverage potential of GTA civic buildings?

Assuming the level of energy-use reduction recommended here were to be enforced broadly, the impact on neighbourhood infrastructure should be tallied and the cost savings to the Regions and the Province should be estimated. One such study has been done, for City of Toronto (Kesick 2008). Additional work is needed to corroborate the results, and help sub-regions understand the issues.

What is the likelihood that economic incentives, or legislation, will create real change in the energy-use of civic buildings?

Legislation respecting energy-intensity exists in the European Union, and is pending at the Federal level in the U.S. Meanwhile the LEED system is being enacted into law in many cities in the U.S., regardless of its poor track record with respect to energy-efficiency. The success of various legislative approaches should be compared, with a view to enacting appropriate incentives or legislation in Ontario. This study may best be conducted in association with a Faculty of Law or Public Policy, in collaboration with a School of Architecture.

What is the cost/value balance in the present market?

As more "green" buildings – labeled or not – are constructed in the GTA, more data will be available, about their cost, in relation to fluctuating market conditions, both locally and globally. Also, the cost of the long-term maintenance of these buildings should be tracked.

What is the "full cost accounting" for these buildings?

Interested citizens, including architects, may continue to want to put a dollar value on the health effects of air pollution. Translating the work of Levy and O'Neill (2003) to the Canadian context would be a substantial project, and a valuable one. Perhaps this also could be a collaborative effort, involving public health researchers, as well as architects in the Toronto area.

How can architectural student be trained to think critically about "sustainable design"?

"Sustainability" is a "hot" topic and, as such, is ripe for the classroom. Because it is prone to being presented in a doctrinaire fashion, it is very much in need of a carefully considered pedagogical approach that encourages productive reflection and helps students develop transferable, higher-order thinking skills. A preliminary study has been conducted, based on the discourse beginning in other disciplines (Ross 2009). This should be developed further, within the Schools of Architecture.

7.6 FINAL THOUGHTS

This research began with a desire to practice in accord with a deeply-held personal belief that human activity can and ought to fit into natural systems harmoniously. Despite the challenges that were identified at the outset, the study has shown that architectural design can contribute, by helping to lower the primary loads that a civic building imposes on the natural environment. However, architects cannot effect all of the required changes in practice entirely alone; significant contributions are needed from clients, engineers, and others in the construction industry.

Many perspectives are needed to address climate change and to use the future fuel supply wisely, but it can be challenging to discuss emerging knowledge, when commercial interests are in play. All parties cannot be expected to align in perfect accord, and yet certain principles must be respected. There is a dire need to avoid the hyperbole that tends to polarize the environmental design discourse. Design professionals have a duty to be factual and accurate and to remain within the bounds of good manners, when commenting on emerging ideas about how to reach an agreed-upon goal. The leadership that we take might lie in resisting the hype and being seen to let go of prejudices, while insisting on better-quality information. The resolve to do this has become firmer through this research.

It can be tough to speak out when poor quality information dominates the discourse. Researchers and educators can play an important role, by framing and testing hypotheses, and assembling verifiable data for analysis, free of commercial pressures. The likelihood of making a substantial contribution, as well as a symbolic one – in practice and in the design schools - seems to increase greatly with the willingness to integrate technical and qualitative concerns in the architectural imagination.

No architect can predict what the future holds, or how other sectors of society will act, and no profession has the duty, or the scope of influence, to “save the planet” single-handedly. However, everyone in the professions leaves a footprint – through their own patterns of consumption and through the advice they offer. A consulting practitioner can, with respect to the work on the desk on any given day, recommend the choices that are most suitable, after considering all of the circumstances that affect both the client and the public at large. If an architect has any duty to the public, to the profession, or to oneself, it is to represent the possible consequences of one’s advice accurately – in a “green” project, as in all other cases. It is no small achievement to really change the default approach to a new normal - but it begins when we design with energy in mind.

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a1

CONTENT REVIEW

In the fall of 2007, the English language popular press and selected architectural journals were scanned for coverage of stories relevant to this research. The findings are discussed in Section 3.2. A tally of the number of stories, and two lists of headlines are included here. The following is a summary of the process.

Content Review, Mainstream Media – Method

- choose two sources from each of Canada, the United States, and the United Kingdom; specify which sections will be scanned:
    - The Globe and Mail – National page
    - The Canadian Broadcasting Corporation (CBC) website – Ten Most Read
    - The New York Times – Main page, Science, Style
    - The Washington Post – Main, Smart Living
    - The Guardian – Breaking News, Features, Science &

Figure A-1.1 (opposite) Number of headlines in the popular press that were relevant to this study

    - Environment, Five Most Read
    - The British Broadcasting Corporation (BBC) – Main, Science & Nature, England
- scan the headlines on each website, once every weekday for 12 weeks, 11 Sept. - 3 Dec., 2007, looking for the following terms:
    - climate change, warming, global heat, emissions, carbon output, carbon footprint, climate program, Kyoto, green pact, hard caps, Greens, arctic ice, Gore, Lomberg, environment, science and politics
    - energy, petrol cars, gas guzzlers, power, nuclear, coal, fuel, clean fuels, biofuel, fuel-cell, ethanol, wind farm, solar,
    - architecture, building, edifice, green building, green resort
- record the relevant headlines and tally:
    - the total number of headlines read, from all sources, each day
    - the percentage of headlines that were relevant, from all sources, each day
    - the percentage of relevant headlines presented by each source, over the search period

Content Review, Architectural Journals - Method

- choose two popular journals from each of three countries – Canada, the United States, and the United Kingdom
    - The Canadian Architect
    - Azure
    - Architectural Record
    - Metropolis
    - Architectural Review
    - Architectural Design (6 times per year)
- examine the Tables of Contents for two periods, ten years apart:
    - August 2006 through July 2007
    - January through December 1997
- scan the headlines for the same words as in the mainstream media scan, plus:
    - "design", followed by: eco-, ecological-, energy-efficient-, passive, sustainable, green
    - zero, zero-carbon, net zero energy, planet, earth, nature
    - holistic, bioclimatic, integrated, high performance, sustainable
    - LEED, Gold, Platinum, Mazria, Hawken, McDonough, BNIM, McHarg, Fitch, PV
- tally:
    - the total number of headlines read, from all sources, each day
    - the percentage of headlines that were relevant, from all sources, each day
    - the percentage of relevant headlines presented by each source, over the search period

	Globe&Mail		Guardian		NYTimes		WashPost		BBC World		CBC		
origin	Canada		UK		USA		USA		UK		Canada		
section surveyed:	National		Main-Sci-Feat		Main-Sci-Style		Main+SmLvg		Main,Eng,Sci		Main		
headlines:	total	relevant	total	relevant	total	relevant	total	relevant	total	relevant	total	relevant	
Date													
11-Sep-07 Tue	11	1	31	3	14	1	18	1	19	2	9	0	8%
12-Sep-07 Wed	10	0	31	3	14	0	17	1	16	3	10	0	7%
13-Sep-07 Thu	9	0	31	3	18	3	23	1	13	1	10	1	9%
14-Sep-07 Fri	18	3	31	1	9	1	20	0	15	2	10	0	7%
17-Sep-07 Mon	9	0	31	3	16	1	19	1	26	3	10	0	7%
18-Sep-07 Tue	18	2	31	0	26	6	21	0	15	1	10	1	8%
19-Sep-07 Wed	18	1	31	1	21	2	15	0	21	4	10	1	8%
20-Sep-07 Thu	15	1	31	0	21	1	13	1	22	2	10	0	4%
21-Sep-07 Fri	15	1	31	0	18	2	18	0	19	2	10	0	5%
24-Sep-07 Mon	14	3	31	0	21	2	22	1	22	3	10	0	8%
25-Sep-07 Tue	14	0	31	2	12	1	20	0	16	2	10	0	5%
26-Sep-07 Wed	16	2	31	2	20	2	20	0	18	2	10	0	7%
27-Sep-07 Thu	14	1	31	4	22	2	22	2	28	7	10	0	13%
28-Sep-07 Fri	10	0	31	0	12	2	19	2	36	3	10	1	7%
1-Oct-07 Mon	13	1	31	3	24	5	17	0	38	5	10	1	11%
2-Oct-07 Tue	17	2	27	0	10	1	17	1	34	2	10	0	5%
3-Oct-07 Wed	18	0	27	2	16	1	17	1	37	1	10	0	4%
4-Oct-07 Thu	16	2	29	2	26	2	17	0	38	3	10	0	7%
5-Oct-07 Fri	13	0	25	1	11	1	20	0	34	2	10	0	4%
8-Oct-07 Mon	10	1	27	1	28	2	19	2	39	6	10	0	9%
9-Oct-07 Tue	12	0	27	1	18	0	15	0	34	1	10	1	3%
10-Oct-07 Wed	14	0	28	0	22	2	16	2	34	4	10	0	6%
11-Oct-07 Thu	11	1	29	1	22	3	17	1	36	4	10	1	9%
12-Oct-07 Fri	15	1	27	1	24	6	17	2	34	2	10	2	11%

	Globe&Mail		Guardian		NYTimes		WashPost		BBC World		CBC		
origin	Canada		UK		USA		USA		UK		Canada		
section surveyed:	National		Main-Sci-Feat		Main-Sci-Style		Main+SmLvg		Main,Eng,Sci		Main		
headlines:	total	relevant	total	relevant	total	relevant	total	relevant	total	relevant	total	relevant	
Date													
15-Oct-07 Mon	15	1	25	1	29	2	18	1	36	4	10	0	7%
16-Oct-07 Tue	12	1	30	2	24	1	15	2	38	3	10	0	7%
17-Oct-07 Wed	13	0	30	2	23	1	16	0	35	3	10	1	6%
18-Oct-07 Thu	15	1	27	0	24	3	18	1	38	2	10	1	6%
19-Oct-07 Fri	15	2	31	3	22	3	20	1	33	1	10	1	8%
22-Oct-07 Mon	13	0	30	3	28	5	21	1	38	2	10	0	8%
23-Oct-07 Tue	13	0	34	2	33	1	17	1	37	2	10	0	4%
24-Oct-07 Wed	15	0	35	1	25	1	18	1	35	1	10	0	3%
25-Oct-07 Thu	17	0	40	3	34	2	17	1	36	4	10	0	6%
26-Oct-07 Fri	16	0	31	2	19	3	14	1	34	1	10	2	7%
29-Oct-07 Mon	15	0	26	4	32	6	21	2	38	3	10	0	11%
30-Oct-07 Tue	15	0	30	2	28	2	18	1	36	2	10	0	5%
31-Oct-07 Wed	15	1	33	2	24	2	17	0	39	0	10	0	4%
1-Nov-07 Thu	15	0	28	2	35	2	20	0	36	3	10	0	5%
2-Nov-07 Fri	11	0	34	3	20	1	20	0	38	2	10	0	5%
5-Nov-07 Mon	15	0	26	2	30	1	17	1	39	3	10	0	5%
6-Nov-07 Tue	15	0	30	0	35	1	13	0	37	3	10	0	3%
7-Nov-07 Wed	14	1	31	2	32	3	19	0	36	3	10	0	6%
8-Nov-07 Thu	14	0	35	1	24	1	19	0	32	3	10	0	4%
9-Nov-07 Fri	17	0	30	1	23	6	16	0	37	3	10	0	8%
12-Nov-07 Mon	14	1	30	2	24	6	14	0	37	3	10	0	9%
13-Nov-07 Tue	14	0	30	2	25	3	17	2	35	2	10	0	7%
14-Nov-07 Wed	15	1	30	2	27	1	16	0	38	4	10	0	6%
15-Nov-07 Thu	14	1	34	1	38	5	17	1	35	5	10	0	9%
16-Nov-07 Fri	13	0	31	0	17	1	17	1	35	2	10	0	3%

	Globe&Mail		Guardian		NYTimes		WashPost		BBC World		CBC		
origin	Canada		UK		USA		USA		UK		Canada		
section surveyed:	National		Main-Sci-Feat		Main-Sci-Style		Main+SmLvg		Main,Eng,Sci		Main		
headlines:	total	relevant	total	relevant	total	relevant	total	relevant	total	relevant	total	relevant	
Date													
19-Nov-07 Mon	14	0	37	1	30	6	17	1	37	5	10	0	9%
20-Nov-07 Tue	15	1	31	0	28	1	16	0	35	1	10	1	3%
21-Nov-07 Wed	15	0	37	2	18	1	15	0	38	1	10	0	3%
22-Nov-07 Thu	15	0	35	2	27	1	19	0	38	3	10	0	4%
23-Nov-07 Fri	13	1	29	2	15	0	16	0	31	0	10	1	4%
26-Nov-07 Mon	8	0	35	4	28	3	18	0	40	3	10	0	7%
27-Nov-07 Tue	14	0	36	5	20	1	15	1	37	4	10	0	8%
28-Nov-07 Wed	16	1	35	3	25	4	15	0	36	1	10	0	7%
29-Nov-07 Thu	14	1	32	4	30	3	16	2	34	1	10	1	9%
30-Nov-07 Fri	11	0	32	2	20	1	19	1	37	1	10	1	5%
3-Dec-07 Mon	13	0	38	5	41	6	19	0	39	5	10	0	10%
4-Dec-07 Tue	15	0	38	6	20	1	21	1	37	3	10	0	8%
5-Dec-07 Wed	16	2	35	4	26	2	17	0	34	0	10	1	7%
6-Dec-07 Thu	15	0	36	6	38	4	20	2	37	2	10	0	9%
7-Dec-07 Fri	15	1	32	3	33	6	18	2	36	2	10	1	10%
10-Dec-07 Mon	15	3	33	5	34	6	14	2	32	4	10	1	15%
11-Dec-07 Tue	15	0	40	8	40	3	15	1	36	4	10	0	10%
12-Dec-07 Wed	13	0	32	6	37	2	16	1	38	5	10	0	10%
13-Dec-07 Thu	15	0	30	5	21	2	18	2	33	2	10	1	9%
14-Dec-07 Fri	16	0	34	5	21	4	14	1	36	5	9	1	12%
17-Dec-07 Mon	12	0	35	3	27	4	16	0	37	8	10	0	11%
18-Dec-07 Tue	15	0	41	4	35	4	18	0	32	0	10	0	5%
19-Dec-07 Wed	17	1	31	3	24	3	18	1	38	1	10	0	7%
20-Dec-07 Thu	12	0	32	3	24	1	12	0	35	1	10	0	4%
21-Dec-07 Fri	13	0	32	0	23	3	14	0	32	0	10	1	3%
		Globe & Mail		Guardian		NYTimes		WashPost		BBC		CBC	
		4.2%		7.3%		10.2%		4.3%		7.9%		3.3%	6.9%

Figure A-1.2
Number of headlines in the architectural press that were relevant to this study

Figure A-1.3 (opposite)
List of headlines from the popular press, Fall 2007

denotes issue features “green”

		Arch. Record		Metropolis		Cdn. Archt		Azure		Arch. Review		Arch’l Design			
	origin:	USA		USA		Canada		Canada		UK		UK			
	section surveyed:														
	headlines:	total	relevant	total	relevant	total	relevant	total	relevant	total	relevant	total	relevant		
Date															
2007	June	21	0	24	2	9	2	16	0	17	0	0	0	5%	87
	May	27	2	24	2	7	1	16	4	14	0	25	2	10%	113
	Apr	25	0	35	3	9	1	0	0	15	2	0	0	7%	84
	Mar	23	9	22	0	9	2	14	0	13	1	21	0	12%	102
	Feb	21	1	22	2	8	1	0	0	14	1	0	0	8%	65
	Jan	22	2	18	4	8	3	18	2	10	0	22	1	12%	98
2006	Dec	14	6	14	2	9	1	0	0	28	0	0	0	14%	65
	Nov	21	3	17	1	11	2	14	2	16	0	38	2	9%	117
	Oct	22	0	19	1	10	0	15	0	12	0	0	0	1%	78
	Sep	13	1	20	5	12	0	21	2	11	1	24	0	9%	101
	Aug	15	10	21	2	8	0	0	0	14	9	0	0	36%	58
	July	15	0	18	0	10	2	15	1	14	0	20	0	3%	92
			14.2%		9.4%		13.6%		8.5%		7.9%		3.3%	10.4%	1,060
1997	Dec	16	1	14	1	8	1	0	0	16	3			11%	54
	Nov	12	0	16	1	12	0	8	1	17	0	28	0	2%	93
	Oct	12	0	19	0	15	0	0	0	19	0			0%	65
	Sep	14	0	14	0	10	2	9	0	19	1	15	0	4%	81
	Aug	13	0	0	0	11	1	0	0	15	1			5%	39
	July	17	1	15	2	10	1	0	0	16	10	33	0	15%	91
	June	15	1	12	1	8	1	0	0	19	0			6%	54
	May	14	0	12	0	11	1	8	0	20	0	23	0	1%	88
	Apr	16	0	14	1	12	0	0	0	17	0			2%	59
	Mar	15	0	11	0	9	0	9	0	19	0	32	0	0%	95
	Feb	14	0	0	0	13	1	0	0	18	0			2%	45
	Jan	15	0	15	2	12	0	8	2	20	0	33	33	36%	103
			1.7%		5.6%		6.1%		7.1%		7.0%		20.1%	7.0%	867

Date		Relevance	Source	Section
Tue 11-Sep-2007				
	Village of Widows renewal, Cleanup of U mine source of hope for Dene	E	G&M	Nat'l
	has env't section, plus button on home page re climate change	cl-ch	Grdn	feature
	Can we fight terrorism by reducing CO$_2$ emissions?	cl-ch	Grdn	Sci+Env
	Men who buy sex could face prosecution	other	Grdn	5most
	Feel good vs. do good on climate - Tierney meets Bornj Lomberg	cl-ch	NYT	Sci+Env
	Eco-friendly bikes, surfboards ... how do they perform?	mktg	WP	SmLivg
	R Leakey on human poverty and saving the gorilla (Congo coal wars)	E	BBC	Sci/Nat
	Deluge defence - will the insurance industry always cover your ppty?	cl-ch	BBC	England
	Changing Arctic - a diary from Greenland	cl-ch	BBC	Sci/Nat
Wed 12-Sep-2007				
	Man-made chemicals blamed-many more girls than boys born in Arctic	pollu	Grdn	front
	Girl 14 appears toples in FHM	other	Grdn	5most
	Threatened species Red List shows escalating 'global extinction crisis'	cl-ch	Grdn	front
	In Austria, Pope Emphasizes Protection of the Environment	eco	NYT	Science
	Oil hits record above $79 (OPEC already pumping over quota)	E	WP	front,sm
	Reformed Libya eyes eco-tourist boom	busines	BBC	Sci/Nat
	Eco-motoring 'to help save planet'	en+cl-	BBC	Sci/Nat
	CFB Gagetown - agent orange victims offered $20,000 payout	pu-hlth	CBC	main
Thur 13-Sep-2007				
	Sustainable living sponsored by Tesco	cl-ch	Grdn	sci/tech
	Tory report backs increased taxes on flights and cars	cl-ch	Grdn	front
	Foster in Beijing	ARC	Grdn	front
	U.S. Court Backs States' Measures to Cut Emissions	cl-ch	NYT	main
	Panel Faults Emphasis of U.S. Climate Program	cl-ch	NYT	sci
	Hopes Dim for Measures to Conserve Energy	E	NYT	sci
	Carmakers defeated in emissions ruling	cl-ch	WP	front,sm
	CN Tower dethroned by Dubai building	ARC	CBC	10most
Fri 14-Sep-2007				
	Greenpeace protest blocks Quebec port	cl-ch	G&M	Nat'l
	Montana accuses B.C. of breaking green pact, Gov, sens decry coal projs	E/cl-ch	G&M	Nat'l
	Green Party support highest between elections	POL	G&M	Reg'l
	Report says Alberta energy regulator illegally spied on objectors to	POL	G&M	Reg'l
	Who deserves your vote?	cl-ch	Grdn	feature
	Sustainalbility takes center stage - Frankfurt auto show	E/cl-ch	NYT	front
	Bush aide says warming man made	cl-ch	BBC	SciNat
	Greenland sees bright side of warming	cl-ch	BBC	SciNat
	Eat less meat, reduce global heat, says study (in Lancet)	cl-ch	CBC	blogs
Mon 17-Sep-2007				
	Prehistoric goo melting; arctic ice retreats to record low	cl-ch	G&M	Science
	Can shopping save the planet?	cl-ch	Grdn	Sc&Env
	Arctice thaw opens fabled trade route (Northwest Passage)	cl-ch	Grdn	Sc&Env
	Lib Dems back call to make UK carbon neutral by 2050	cl-ch	Grdn	main
	Vatican Penance: Forgive Us Our Carbon Output	cl-ch	NYT	Science
	Climate Change affects animals	cl-ch	WP	main
	Chernobyl to be covered in steel	E	BBC	main
	More progress urged on ozone hole	cl-ch	BBC	SciNat
	Call to ban petrol cars by 2040	cl-ch+E	BBC	SciNat
	DNA test hope over damages claims	pu-hlth	BBC	SciNat
Tues 18-Sep-2007				
	Most of Saskatchewan left in dark	E	G&M	Nat'l
	Alberta should hike oil sands royalties: report	E	G&M	main
	Effort to get companies to disclose climate risk	cl-ch	NYT	Science

Date		Relevance	Source	Section
	From Ozone Success, a Potential Climate Model	cl-ch	NYT	Science
	For New Center, Harvard Agrees to Emissions Cut	ARC	NYT	Science
	Suit Blaming Automakers Over Gases Is Dismissed	cl-ch	NYT	Science
	Economists v. Ecologist (Tierney re Lomberg)	eco	NYT	Science
	Through the forest, a clearer view of the needs of a people (agent	pollu	NYT	Science
	Making EU climate goal unlikely	cl-ch	BBC	SciNat
	Power back on in Saskatchewan	E/wthr	CBC	10most
Wed 19-Sep-2007				
	Urgent action urged to clean and protect Great Lakes	pollu	G&M	Reg'l
	VANOC dips into contingency fund (Olympic res, arena, elec quotes)	ARC	G&M	Nat'l
	How climate change will affect you (*map)	cl-ch	Grdn	Sc&Env
	How climate change will affect the world	cl-ch	Grdn	Sc&Env
	Lunch with Alice Waters, food revolutionary	sust	NYT	Style
	A Chicken on every plot, a coop in every backyard	city	NYT	Style
	Ministers discuss trade, climate change in APEC talks	cl-ch	G&M	bg most
	Environment Canada budget cuts threaten wildlife programs (cc or 0?)	cl-ch	G&M	mostread
	Eco experiment: NY family turns off power in search of a no impact life	eco	BBC	main
	Do the maths: calculating the carbon footprint of a potato	cl-ch	BBC	Sci/Nat
	Shrinking ice - why it has been plain sailing on the fabled NW Passage	cl-ch	BBC	Sci/Nat
	Bog helps build climate insights	cl-ch	BBC	Sci/Nat
Thurs 20-Sep-2007				
	Court action presses Ottawa to obey Kyoto (+21 reader responses)	cl-ch	G&M	Nat'l
	slide show including Shigeru Ban's Manhatten lofts that open entirely	ARC	NYT	Style
	Mow down the chemicals	cl-ch	WP	Style
	Brunels' tunnel vision lives on (workmanships - East London Olympics)	eng'g	BBC	Sci/Nat
	July floods cost insurers £1.5bn	cl-ch?	BBC	England
Fri 21-Sep-2007				
	Greens hold their own debate	cl-ch?	G&M	Nat'l
	Report severe retreat of arctic ice	cl-ch	NYT	Science
	Brazil: Amazon forest resilient to drought	cl-ch	NYT	Science
	Protecting paradise … Ecuador (biodiversity vs. oil patch)	cl-ch/E	BBC	main
	Ice withdrawal shatters record	cl-ch	BBC	Sci/Nat
	$1 Cdn = $1 US	general	CBC	most
	Eating fewer calories could mean living longer	food	CBC	most
	The Denial Machine - the fifth estate 15 Nov 2006 - watch online	cl-ch	CBC	main
Mon 24-Sep-2007				
	Great Lakes disappearing act	cl-ch	G&M	Nat'l
	Harper proposes less rigid climate change plan	cl-ch	G&M	Nat'l
	Governments doing nothing as grizzly bears disappear	cl-ch	G&M	Nat'l
	Seniors' bus hits moose	hoho?	G&M	Reg'l
	UN Chief urges climate action	cl-ch	WP	main
	NRG to seek permit for nuclear reactors	E	NYT	main
	Gas emissions rarely figure in investor decisions	cl-ch	NYT	Science
	Poll blames people for climate change	cl-ch	BBC	main
	Bring it on - Russians hear little about global warming but it sounds	cl-ch	BBC	main
	Chaos or accounts? Investors urge firms to quantify impact of cl-ch	cl-ch	BBC	Sci/Nat
Tues 25-Sep-2007				
	Has the US stand-off run out of steam? Berger (UN summit this week)	cl-ch	Grdn	main
	The Nat'l Grand Theatre in Beijing, Jean Andreu	ARC	Grdn	main
	Climate Change: Roadmap to a greener future	cl-ch	CBC	main
	Arne, Al push climate action	cl-ch	NYT	Science
	UN Chief calls for global action	cl-ch	BBC	main
	New study for Severn E plan (tidal generation)	E	BBC	Sci/Nat

Date		Relevance	Source	Section
Wed 26-Sep-2007				
	Exx files - green group attacks oil giant in cartoons	E	Grdn	main
	Diplomats accuse Bush of attempting to derail UN climate conference	cl-ch	Grdn	main
	Lush lawns not quite so green	cl-ch	G&M	Nat'l
	PM wants hard caps scrapped in next green deal	cl-ch	G&M	Nat'l
	Banks urging US to adopt the trading of emissions	cl-ch	NYT	Science
	UN chief urges fast action on global climate challenge	cl-ch	NYT	Science
	Lovelock urges ocean climate fix	cl-ch	BBC	Sci/Nat
	Fortis group buys carbon rights	cl-ch	BBC	Sci/Nat
Thur 27-Sep-2007				
	Beneath cities, China's future dries up	ARC	NYT	main
	Currents slideshow - Quincy Jones houses in LA	ARC	NYT	Style
	Climate change "threatens equality" UK Foreigh Secretary	cl-ch	BBC	main
	US urges climate change unity	cl-ch	BBC	main
	China dam "catastrophe" warning	E	BBC	Sci/Nat
	Legal battle on Gore climate film (in UK re schools presenting "mush")	cl-ch	BBC	Sci/Nat
	Switch off for traditional bulbs	cl-ch	BBC	Sci/Nat
	Motives behind Bush's climate summit	cl-ch	BBC	Sci/Nat
	Countdown to terminal's takeoff - Heathrow T5 "green"	ARC	BBC	England
	Shoppers hail new monument to SA liberation (Soweto mall)	ARC	Grdn	main
	Rice defends Bush's climate talks	cl-ch	Grdn	main
	Size is everything to a mayor consumed by edifice complex - London	ARC	Grdn	main
	Lights out for old bulbs by 2012	cl-ch	Grdn	Science
	Ads recast big oil's battered image	E	WP	main
	Rice urges nations to find cleaner fuels	cl-ch	WP	main
	Oil giants taking Canada to court	E	G&M	Nat'l
Fri 28-Sep-2007				
	Bush seeks flexible CO_2 targets	cl-ch	BBC	main
	Biofuel trial flight set for 747	E	BBC	Sci/Nat
	Orkney tidal power plans unveiled	E	BBC	Sci/Nat
	Bush seeks new climate image	cl-ch	WP	main
	Keeping the fire going in the furnace	E	WP	main
	Bush outlines proposal on climate change	cl-ch	NYT	main
	At its session on warming, US is seen to stand apart	cl-ch	NYT	Science
	Toyota rolls out upgraded fuel-cell vehicle	E	CBC	most
Mon 1-Oct-2007				
	Gov. Spitzer picks activists to make state a bit greener	cl-ch	NYT	Science
	Human behaviour, global warming, and the ubiquitous plastic bag	cl-ch	NYT	Science
	Ethanol's boom stalling as glut depresses price	E	NYT	Science
	At climate meeting, Bush does not specify goals	cl-ch	NYT	Science
	Beneath booming cities, China's future is drying up	ARC	NYT	Science
	Advisors endorse tidal power plan	E	BBC	Sci/Nat
	Arctic ice island breaks in half	cl-ch	BBC	Sci/Nat
	Why local knowledge is the key to averting climate chaos	cl-ch	BBC	Sci/Nat
	Bush climate plans spark debate	cl-ch	BBC	Sci/Nat
	Restoration period - an ancient church in the heart of London	ARC	BBC	Sc&Env
	Portugal gambles on "sea snakes"	E	Grdn	Sc&Env
	Old masters aid climate change study	cl-ch	Grdn	Sc&Env
	Environment: gas guzzlers (10 worst)	cl-ch/E	Grdn	main
	CEOs call for aggressive action on climate change	cl-ch	CBC	10most
	Climate change: the new talk of farm country	cl-ch	G&M	Nat'l
	Lake Superior hits record lows	cl-ch	G&M	Nat'l
Tues 2-Oct-2007				
	Alberta to curb pollution and water use from massive growth	pollu	G&M	Nat'l

Date		Relevance	Source	Section
	Jeffrey Simpson on solutions to climate change	cl-ch	G&M	Nat'l
	Arctic melt unnerves the experts	cl-ch	NYT	Science
	Keep the heat inside your home	E?	WP	SmLivg
	Bush climate plans spark debate	cl-ch	BBC	Sci/Nat
	Climate film allowed in schools	cl-ch	BBC	England
	BC Premier rolls out sweeping green plan	cl-ch	CBC	BC
Wed 3-Oct-2007				
	Greenland - changing scape	cl-ch	Grdn	main
	Eco POL - green dilemma	cl-ch	Grdn	main
	Herbert Muschamp, architecture critic, Is Dead	ARC	NYT	main
	Lawmakers focus on climate	cl-ch	WP	main
	Fuel cell cars to get test drive	cl-ch/E	BBC	Sci/Nat
Thurs 4-Oct-2007				
	Salmon need help to survive climate change	cl-ch	G&M	Nat'l
	Dragonflies, open water, reveal arctice change	cl-ch	G&M	Nat'l
	UN warning: climate change disaster is upon us	cl-ch	Grdn	main
	World's largest offshore wind farm is given gov't approval in Kent	E	Grdn	main
	Can a plucky US economy surmount $80 oil?	E	NYT	main
	Australian fires add to fears on climate change	cl-ch	NYT	Science
	Paper, plastic, or other?	eco	WP	SmLivg
	Democrats eye climate summit	cl-ch	BBC	Sci/Nat
	Athens trailblazer: solar powered building sets green example for	ARC-E	BBC	Sci/Nat
	Restored glory: Birmingham's Town Hall	ARC	BBC	England
Fri 5-Oct-2007				
	New series: great modern buildings - The Empire State Building	ARC	Grdn	main
	Clinton says she would shield science from politics	cl-ch	NYT	Science
	Food for thought - ...to make fuel from food while people are starving?	E - food	BBC	Sci/Nat
	Clear up at reactor 50 years on (Sellafield)	E	BBC	England
	first time Grdn's top 5 included one on cl-ch - UN warning from 4 Oct	cl-ch	Grdn	5most
Mon 8-Oct-2007				
	A quest for energy in ... remote places	E	NYT	main
	A heavy toll from disease fuels suspicion and anger - Middleboro, MA	pollu	NYT	Science
	Nuclear power tries comeback	E	WP	main
	How to dispose of compact fluorescent bulbs	E	WP	SmLivg
	New coal age - new mine that will be Britain's biggest hole, G. Monbiot	E	Grdn	main
	Arctic sea legs - Shukman on the Amundson	cl-ch	BBC	Sci/Nat
	Ice melt raises passage tension	cl-ch	BBC	Sci/Nat
	Smoke signals - clear clim. policies urgently needed says Shell UK's boss	cl-ch	BBC	Sci/Nat
	UK exporting emissions to China	cl-ch	BBC	Sci/Nat
	Windscale fallout underestimated (nuclear accident Cambria 1957)	E/pollu	BBC	Sci/Nat
	Protestors raid coal power plant	cl-ch	BBC	England
Tues 9-Oct-2007				
	Condo binge building continues	ARC	CBC	10most
	Utopia with no poor people: Moscow's new billionaire's row	ARC	Grdn	main
	Europe's biggest screen for city - Liverpool	ARC	BBC	England
Wed 10-Oct-2007				
	Gore climate film's "nine errors"	cl-ch	BBC	Sci/Nat
	Warmth makes world more humid	cl-ch	BBC	Sci/Nat
	Pulling the plug - is there just too much light at the heart of the mod	ARC	BBC	Sci/Nat
	Green Darling? how did the chancellor perform on the environment?	cl-ch	BBC	Sci/Nat
	Seattle's recycling success is being measured in scraps	pollu	NYT	Science
	Having the fizz without the guilt - making seltzer at home	cl-ch	NYT	Style

Date		Relevance	Source	Section
	Why its important to leave mulch alone	?	WP	SmLivg
	The greenest way to bag groceries	?	WP	SmLivg
Thurs 11-Oct-2007				
	Ottawa boosts spending to get VIARail back on track	cl-ch	G&M	main
	Via gets hundreds of millions in federal funding - "cleaner"	cl-ch	CBC	10most
	Save planet, win presidency?-rumours that Gore may be in run for	cl-ch	WP	main
	Nobel in chemistry honours expert in surface ... Gerhard Ertl	E/pollu	NYT	Science
	A climate meeting with Nobel laureates	cl-ch	NYT	Science
	When the heat cannot be outrun - marathon & warming	cl-ch	NYT	Style
	The unheralded polluter: cement industry comes clean on its impact	cl-ch	Grdn	Science
	Movie meltdown: why a former US VP's Oscar winner went to court	cl-ch	BBC	Sci/Nat
	Facts in the spin-how sci'fic advisors influenced politics down the years	POL	BBC	Sci/Nat
	Chain reaction - why the US nuclear industry is on its way back	E	BBC	Sci/Nat
	Over and out from tagged walruses	cl-ch/E	BBC	Sci/Nat
Fri 12-Oct-2007				
	Gore says prize must spur action	cl-ch	BBC	main
	Warm words - what the choice of Nobel laureates tell us about climate	cl-ch	BBC	Sci/Nat
	Gore and UN Panel share peace prize	cl-ch	Grdn	main
	Gore and UN Panel win peace prize for climate work	cl-ch	NYT	main
	Two voices, one message on climate	cl-ch	NYT	main
	E costs push up producer prices	E	NYT	main
	To the would-be presidents; don't forget the city issues … cl-ch,	cl-ch	NYT	NY Reg
	Parked cars as buffer for cyclists	city	NYT	NY Reg
	Gore vows to use Nobel prize to raise awareness	cl-ch	WP	main
	An Inconvenient Truth for Gore?	cl-ch	WP	main
	Gore: Nobel prize win shows climate change a planetary emergency	cl-ch	CBC	10most
	Tory throne speech to embarrass liberals over Kyoto: report	cl-ch	CBC	10most
	Watt-Cloutier applauds Gore's Nobel win	cl-ch	G&M	Nat'l
Mon 15-Oct-2007				
	Greenhouse gases stay well above target	cl-ch	G&M	Nat'l
	Khoffi Annan - now is the time to act	cl-ch	G&M	web
	Climate change moves to the boardroom	cl-ch	G&M	Business
	Home insurers cancelling in East	cl-ch	NYT	main
	A green resort is planned to preserve ruins and coastal waters	ARC	NYT	Science
	Dim hopes for "green" games	pollu	WP	main
	Growth is not our only goal says Hu - sustainability in China	resourc	Grdn	main
	Lula promotes biofuels in Africa (Pres. of Brazil)	E	BBC	main
	Curbing the carbon - car firms blow their horns over emission redux	E	BBC	Sci/Nat
	Arctic voice drowning in climatic shift (kayaker thru NW Passage)	cl-ch	BBC	Sci/Nat
	Arctic muds reveal sea ice record	cl-ch	BBC	Sci/Nat
Tues 16-Oct-2007				
	Throne speech leaked … cannot meet Kyoto commitments	cl-ch	G&M	Nat'l
	Va. Tech., investor, aim to cut E use	E	WP	main
	Five ways to lower your E bill	E	WP	SmLivg
	Oil futures hit high of $88 a barrel	E	NYT	Business
	Going underground - modern arch're series - classic London	ARC	Grdn	main
	Greening the web - bloggers unite	eco	Grdn	main
	Explorers' quest for key ice data - next winter	cl-ch	BBC	Sci/Nat
	Field of dreams - is race to grow biofuel crops another gold rush?	E	BBC	Sci/Nat
	Firms need clear climate policies - Viewpoint, J Smith (cap n trade)	cl-ch	BBC	Sci/Nat
Wed 17-Oct-2007				
	Canada missing on env'l targets, Statscan says	cl-ch	CBC	most bg
	Record price of oil raises new fears (espect $100/barrel)	E	NYT	Business

Date		**Relevance**	**Source**	**Section**
	Sucked dry - re Bjorn Lomberg	cl-ch	Grdn	Sc&Env
	Cool it - is global warming a myth? - (history on Lomberg's books)	cl-ch	Grdn	Sc&Env
	Oil prices pull back from highs	E	BBC	main
	What is driving oil prices so high?	E	BBC	main
	Home brew - why people are turning to home-made fuel to run their	E	BBC	Sci/Nat
Thur 18-Oct-2007				
	Russian ships cross "arctic bridge" to Manitoba	cl-ch	G&M	Nat'l
	Cement makers come clean	cl-ch	BBC	Sci/Nat
	"Warm wind" hits arctic climate	cl-ch	BBC	Sci/Nat
	Oil settles over $89 as dollar falls	E	WP	main
	Recycling the whole house	ARC	NYT	Science
	Dollar hits a new low, oil hits a new high (Euro 1.42; oil over $90)	E	NYT	Business
	Seeing sugar's future in fuel	E	NYT	Business
Fri 19-Oct-2007				
	Gas prices send inflation to 16 month high	E	G&M	Nat'l
	Canada won't withdraw from Kyoto: Baird	cl-ch	G&M	Nat'l
	Ships' CO_2 twice that of planes	cl-ch	BBC	Sci/Nat
	Great buildings - Fallingwater	ARC	Grdn	main
	Tesco turns to barges to cut emissions (canal barges)	cl-ch	Grdn	Sc&Env
	BT leads green revolution with 250M Pound wind farm project	E	Grdn	Sc&Env
	Power plant rejected over Carbon dioxide for first time	cl-ch	WP	mostread
	Oil futures retreat from $90 record (expected to go up again)	E	NYT	Business
	Wal-Mart is reassigning its environmental chief	cl-ch	NYT	Business
	New coast guard tasks in arctic's warming seas	POL	NYT	Science
Mon 22 Ocr 2007				
	Washington feels Hollywood's heat - ecowives lobby on climate change	cl-ch	NYT	Style
	Save the planet: vote smart - Friedman Sunday OpEd - NY taxis	cl-ch	NYT	Op Sun
	The Future is drying up - climate change may be making matters worse	cl-ch	NYT	Science
	Criminal Element - getting lead out of gas lowers crime rate?	pollu	NYT	Science
	Members of new group in Britain - CRAGs	cl-ch	NYT	Science
	Fight against coal plants draws diverse partners	cl-ch	NYT	Science
	Citing global warming, Kansas denies plant permint	cl-ch	NYT	Science
	Green baby on board	eco	WP	SmLivg
	MPs concerns over carbon plan	cl-ch	BBC	Sci/Nat
	Oceans soaking up less CO_2	cl-ch	BBC	Sci/Nat
	Labour plans to abandon renewable E targets	cl-ch	Grdn	main
	Brown gets down to business with his captains of industry	cl-ch	Grdn	Business
	Steep decline in oil production brings risk of war and unrest, new study	E	Grdn	mostread
Tues 23-Oct-2007				
	Profit declines sharply at BP	E	NYT	Business
	Provocative eco-reporting - CNN's Planet in Peril	cl-ch	WP	main
	Unexpected growth in CO_2 found	cl-ch	BBC	Sci/Nat
	Final four in 50M lottery race - Eden Project plus 2	ARC	BBC	England
	Going nuclear - cartoonist Rowson	E	Grdn	main
	Carbon output rising faster than forecast says study	cl-ch	Grdn	Science
Wed 24-Oct-2007				
	Veterans win court battle in Agent Orange fight	pollu	G&M	Nat'l
	White House editing alleged in climate testimony	cl-ch	WP	main
	China's green E gap	E	NYT	Business
	Climate threat to biodiversity	cl-ch	BBC	Sci/Nat
	Warming could wipe out half of all species	cl-ch	Grdn	Envir't

Date		Relevance	Source	Section
Thurs 25-Oct-2007				
	Sen. seeks answers on edited climate testimony	cl-ch	WP	main
	Conservationists name 25 primates about to disappear - biofuel	E	Grdn	main
	BP agrees to pay $373 M in fines - oil spill, price fixing propane	E	Grdn	main
	Minister confirms retreat from 20% renewable E target	E	Grdn	Sc&Env
	Reality check: the UN's Geo4 report reveals the true state of the planet	eco	BBC	main
	Huge US fines for oil giant BP	E	BBC	main
	German church rolled to new home - coal deposit below	E	BBC	Sci/Nat
	Natural decline hurting lives	eco	BBC	Sci/Nat
	Sarkkozy details green France plan	POL	BBC	Sci/Nat
	Climate Change testimony was edited by White House	cl-ch	NYT	Science
	Oil price surge adds to economic jitters	E	NYT	Business
Fri 26-Oct-2007				
	Electric car maker charges Ottawa blocking its sale in Canada	E/pollu	CBC	main
	Alberta increases royalties charged to E companies	E	CBC	main
	Secret village - a man who has spent 30 years quietly bldg a Tudor town	art	BBC	England
	Oil retreats from $92 record on profit-taking	E	WP	main
	Oil prices continue to rise	E	NYT	main
	UN warns of rapid decay of the environment	cl-ch	NYT	Science
	Cement industry is at center of climate change debate	cl-ch	NYT	Business
	Plummet of the apes - 25 primate species "about to disappear"	cl-ch	Grdn	main
	Environment lapses "put humanity at risk"	cl-ch	Grdn	Sc&Env
Mon 29-Oct-2007				
	Warming revives flora and fauna in greenland	cl-ch	NYT	Science
	Indonesia seeks allies in pay-for-forests plan	cl-ch	NYT	Science
	Dozens of species of primates are under threat, study finds	cl-ch	NYT	Science
	For a devotee of solar E, a shot at respect	E	NYT	Science
	Two new (and very different) roadmaps for climate progress A. Revkin	cl-ch	NYT	Science
	Oil price up again ahead of Fed meeting - future $93.53	E	NYT	Business
	GM to build hybrid research center in China	E	NYT	Business
	High court to hear Exxon appeal (re oil spill)	E/pollu	WP	main
	Spotting a fake eco-friendly product	eco	WP	SmLivg
	Malaria moves in behind the loggers (Peru)	cl-ch	Grdn	main
	Canada's "black gold" is mixed blessing	E	Grdn	feature
	Tread lightly and make a difference - help readers reduce C footprint	cl-ch	Grdn	Sc&Env
	Our progress - being green	cl-ch	Grdn	feature
	Exxon can appeal L2.5 billion oil fine	E/pollu	BBC	Sci/Nat
	Benn pledges tougher climate bill	cl-ch	BBC	Sci/Nat
	Breaking the ice - how sailors must have yearned for one effect of cc	cl-ch	BBC	Sci/Nat
Tue 30-Oct-2007		:-)		
	Top 10 Home improvements to conserve E	E	WP	SmLivg
	From conservation to population a new look a planet Earth	eco	NYT	Science
	Oil falls as Mexican production resumes	E	NYT	Business
	How Peterborough is leading the way in personalized transit (bike)	cl-ch	BBC	England
	BBC launches voyage to chart climate change in Bangladesh	cl-ch	BBC	Sci/Nat
	More transport "won't increase CO_2"	cl-ch	Grdn	main
	It's too late for greenhouse gas cuts, says scientist	cl-ch	Grdn	Sc&Env
Wed 31-Oct-2007				
	New global warming villain fingered: trees	cl-ch	G&M	Nat'l
	"Fit towns" plan to tackle child obesity	cl-ch	Grdn	main
	Power from the final frontier - solar panels that beam E back	E	Grdn	Sc&Env
	Betting on cheaper oil - Tierney Lab - and blog	E	NYT	Science
	Architects go green at the office - Cook & Fox	ARC	NYT	Business
	Climate change and tourism	cl-ch	G&M	web

Date	Relevance	Source	Section
Thur 1-Nov-2007			
Isle of Wight to be eco trailblazer	E	Grdn	Sc&Env
US edges toward cap on greenhouse gases	cl-ch	Grdn	Sc&Env
Tapped out but hopeful: a break in Texas' oil decline	E	NYT	Business
Fresh-faced eco-consumers	cl-ch	NYT	Style
New York sues real estate appraisal firm	other	WP	main
US mayors meet on climate	POL	BBC	main
Biofuel rush harmful - Oxfam	E	BBC	Sci/Nat
UK E savings "miscalculated"	cl-ch	BBC	Sci/Nat
Fri 2-Nov-2007			
Climate -induced food crisis looms (biofuel land)	cl-ch	Grdn	main
Tories fly 184,000 miles in private jet (cost and environmental impact)	cl-ch	Grdn	main
Tread lightly - tune in and turn off pledge re standby appliances	cl-ch	Grdn	feature
On an upstate wind turbine project, opinions as varied as the weather	E	NYT	Sc&Env
Seeing the carbon for the trees	cl-ch	BBC	Sci/Nat
Parrotfish to aid in reef repair	cl-ch	BBC	Sci/Nat
Mon 5-Nov-2007			
Monbiot - The western appetite for biofuels is causing starvation	E	Grdn	feature
The green list: which leading British firms are fighting - (17 articles)	cl-ch	Grdn	feature
Mayors, looking to cities' future, are told it must be colored green	cl-ch	NYT	Science
St Pancras faced demolition ball (restored)	ARC	BBC	England
Most ready for green sacrifices	E	BBC	Sci/Nat
Humanity is the greatest challenge	cl-ch	BBC	Sci/Nat
Tues 6-Nov-2007			
Massachusetts looks at using biofuel in home heating oil	E	NYT	Sc&Env
Burning questions: can US make oil from coal an eco-friendly policy?	cl-ch	BBC	main
Queen opens St. Pancras Station	ARC	BBC	main
Climate bills' 60% emissions cut	cl-ch	BBC	Sci/Nat
Wing power - why swans may decide the wind E future	E	BBC	Sci/Nat
Wed 7-Nov-2007			
Watchdog says Ottawa hiding pollu figures (industry)	pollu	G&M	main
London 2012 stadium revealed	ARC	Grdn	main
St Pancras Station	ARC	Grdn	feature
The Warming World is not flat (Revkin)	cl-ch	NYT	Science
Project to capture CO$_2$ with plankton put to sea	cl-ch	NYT	Science
For Fiji water, a big list of green goals	cl-ch	NYT	Science
Business of Green: a special section	cc-bus	NYT	Business
High priced oil adds volatily to power scramble	E	NYT	Business
Warning on impact of China and India oil demand	E	NYT	Business
E needs "to grow inexorably"	E	BBC	Sci/Nat
Have your say - is the effect of climate change underestimated?	cl-ch	BBC	Sci/Nat
Prince "alarm" at climate change	cl-ch	BBC	Sci/Nat
Thurs 8-Nov-2007			
New disaster movie warns world of oil apocalypse	E	Grdn	Envir't
The antisuburbanites	ARC	NYT	Style
In pictures - unseen areas of St. Paul's are opened up to the public	ARC	BBC	England
Ice expedition tests "successful"	cl-ch	BBC	Sci/Nat
Funds freed up for UK innovation … green E	E	BBC	Sci/Nat
Fri 9-Nov-2007			
California oil spill "emergency" (tanker hits SanFranBay bridge)	E/pollu	BBC	main
Congo arrests after toxic dumping (radioactive into river)	E/pollu	BBC	main
California sues US over car fumes	cl-ch	BBC	Sci/Nat

Date		Relevance	Source	Section
	What's your environmental "eureka" moment?	eco	Grdn	feature
	The complexities of keeping it small and simple (vac. home in Oregon)	ARC	NYT	main
	Oil spill fouls shores in SanFran Bay Area	E/pollu	NYT	Science
	Fuel without the fossil	E	NYT	Sci &
	Study finds carcinogens in water near Alberta oil sands projects	E/pollu	NYT	Science
	Rising demand for oil provokes new E crisis	E	NYT	Business
	What does the present owe the future? Revkin blog	eco	NYT	Business
Mon 12-Nov-2007				
	Meet Canada's new green Queen	eco	G&M	Nat'l
	Disaster in Black Sea as tanker sinks	E/pollu	Grdn	main
	Free E? it doesn't add up	E	Grdn	Sci/Nat
	Warmest of times? evid. sceptics use to challenge the cl-ch consensus	cl-ch	BBC	main
	New green standard for big events	cl-ch	BBC	Sci/Nat
	Climate alarm - UN chief sees global warming close up on Antarctic	cl-ch	BBC	Sci/Nat
	Gore joins venture capital firm	cc-bus	NYT	main
	3 dead in storm that caused oil spill	E/pollu	NYT	main
	Heavy storm splits tanker, spilling oil off Russia	E/pollu	NYT	Science
	John Firor, early voice on env't, is dead (linked cl-ch to human activity)	cl-ch	NYT	Science
	Human error cited in California oil spill	E/pollu	NYT	Science
	Experts discuss eng'g feats, like space mirrors, to slow climate change	cl-ch	NYT	Science
Tues 13-Nov-2007				
	Stocks rally, oil drops, Dow up 300	E	WP	main
	Saudi oil minister tries to calm markets	E	WP	main
	Europe advances plan to cut jet emissions	cl-ch	NYT	Business
	Oil drops on lower demand forecast	E	NYT	Business
	Challenges to both left and right on global warming, Revkin on 2 books	cl-ch	NYT	Science
	Croydon reborn: from concrete hell to the new Barcelona	ARC	Grdn	feature
	Spanish lesson - images of Spain showing what clim. change would do	cl-ch	Grdn	feature
	Climate of truth: why we should trust the IPCC's conclusions	cl-ch	BBC	main
	Muzzling dissent: why world's clim. body may not tell the whole truth	cl-ch	BBC	Sc&Env
Wed 14-Nov-2007				
	We'll dig deep to go green, poll	cl-ch	G&M	Nat'l
	The road to enlightenment - 70% cuts must be at local level	cl-ch	Grdn	Envir't
	Oil spill disaster in Black Sea	E/pollu	Grdn	Envir't
	Power plants' CO_2 levels revealed	cl-ch	BBC	main
	Fishy climate - is science itself biased against the climate sceptics?	cl-ch	BBC	main
	Sceptics' salvation-could Sun really be behind modern-day clim.	cl-ch	BBC	Sci/Nat
	Reduced emissions - why car makers and drivers must share the burden	cl-ch	BBC	Sci/Nat
	America's leaky buildings and the climate challenge, Revkin	cc-ARC	NYT	Science
Thurs 15-Nov-2007				
	Richard Florida at the intersection of immigrant and hippie-Kensington	ARC	G&M	Nat'l
	Chocs away … the confectionary expedition to Africa, M Wainwright	cl-ch	Grdn	Sc&Env
	Court voids mileage standards for light trucks	E	NYT	main
	In eco-friendly factory, low guilt potato chips	cl-ch	NYT	Business
	Governors pushing caps on greenhouse gases	cl-ch	NYT	Science
	Governors join in creating Reg'l pacts on climate change	cl-ch	NYT	Science
	Will game's impact surpass an Inconvenient Truth? SimCity, Revkin	cl-ch	NYT	Science
	In Chinese Dam's wake, ecological woes	eco	WP	main
	Peru pollu - clean up challenge in one of world's most polluted places	eco	BBC	main
	The Editors - how should the BBC report on climate change sceptics?	cl-ch	BBC	main
	Biofuels bonanza facing "crash"	E	BBC	main
	Tourist footprints - will travel industry kill itself by fuelling cl-ch?	cl-ch	BBC	main
	Apocalypse curbed - why progress can overcome climate catastrophe	cl-ch	BBC	Sci/Nat
	Eco-ruin "felled early society"	eco	BBC	Sci/Nat

Date		Relevance	Source	Section
	Australians named worst emitters	cl-ch	BBC	Sci/Nat
Fri 16-Nov-2007				
	High oil prices confound OPEC	E	NYT	Business
	Scientists fault climate exhibit changes	cl-ch	WP	main
	IPCC to warn of "abrupt warming"	cl-ch	BBC	main
	Verbal warming - do sceptics still have a role to play debates on cl-ch?	cl-ch	BBC	Sci/Nat
Mon 19-Nov-2007				
	obit: Alan Southward, marine biologist, expert on climate-driven change	cl-ch	Grdn	Science
	Home truths - why Gordon Brown believes climate care begins at home	cl-ch	BBC	Sci/Nat
	Climate dilemma-trying to square economic growth w/fossil fuel redux	cl-ch	BBC	Sci/Nat
	PM outlines climate action plan	cl-ch	BBC	Sci/Nat
	UN challenges states on warming	cl-ch	BBC	Sci/Nat
	Climate will "undo Asian success"	cl-ch	BBC	Sci/Nat
	J Fairweather, Digging toward Decline, spends on energy security	E	WP	Ed/Op
	A greenwash brigade - Dot Earth blog	eco	NYT	Sc&Env
	Chinese Dam projects criticized for their human costs	E/pollu	NYT	Sc&Env
	A deeply green city confronts its E needs & nuc. worries, Ft.Collins CO	E-city	NYT	Sc&Env
	UN Chief seeks more climate change leadership	cl-ch	NYT	Sc&Env
	US won't define dangerous warming, Revkin	cl-ch	NYT	Sc&Env
	UN report describes risks of inaction on climate change	cl-ch	NYT	Sc&Env
Tues 20-Nov-2007				
	Canadian cities near collapse: FCM	ARC	G&M	Nat'l
	Infrastructure needs $123 billion to avoid collapse: study	ARC	CBC	10most
	Through genetics, tapping a tree's potential as a source of E	E	NYT	Science
	At a crossroads - political power needs to turn the hydrogen economy	E	BBC	Sci/Nat
Wed 21-Nov-2007				
	China to address issues around Dam	E	NYT	main
	Brown sets tough carbon targets	cl-ch	Grdn	Sc&Env
	We'll fight you all the way, airlines warn EU over carbon-trading plans	cl-ch	Grdn	Sc&Env
	UN scientist urge carbon tax to fight global warming	cl-ch	Grdn	Sc&Env
	Playing the meter - will "smart meters" make us E obsessives?	E	BBC	Sci/Nat
Thur 22-Nov-2007				
	Top Ten eco-buildings (UK)	ARC	Grdn	feature
	Council defers Kent power-station decision	E	Grdn	Sc&Env
	Sixth terminal plan at Heathrow	ARC	BBC	England
	Laos wants hydro-electric power to pump up its development	E	BBC	Sci/Nat
	UN plots Chernobyl zone recovery	E/pollu	BBC	Sci/Nat
	Sweden turns to a promising power source, with flaws (wind)	E	NYT	Business
Fri 23-Nov-2007				
	Canada assailed over climate change (Commonwealth vs. Harper)	cl-ch	G&M	Nat'l
	Harper alone on climate change at Commonwealth summit	cl-ch	CBC	10most
	Tread lightly - how much C can you save by cutting down on car travel?	cl-ch	Grdn	feature
	Exposed: UK's highest emitters … County Down households	cl-ch		
Mon 26-Nov-2007				
	Monbiot - need for new housing	ARC	Grdn	feature
	EU President backs Brown's CO_2 target	cl-ch	Grdn	Envir't
	The carbon cost of protecting our heritage	cl-ch	Grdn	Envir't
	CBI report urges business to tackle climate change	cl-ch	Grdn	Envir't
	Better ocean monitoring "vital"	cl-ch	BBC	Sci/Nat
	Homes can cut CO_2 by up to 80%	cl-ch	BBC	Sci/Nat
	Australian change - new PM to steer away from US on cl-ch and Iraq	cl-ch	BBC	Sci/Nat

Date	Relevance	Source	Section
Jolly and Green, with an agenda	eco	NYT	Style
Climate, coal and Crematoria	cl-ch	NYT	Science
Tues 27-Nov-2007			
China challenges critics on dam safety	E	WP	main
Google's search for clean electricity, Revkin	cl-ch	NYT	Business
10 years to mend our ways, warns UN	cl-ch	Grdn	main
Eco-park to lead Falkirk regeneration (Scotland)	cl-ch	Grdn	Envir't
Report sets out blueprint for 80% home carbon cuts	cl-ch	Grdn	Envir't
UK companies need to "take the challenge of climate change seriously"	cl-ch	Grdn	Envir't
Google invests in renewable E development	cl-ch	Grdn	Envir't
Science advisors' independence of mind - Sir David King	cl-ch	BBC	Sci/Nat
Homes can make deep CO_2 cuts	cl-ch	BBC	Sci/Nat
Poorest in climate front line	cl-ch	BBC	Sci/Nat
Google's cheaper-than-coal target	cl-ch	BBC	Sci/Nat
Wed 28-Nov-2007			
Quebec to voice dissenting view at Bali	cl-ch	G&M	Nat'l
Scientists pinpoint sunniest places on earth 6.92 & 6.78 KWh/m^2/day	cl-ch	Grdn	main
UN calls for huge push on climate change	cl-ch	Grdn	Sc&Env
UK carbon reduction strategy attacked	cl-ch	Grdn	Sc&Env
British E draws up new reactor plans	E	Grdn	Sc&Env
Boeing ad grounded over green claims	cl-ch	Grdn	Sc&Env
Venus offers earth climate clues	cl-ch	BBC	Sci/Nat
Candidates offer different views on E policy	E	NYT	Business
UN warns of climate-related setbacks	cl-ch	NYT	Science
Congress called near compromise on fuel economy bill	E	NYT	Science
China says Three Gorges Dam is not responsible for landslides	E	NYT	Science
Thurs 29-Nov-2007			
Quebec distancing itself from Ottawa on Kyoto	cl-ch	G&M	Nat'l
Enbridge aims at restart after pipeline explosion (Minn, 2 died)	E	CBC	10most
Green gifts - real treats that don't cost the earth	eco	Grdn	feature
Stern raps "market failure" on climate	cc-bus	Grdn	Sc&Env
Report reveals poor green record of luxury firms	cc-bus	Grdn	Sc&Env
Europe's trees absorbing more carbon	cl-ch	Grdn	Sc&Env
Venus offers earth climate clues	cl-ch	BBC	Sci/Nat
Fire shuts key Canada-US pipeline	E	WP	main
Christmas' Green makeover	eco	WP	SmLvg
Can fabulous save the planet? The year of eco-decorating	eco	NYT	Style
Not down and out in Moscow (oil boom)	E	NYT	Style
UN warns of climate-related setbacks, Revkin	cl-ch	NYT	Science
Fri 30-Nov-2007			
Cold beers warming the planet, study says	cl-ch	CBC	10most
Study details how US could cut 28% of greenhouse gases	cl-ch	NYT	Business
Business leaders call for climate pact	cl-ch	Grdn	main
Consumers name green "sins" (wasting energy at home big for Britons)	E	Grdn	Sc&Env
Business call for plan on climate	cl-ch	BBC	Sci/Nat
Mon 3-Dec-2007			
The threat from cl-ch demands a reappraisal of who we are, Monbiot	cl-ch	Grdn	feature
UK to seek pact on shipping and aviation at climate talks	cl-ch	Grdn	Sc&Env
IT industry urged to address growing carbon footprint	cl-ch	Grdn	Sc&Env
Us/UK accused of ignoring impact of rising sea level	cl-ch	Grdn	Sc&Env
Parties unite to stop government backsliding over renewables rule	E	Grdn	Sc&Env
Ice scream - Ben and Jerry's founder turns attention to climate change	cl-ch	BBC	main
Tropics "expand" as world warms	cl-ch	BBC	Sci/Nat

Date		**Relevance**	**Source**	**Section**
	Key climate summit opens in Bali	cl-ch	BBC	Sci/Nat
	50 years on: the Keeling curve	cl-ch	BBC	Sci/Nat
	Carbon capture plan for the Forth	cl-ch	BBC	Sci/Nat
	Southern California ports move to curb emissions from shipping	cl-ch	NYT	Science
	Climate talks take on an added urgency after report	cl-ch	NYT	Science
	Algae emerges as a potential fuel source	E	NYT	Science
	San Fransisco fleet is all biodeisel	E	NYT	Science
	In Alaska, whalers fear oil drilling may curtail way of life	E	NYT	Business
	Calculating E bills' real figures	E	NYT	Business
Tues 4-Dec-2007				
	Floods threaten millions of lives	cl-ch	Grdn	Sc&Env
	Mayor launches green homes service for Londoners	ARC	Grdn	Sc&Env
	Internet hoax raises pressure over emissions	cl-ch	Grdn	Sc&Env
	New US E bill meets green lobby approval	E	Grdn	Sc&Env
	Brad Pitt's plan for New Orleans homes	ARC	Grdn	Sc&Env
	Top 20 carbon-emitting countries	cl-ch	Grdn	Sc&Env
	Australia ends 10-year Kyoto exile	cl-ch	Grdn	Sc&Env
	A new business perspective on climate change, Tony Juniper	cl-ch	Grdn	Sc&Env
	Ratifying Kyoto - how cl-ch lept to the top of Australia's agenda	cl-ch	BBC	main
	E companies "exploit poor"	E	BBC	England
	Poorer nations should stop whining and start leading on climate	cl-ch	BBC	Science
	Need some eco-coaching to live more green?	eco	WP	SmLvg
	Geo-engineerging Earth? Homer-Dixon	cl-ch	G&M	Nat'l
	Stuck on coal, and stuck for words in a high-tech world, Revkin	E	NYT	Science
	A few hundred things the next President can do to limit warming	cl-ch	NYT	Science
Wed 5-Dec-2007				
	Lasers point way to clean E (renewables)	E	Grdn	Sc&Env
	Every reason for optimism at Bali	cl-ch	Grdn	Sc&Env
	Sea of troubles - sea bed, rich trove of minerals, oil and gas	E	Grdn	Sc&Env
	Activists stop Welsh coalmine excavation	E	Grdn	Sc&Env
	Crossing a threshold on E legislation	cl-ch	NYT	Science
	Ethanol advocates push for more in regular cars	E	NYT	Business
	Ont. reactor shutdown forces cancellation of cancer tests worldwide	E	CBC	10most
	Key medical tests hit by Cdn reactor shutdown (Chalk R mntnce)	E	G&M	Nat'l
	Thomas Homer-Dixon discussion on global warming	cl-ch	G&M	Nat'l
Thurs 6-Dec-2007				
	The greening of Sen Warner - near career's end, goal pass bill on ghgs	cl-ch	WP	main
	Outdoor holiday displays using LEDs to save E	E	WP	main
	Turnabout on fuel standards	E	NYT	Business
	House sets higher goal for vehicle fuel efficiency	E	NYT	Science
	Forest loss in Sumatra becomes a global issue	cl-ch	NYT	Science
	Senate panel passes bill to limit greenhouse gases	cl-ch	NYT	Science
	US congress passes global warming bill	cl-ch	Grdn	main
	Katine, climate concerns - Watching where they tread, John Vidal	cl-ch	Grdn	feature
	Most of Amazon "lost" by 2030	cl-ch	Grdn	Sc&Env
	People power: Tories see 1 M households selling elec. back to suppliers	E	Grdn	Sc&Env
	BP to pump billions into oil sands	E	Grdn	Sc&Env
	All nations "need emission goals"	cl-ch	BBC	Sci/Nat
	Australia to be "climate bridge"	cl-ch	BBC	Sci/Nat
Fri 7-Dec-2007				
	Tread lightly - turn your Ch-mas lights off for longer and help cut emiss	cl-ch	Grdn	feature
	BP's oil sands plan condemned	cl-ch	Grdn	Envir't
	Tax deal for North Sea oil fields	E	Grdn	Envir't
	Oil spill after South Korea collision	E/pollu	BBC	Science

Date		Relevance	Source	Section
	Scientists consider taking solar E out of this world	E	BBC	Science
	Make big emitters sign on to targets: Baird	cl-ch	G&M	Nat'l
	MEC halts sales of plastic containers with BPA	eco	CBC	10most
	E bill vote blocked (in Senate, after House passed it)	E	WP	main
	Officials: major oil spill off South Korea	E/pollu	WP	main
	Senate blocks E bill (fuel economy standards)	E	NYT	main
	Trucks power China - at a suffocating cost	E/pollu	NYT	main
	Automakers change course on fuel standards (cheering sen. vote contra)	E	NYT	Business
	A leading Asian utility to cut carbon emissions - CLP	cl-ch	NYT	Business
	Bali update: pushing for action, not talk	cl-ch	NYT	Science
	Warming takes out defense radars (NORAD bases slipping into arctic	cl-ch	NYT	Science
Mon 10-Dec-2007				
	Business gets voice on Canada's Bali delegation	cc-bus	G&M	Nat'l
	Baird announces $85.9 million for climate change	cl-ch	G&M	Nat'l
	McGuinty tells Harper Canada must have hard targets for emissions	cl-ch	G&M	Nat'l
	Gore urges bold moves in Nobel speech	cl-ch	NYT	main
	Pete Seeger's day of climate action	cl-ch	NYT	Science
	Koreans struggle to clean up oil spill	E/pollu	NYT	Science
	Two top polluters oppose caps in Bali	cl-ch	NYT	Science
	Efforts to harvest ocean's E open up new debate front	E	NYT	Science
	Warming and the right	cl-ch	NYT	Science
	Dems, White House split on warming	cl-ch	WP	main
	In Nobel speech, Gore pushes US, China, on action	cl-ch	WP	main
	Gore plea to US and China	cl-ch	BBC	main
	Wind farm plans	cl-ch	BBC	England
	Rainforest dilemma - deforestation adds to climate woes, but …	cl-ch	BBC	Sci/Nat
	Taming Timbuktu … farmers … turn Mali's desert green	cl-ch	BBC	Sci/Nat
	Dirty words - why the world is unlikely to keep climate under control	cl-ch	BBC	Sci/Nat
	US balks at Bali carbon targets	cl-ch	Grdn	main
	Fuel activists plan weekend protests	cl-ch	Grdn	main
	Hot air - is the government serious about wind farms?	cl-ch	Grdn	feature
	South Korea - oli clean up image gallery	E	Grdn	Sc&Env
	Pioneering project to save Sierra Leone forest from loggers	cl-ch	Grdn	Sc&Env
Tues 11-Dec-2007				
	Gas terminal proposed off New Jersey	E	NYT	main
	White House seeks change in mileage measure	E	NYT	main
	In duck blinds, visions of global warming	cl-ch	NYT	Science
	Always on, appliances - link to Lawrence Berkeley Labs studies	E	NYT	Science
	Holiday guide: eco-friendly gifts	eco	WP	SmLvg
	Bali breakthrough on deforestation	cl-ch	Grdn	main
	Global warming threatens four Antarctic penguin species	cl-ch	Grdn	feature
	Big oil lets sun set on renewables (Shell sold off)	E	Grdn	Sc&Env
	Electrolux urges EU to offer cash for green white goods	cl-ch	Grdn	Sc&Env
	Use eco-celebs to promote green message, ministers told	cl-ch	Grdn	Sc&Env
	Green realtiy - Furniture store … story about renewables	E	Grdn	Sc&Env
	The real answer is to leave fossil fuels in the ground, Monbiot	cl-ch	Grdn	Sc&Env
	Special report: low-carbon UK	cl-ch	Grdn	Sc&Env
	Beach fest - can the balmy seas of Bali ease the path to cl- solutions?	cl-ch	BBC	main
	Blooming stupid - why ocean fertilization ... more harm than good	cl-ch	BBC	Sci/Nat
	Green innovation - Japan's struggle to maintain its rep for E efficiency	E	BBC	Sci/Nat
	Low faith in biofuels for climate	cl-ch	BBC	Sci/Nat
Wed 12-Dec-2007				
	An eco-friendly use for old TVs	eco	WP	SmLvg
	Federal judge upholds law on emissions in California (cars & trucks)	cl-ch	NYT	Business
	Deadlock stymies global climate talks	cl-ch	NYT	Science

Date		**Relevance**	**Source**	**Section**
	Benn: we may not get carbon deal	cl-ch	Grdn	main
	Podcast: eco-talk, 4 columnists online from Bali	cl-ch	Grdn	feature
	Algae give Shell a greener tinge (to convert to biofuel)	E	Grdn	Sc&Env
	The winds of change: Bangladesh, recent cyclone part of trend	cl-ch	Grdn	Sc&Env
	Carbon myths, Chris Goodall	cl-ch	Grdn	Sc&Env
	Science chief calls for green technologies	E	Grdn	Sc&Env
	Climate maps - forecast for global env'l change and its impacts	cl-ch	BBC	main
	Oil spill in North Sea off Norway	E/pollu	BBC	Science
	Arctic summers ice-free by 2013	cl-ch	BBC	Science
	Crunch time for climate change	cl-ch	BBC	Science
	A greener way to recover methane	cl-ch	BBC	Science
Thurs	***13-Dec-2007***			
	Gore quotes NHL icon in apparent dig at Canada's climate stance	cl-ch	CBC	10most
	Bitter divisions at climate talks	cl-ch	NYT	main
	Senate moves toward final vote on E bill	E	NYT	main
	Impasse deepens at Bali talks	cl-ch	WP	main
	Senate GOP blocks E bill	E	WP	main
	EU tells US "wake up" to climate peril	cl-ch	Grdn	main
	The mighty fallen (great forests)	cl-ch	Grdn	feature
	War of words on climate change escalates	cl-ch	Grdn	Sc&Env
	German solar power goes into eclipse (Conergy)	E/pollu	Grdn	Sc&Env
	2007 data confirms warming trend	cl-ch	BBC	Science
	Pricing the forest - the Borneo village taking a chance on carbon trading	cl-ch	BBC	Science
Fri	***14-Dec-2007***			
	At Bali climate talks, signs of compromise	cl-ch	NYT	main
	Carbon dioxide threatens reefs, report says	cl-ch	NYT	Science
	A world consumed by guilt - eco-shopping (clothes)	eco	NYT	Style
	Homespun electricity, from the wind	E	NYT	Style
	Gas prices spark inflation (clothing, air tickets, prescrips. most in 2yrs)	E	WP	main
	Envoys take overnight break as Bali conference extended	cl-ch	CBC	10most
	Climate change talks on brink of agreement	cl-ch	Grdn	main
	Acidic seas may kill 98% of world's reefs by 2050	cl-ch	Grdn	Sc&Env
	UK heading for second hottest year	cl-ch	Grdn	Sc&Env
	Climate talks edge towards deal	cl-ch	Grdn	Sc&Env
	Barratt to build UK's first eco-village	ARC	Grdn	Sc&Env
	Iraqi oil exceeds pre-war output	E	BBC	main
	Climate talks "on brink" of deal	cl-ch	BBC	main
	Keep to law, fuel protestors told (price over £1 per litre)	E	BBC	England
	The "other hole" - scientists watch surface ozone collapse in the Arctic	cl-ch	BBC	Science
	Planet Bali - exploring the parallel worlds of the UN climate conference	cl-ch	BBC	Science
Mon.	***17-Dec-2007***			
	Climate plan looks beyond Bush's tenure	cl-ch	NYT	Science
	As China goes, so goes global warming	cl-ch	NYT	Science
	Our decrepit food factories - what sustainability is all about	food	NYT	Science
	Before it disappears - travellers chasing	bus	Grdn	Envir't
	Planning boost for green homes	ARC	Grdn	Envir't
	Hutton warns on politicization of E supplies	E	Grdn	Envir't
	US pours cold water on Bali optimism	cl-ch	Grdn	Envir't
	UN warns on soaring food prices - crops for biofuel displacing food	cl-ch	BBC	main
	Green Land Rover? - carbon offsetting schemes in Uganda	cl-ch	BBC	Sci/Nat
	US sets terms for climate talks	cl-ch	BBC	Sci/Nat
	Rising seas "to beat predictions"	cl-ch	BBC	Sci/Nat
	Fuel or future? - officials attempt to stop felling of trees in Gorilla sector	E	BBC	Sci/Nat
	The big melt - scientists reflect on an astonishing summer in the Arctic	cl-ch	BBC	Sci/Nat
	Bali roadmap - the climate deal that has something for everyone	cl-ch	BBC	Sci/Nat

Date		Relevance	Source	Section
Tues. 18-Dec-2007				
	House passes sweeping E bill	E	NYT	main
	Contrarians vs. Bali, Tierney lab	cl-ch	NYT	Science
	Food and fuel compete for land	E	NYT	Business
	As ethanol takes its first steps, Congress proposes a giant leap	E	NYT	Business
	Twisting the Pope's words on climate change (Bad Science)	cl-ch	Grdn	Sc&Env
	climate change at heart of planning	cl-ch	Grdn	Sc&Env
	What did we achieve in Bali?	cl-ch	Grdn	Sc&Env
	Bali talks - getting weepy (chair led away in tears)	cl-ch	Grdn	Sc&Env
	Carbon atlas	cl-ch	Grdn	Sc&Env
Wed 19-Dec-2007				
	Rail line could put Alberta on green track, Premier says	cl-ch	G&M	Nat'l
	President Bush signs E bill	E	WP	main
	EPA says 17 states can't set emission rules for cars	E	NYT	main
	Park plan is chosen for Governor's Island - architect selected	ARC	NYT	main
	The E future ... first utility scale zero-emiss coal fired elec	E	NYT	Science
	Bush signs US climate change bill	E	Grdn	main
	EU unveils plans to cut car emissions	cl-ch	Grdn	Sc&Env
	Racing round the world on biofuel	E	Grdn	Sc&Env
	Are driverless pods the future?	cl-ch	BBC	Sci/Nat
Thurs 20-Dec-2007				
	EU cap on air emissions (2012 airlines into emissions trading scheme)	cl-ch	BBC	main
	Cold comfort - a new service... reducing heat loss in your home	E	Grdn	Sc&Env
	Carmakers angry over European emissions curbs	cl-ch	Grdn	Sc&Env
	The Green House as classroom	ARC	NYT	Science
Fri 21-Dec-2007				
	Economic bite from g-house gas reductions will spark criticism: Harper	cl-ch	CBC	10most
	Russia signs deal for gas pipeline along Caspian Sea	E	NYT	Science
	Plan on airline emissions hints at US-Europe rift	cl-ch	NYT	Science
	Climate message - you are caught in an elevator w/pres'ial candidate…	cl-ch	NYT	Science

LEGEND

Relevance

ARC	architecture
bus	business
cl-ch	climate change
cc-bus	climate change & business
city	city planning
E	energy
E/c-ch	energy & climate change
E/poll	energy & pollution
E/wthr	energy & the weather
eco	ecology or the environment, general issue(s)
eng'g	engineering
food	agriculture, food production, sustainability
pollu	pollution
pu-hlth	pollution related to health effects in humans
POL	politics
sust	sustainability, in general

Source

BBC	British Broadcasting Corporation
CBC	Canadian Broadcasting Corporation
G&M	Globe & Mail
Grdn	The Guard
NYT	The New York Times
WP	The Washington Post

Section

5most	5 most-often read stories on news service website
10most	10 most-often read stories on mews service website
bg most	blogged-most for the previous day
feature	special section
front	home page on news service website
main	home page on news service website
NY Reg	New York Region section in The NY Times
Science	Science section in The NY Times
Sci+Env	Science and Environment section in The Guard
Sci/Nat	Science and Nature section in the BBC
SmLivg	Smart Living section in The Washington Post

Figure A-1.4
List of headlines from the architectural press, January – December, 1997

Date		Relevance	Source	Page
Jan-1997	The Metropolis Observed: coal still heats schools	E	Metrop	33
	Building holistically: Elix Wright Ingraham, by Eugenia Bone	ideas	Metrop	76
	Solar E in Archre and Urban Planning, ed. T Herzog, Prestel	books	Azure	36
	Some Glowing Issues, Overhill on light bulbs-Fed E-Eff Act	E	Azure	46
Feb-1997	Technical Green building in the Healthy House	res	CdnA	29
Apr-1997	What architecture can do - Samuel Mockbee's students	res	Metrop	76
May-97	Strawberry Vale School, Patkau	passive	CdnA	16
	A Critic writies: Essays by Reyner Banham, book review	books	Azure	49
Jun-97	Are arch awards superficial - should enviro factors be given more weight?	awards	CdnA	24
	For office buildings, now is the right time to change	practice	A-REC	3
Jul-1997	APEGBC, Busby - review by J McMinn	non-res	CdnA	17
	EPA hopes its renovated bldgs will set new "green" standard	policy	A-REC	25
	Chapel of St. Ignatius, Seattle University, Steven Holl	other	A-REC	40
	Energetics issue: Who's responsible?	E, eng'g	ArRev	4
	Commerzbank, Essen, Dresden, Nuremberg	non-res	ArRev	25
	Austin TX, Hotson Bakker Prince George, Victoria, Nairobi	various	ArRev	25
	Island outposts-C Blackwell sust. resort, Jamaica Strawb. Hill	res	Metrop	60
	By design … supercars - Amory Lovins at RMI	ideas	Metrop	44
Aug-1997	NBC goes digital and NMS goes green	spec	CdnA	41
	Skyscraper bioclimatically considered, Yeang; eco culture, Abel	books	ArRev	88
Sep-97	North of 60 - Pin/Matthews Arch face unique challenges	north	CdnA	10
	Tech-HiPerf windows in C2000 model office bldgs (D Kerr)	product	CdnA	27
	Ian McHarg's Quest for Life (book review)	books	ArRev	96
Oct-1997	GDGB - Business Week/Arch Record	business	A-REC	54
	re Herman Miller	cases	A-REC	65
	private enterprise embraces sust. design (Bostono-Duracell)	business	A-REC	39
	Fred Thompson on public space in Japan	other	ArRev	78
Nov-1997	Building in a grunkultur, Slessor checks out 3 new office bldgs	ideas	Metrop	86
	Mapping the Green - Montreal	-	Azure	19
Dec-1997	Cdn Archt Awards of Excellence - Shades of Green		CdnA	15
	Bldg for communities - improve self image of user and society	ideas	A-REC1	59
	How long should buildings last?	durable	A-REC	135
	Art gallery, Beyeler, Basle, SW, Piano	non-res	ArRev	59
	Nature centre, Norway, Lund & Slaatto	non-res	ArRev	67
	Books of the year: Commerzbank, Eco-Tech	books	ArRev	90
	Smog can be wiped out - Douglas Page on air scrubbers	infra	Metrop	43

Figure A-1.5
List of headlines from the architectural press, July 2006 to June 2007

Date		Relevance	Source	Page
Jul-06	Housing: off-grid mobilehome, sust'le house comp'n Wdbrg "Archetype"	res	CdnA	
J-A-06	Q&A Ken Yeang	non-res	Azure	32
Aug-06	Super tall and Ultra Green - SOM tower, Guangzhou to generate power	non-res		106
	"Green by Design" issue - exhibits, books, tech, lighting, products	books	A-REC	
	Big Ideas for a Little Planet	ideas	A-REC	73
	Hearst Tower, NYC	non-res	A-REC	74
	Fed Envi'l Agency, Dessau	non-res	A-REC	82
	National Library, Singapore	non-res	A-REC	90
	National Assembly for Wales	non-res	A-REC	100
	View; Change of climate (hot latitudes) +6 projects in hot; book review	books	ArRev	theme
Sep-06	E-Effic Arch're: Basics for Planning and Construc - review	books		96
	Green roofs: the key to cooling our concrete cities - 4 articles	gn roof	Metrop	98
	NA colleges and univs integrating envl practices into design education	EDU	Metrop	82
	Wine in a Box - Stratus	Gt Lakes	Azure	134
	On the Up in New York - trends include sustainable design	trends	Azure	158
	Selling the light of day: The future looks bright for bldg-integated PV	products	A-REC	149
Oct-06	book reviews 2: Ten Shades, Sustl Living, Gauzin-Muller	books	Metrop	134
	none		A-REC	
Nov-06	Peter Cook - on the meaning of the actual stuff of architecture	ideas	ArRev	34
	Cook + Fox turns its office into the kind of green archr the firm espouses	non-res E	Metrop	70
	ad re Armstrong ceiling recycling program - gg redux, elec e saved	products	Metrop	toc
	News U Calgary, Pavillion Lassonde	Gt Lakes	CdnA	
	Civic buildings (Murdock) and 2 examples - southern enviro centers	non-res	A-REC	167
N-D-06	The Straw House and Quilted Office	aesthetic	AD	27
	Camouflage as aesthetic sustainability	aesthetic	AD	62
	Stephen Holl's elegant and energy-efficient Swiss Res in Washington DC	res E	Azure	
	Q&A: Rick Fedrizzi	LEED	Azure	
	136 pp on houses and city plans - almost nothing at med bldg scale	res & city	Azure	
Dec-06	The Path to Platinum - Ken Shulman on BNIM	practice	Metrop	108
	Ed Mazria's environmental progress	2030 Ch	Metrop	46
	Arch Tech - bldgs are the greatest of all energy consumers	E	A-REC	153
	Centre for Interactive Res on Sust'y (Van)	non-res	A-REC	155
	When Less powers more (graphs)	E	A-REC	164
	In search of the zero energy holy grail	E	A-REC	170
	SOM's Pearl River Tower	non-res	A-REC	172
	Top Ten Green products (BuildingGreen)	products	A-REC	219
	Awards: Manitoba Hydro	non-res	CdnA	

Date		Relevance	Source	Page
Jan-07	Six projects set a new benchmark for green interiors - 2 deal w/energy	E	Metrop	66
	historic pres meets planet preserv in Portland - armory theatre	hist pres	Metrop	38
	Mark Oberholzer explores the urban highway's potential for wind power	E gen	Metrop	52
	Systems of sustainability + Cultural landscapes theme issue	ideas	CdnA	
	Viewpoint-DionCC, McFarland, Brickworks (*& Welland Civic Centre)	ideas	CdnA	
	Office Buildings - James Murdock LEED 6% commercial real estate 2006	non-res	A-REC	101
	Always green building, always, Wal-Mart announces (news)	bus policy	A-REC	22
J-F-07	Terrence Donnelly Centre	Gt Lakes	AD	124
	New Kid on the Block - Tor home mod sust'le - Levitt Goodman	res	Azure	54
	The Green Indoors - IIDEX/NeoCon - more green in your wallet	business	Azure	104
Feb-07	Engineering architecture … Werner Sobek	eng'g	ArRev	74
	The Greening of Science - biomolecular labs Behnisch	Gt Lakes	Metrop	81
	LEED by any other name: Ripple Rock Elem, McFarland	LEED	Metrop	46
	News - LEED Silver Port Moody School, Coq.- 1st LEED school in Cda	LEED	CdnA	12
	Cities begin requiring private devel's to go green - with and w/out LEED	policy	A-REC	28
Mar-07	reviews: Ecodesign: A Manual for Ecological Design, Ken Yeang	books	ArRev	92
	Winners of Equilibrium competition announced	zero	CdnA	40
	book review: Cda Innovates, Ferrara and Visser	books		
	Mayor Blumberg creates sustainability office - NY	policy	A-REC	38
	Wm McDonough - interview by Robert Ivy	ideas	A-REC	82
	PAAM	Gt. Lakes	A-REC	102
	Government Buildings - open and shut - curtain walls and skylights	non-res	A-REC	129
	Limerick County Council - green agenda	non-res	A-REC	140
	Less than zero - or how to design a C neutral world before its too late	zero	A-REC	151
	The Zero Effect	zero	A-REC	153
	Zero-carbon cities	zero	A-REC	161
	Following C ftprnts leads archs and consults to their own doorsteps	practice	A-REC	166
Apr-07	Capturing and enhancing light in buildings	light	ArRev	82
	Aalto through the eyes of Shigeru Ban (exhibition review)	ideas	ArRev	96
	A trip to the Persian Gulf… cities based on principles of sustainabiity	cities	Metrop	30
	Blessed Unrest, Hawken, book review	ideas	Metrop	92
	The colour forecast …. earthier	mktg	Metrop	146
	Places to Grow - intensification of GTA	policy	CdnA	47
May-07	What extreme env'ts … teach us about living on Earth	ideas	Metrop	24
	The Power of Youth … energy … generate sust'l design concepts	E	Metrop	164
	Report - how much sustainable arch're is really being produced in NW	ideas	CdnA	60
	The Green Revolution (feature issue)	ideas	Azure	
	A Growing Concern - Tor Bot Gdn, Pamela Young	Gt. Lakes	Azure	74
	Q&A Peter Busby (calling other archts liars)	ideas	Azure	36
	Material world: renewable energy	ren E	Azure	123
	book review: the Green Studio Handbook	books	Azure	128
	AIA to green its HQ	non-res	A-REC	48
	Getting aggressive about passive design - is a/c the dirty word …	E	A-REC	241
M-J-07	Defining distinction …. Renzo Piano		AD	20
	Yeang's Eco Files - Power Plants (Ken Yeang)	non-res h	AD	130
Jun-07	reviews: Eco'l Design, vanderRyn, Judging Arch'l Value, Wm. S. Saunders	books	Metrop	174
	cities need your skills to take them into a carbon-free future	zero	Metrop	28
	The Road to 2030, Brian Lilley on 3 landmark projects	non-res C	CdnA	23
	Nominations open for 2008 Annual Global Award for Sust'le Archre	awards	CdnA	11

a2

two BUILDINGS x three YARDSTICKS

PURPOSE

- to determine whether three of the “whole building” yardsticks differ significantly in their overall assessment of the “greenness” of buildings
- if they do differ, to determine whether the difference falls along the following lines: one rewards energy efficiency/ climate change mitigation while another prefers other measures rather than energy (such as land-use, indoor air/ light/temperature qualities, or material selection)
- be able to comment on any issues/complications with using BREEAM and Green Globes for the fist time

HUNCHES GOING IN

- since BREEAM is the “parent” of the other two yardsticks, there should not be a significant difference in the score resulting from each, but there may be

- if there is a difference, then BREEAM will reward energy/ pollution while LEED will reward "bike racks and bamboo flooring"; Green Globes may be a moderate, in between
- BREEAM may contain technical assumptions (reference standards, etc.) that are difficult to translate to a North American application

METHOD

- select two buildings from the LEED Ca list (why? two-is enough to start; LEED-gives full list of all rated buildings and their rating, so can choose two reasonably similar in use, size and location; Ca-can pick two in a very cold climate, can get full LEED point summary for it plus recent info published elsewhere)
- pick one building that shows max points in LEED for energy
    - AUMA, at 10/10 though only Certified overall, shows a distinct preference for energy points over other types of points
- pick a second building that shows far fewer energy points, but a very good overall LEED rating
    - in LEED Gold, there are projects that earned 4-10 energy points; the PCL Centennial Learning Centre was chosen because it is in the same city as building 1, its floor area is in the same order of magnitude (although very different design), and a comparable use
- apply BREEAM pre-assessment estimator and Green Globes Post-Construction Assessment list to each building, and estimate score in each
- observe the differences and reflect on values inherent in the yardsticks

OBSERVATIONS

- looking at the overall placement of the buildings:
    - the assessment of the two buildings in LEED is the inverse of the assessment in the other two yardsticks
    - even if AUMA had gotten credit, in LEED, for some things it maybe did (building re-use 1, waste mgmt 1, construction IAQ 1, indoor chemical. control 1, thermal comfort 1, renewables 3) it would get to 37ish, or high Silver – would need several (4+) more points to trump Building 2 by any margin
    - in BREEAM, Building 1 betters Building 2 by a wide margin (not just a little)
    - in Green Globes Building 1 better Building 2 (as in

BREEAM), by only a small margin (close to nil)

- looking at the comparative proportions of the yardsticks themselves
    - the territory of LEED Certified and Silver is small, proportionally (makes it easier to go up a notch?)
    - 3 Globes sounds like it should equate to Very Good or Gold, and the score of these buildings supports that assumption (although the yardstick and % score look differently proportioned); Green Globes offers a wide territory for 1 and 2 Globes, but very little for 4 Globes (a different way of encouraging participation at the entry level?)
    - BREEAM starts its "pass" at a lower % that the others (25% vs. 38% in LEED and 35% in GG) – this magnifies the lense in which green buildings may be gauged by BREEAM, and disavows non-green buildings (seems to make more sense … a product of an older, more developed, more widely adopted system?)
- comments on usability:
    - BREEAM is much easier to apply than anticipated
    - Green Globes is much less easy to apply than anticipated – very frustrating – after 6 hours of trying: shoddy, sloppy wording (esp energy section) leaves lack of clarity as to compliance; still not clear what scores are cumulative or how "n/a" points are dealt with
    - Green Globes is highly prescriptive – almost every point includes a specific design measure (e.g. sunshades) – many of the m/e measures seem to be A 90.1 compliant (e.g. min code) so rewarding points seems inappropriate

CONCLUSIONS

- the yardsticks differ significantly in what they measure,
- reward is given in significantly different proportion, by BREEAM vs. LEED, for the various aspects measured
- the difference does fall along energy-climate change vs. other issues
    - BREEAM rewards land-use and renovation highly
    - BREEAM also rewards material selection, but NOT enough to over-ride energy/climate change measures
- difficulty tallying GG prevents certain-sure assessment where it fits, relative to the other two (appears to favour energy more than LEED)

Figure A-2.1 (opposite) LEED scorecard for Building 1, AUMA

BUILDING 1, "LOW ENERGY" (AUMA)

- expansion and renovation = 9,600 sf office building
- established suburban/urban lot, well-served by transit bus
- design emphasizes energy-efficiency (10/10 pnts in LEED v 2 (US), for 60% performance vs. A 90.1) and water conservation
- energy measures:
    - reduced loads: punched openings in brick exterior wall
    - free energy: geothermal heating and cooling
    - efficient equipment: ?
    - renewable sources: purchased 100% green power
- other measures:
    - locally sourced materials
    - low- and no-water fixtures
    - bicycle racks and showers
    - low VOC paints and other finishes
    - > 90% workspaces w/access to daylight (small floorplate)
- rated LEED Certified (29/69 points) in June, 2004
- not listed on CBIP register

BUILDING 2, "GREEN MATERIALS" (PCL)

- new approx. 26,157 sf office and conference building
- light industrial site, attached to 2 other buildings, all surrounded by parking, served by transit bus
- modest improvement in energy performance is coupled with more measures related to material selection
- energy measures:
    - reduced loads: triple-glazing, R-15 walls, R-20 roof
    - free energy: pre-heating and cooling via 50 m. underground air intake trench; passive cooling via solar chimney with motorized dampers
    - efficient equipment: high-efficiency boilers, demand-controlled ventilation
    - renewable sources: green power
- other measures:
    - green roofs and white "Energy Star" roofs
    - rainwater harvesting,
    - low- and no-water fixtures
    - bicycle racks and showers
    - low VOC paints and other finishes
    - construction waste diversion & IAQ plan
    - monitoring: CO_2, thermal
    - innovation credits (unspecified)
- rated LEED Gold (39/69) in September, 2006
- listed on CBIP register, predicted energy intensity: 1,433 MJ/m^2/yr which is 398 kWhr/m^2/yr – mid-current-average range

Alberta Urban Municipalities Association Addition and Renovations

LEED® Project # 2078

LEED Version 2 Certification Level: CERTIFIED

June 25, 2004

29 **Points Achieved** Possible Points: **69**

Certified 26 to 32 points **Silver** 33 to 38 points **Gold** 39 to 51 points **Platinum** 52 or more points

5	**Sustainable Sites**	Possible Points:	**14**
Y			
Y	Prereq 1	**Erosion & Sedimentation Control**	
1	Credit 1	**Site Selection**	1
	Credit 2	**Urban Redevelopment**	1
	Credit 3	**Brownfield Redevelopment**	1
1	Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
1	Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
	Credit 4.3	**Alternative Transportation**, Alternative Fuel Refueling Stations	1
1	Credit 4.4	**Alternative Transportation**, Parking Capacity	1
	Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	1
	Credit 5.2	**Reduced Site Disturbance**, Development Footprint	1
	Credit 6.1	**Stormwater Management**, Rate and Quantity	1
	Credit 6.2	**Stormwater Management**, Treatment	1
	Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	1
	Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof	1
1	Credit 8	**Light Pollution Reduction**	1

2	**Water Efficiency**	Possible Points:	**5**
Y			
	Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
	Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
	Credit 2	**Innovative Wastewater Technologies**	1
1	Credit 3.1	**Water Use Reduction**, 20% Reduction	1
1	Credit 3.2	**Water Use Reduction**, 30% Reduction	1

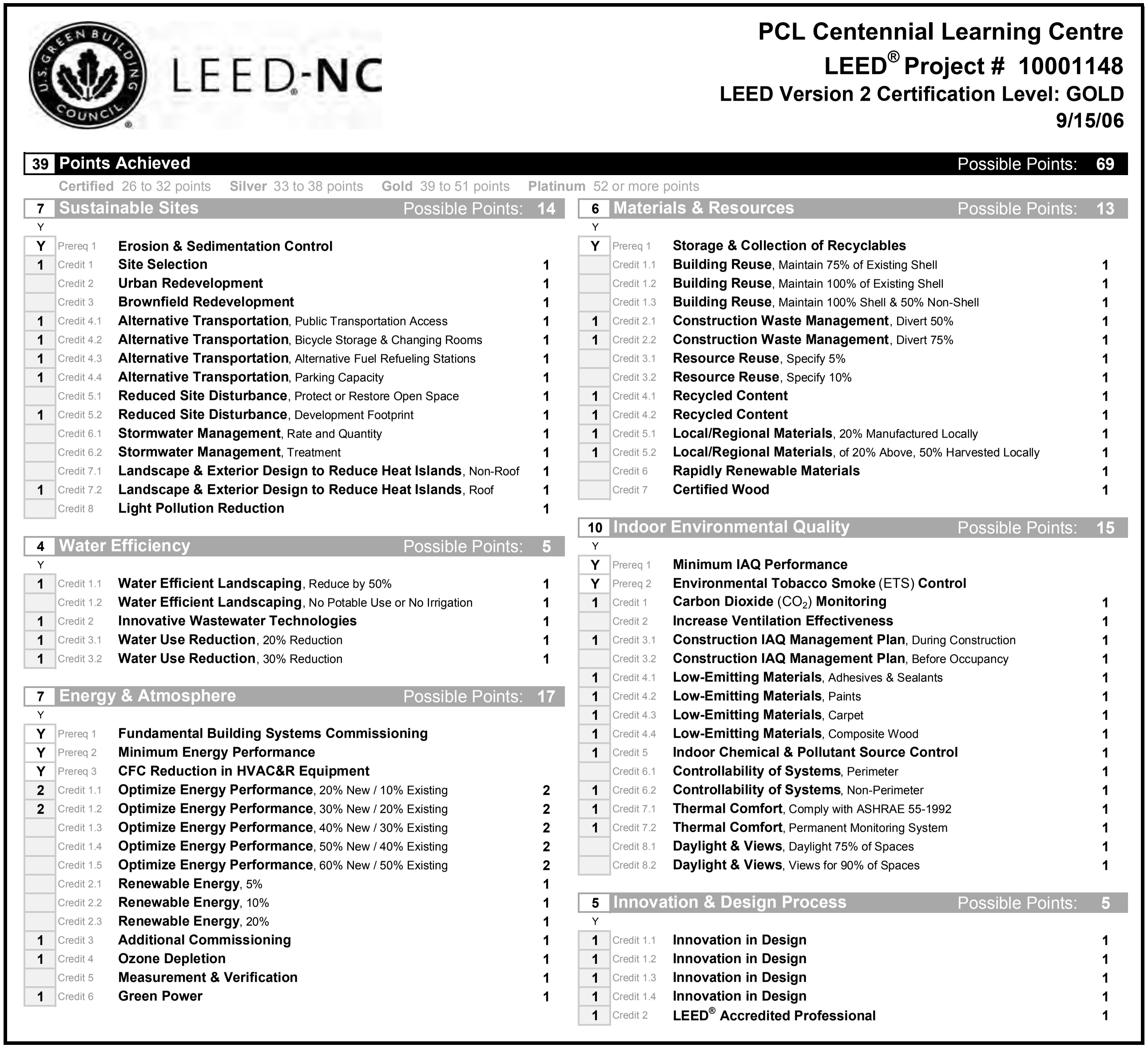
12	**Energy & Atmosphere**	Possible Points:	**17**
Y			
Y	Prereq 1	**Fundamental Building Systems Commissioning**	
Y	Prereq 2	**Minimum Energy Performance**	
Y	Prereq 3	**CFC Reduction in HVAC&R Equipment**	
2	Credit 1.1	**Optimize Energy Performance**, 20% New / 10% Existing	2
2	Credit 1.2	**Optimize Energy Performance**, 30% New / 20% Existing	2
2	Credit 1.3	**Optimize Energy Performance**, 40% New / 30% Existing	2
2	Credit 1.4	**Optimize Energy Performance**, 50% New / 40% Existing	2
2	Credit 1.5	**Optimize Energy Performance**, 60% New / 50% Existing	2
	Credit 2.1	**Renewable Energy**, 5%	1
	Credit 2.2	**Renewable Energy**, 10%	1
	Credit 2.3	**Renewable Energy**, 20%	1
	Credit 3	**Additional Commissioning**	1
1	Credit 4	**Ozone Depletion**	1
	Credit 5	**Measurement & Verification**	1
1	Credit 6	**Green Power**	1

1	**Materials & Resources**	Possible Points:	**13**
Y			
Y	Prereq 1	**Storage & Collection of Recyclables**	
	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Shell	1
	Credit 1.2	**Building Reuse**, Maintain 100% of Existing Shell	1
	Credit 1.3	**Building Reuse**, Maintain 100% Shell & 50% Non-Shell	1
	Credit 2.1	**Construction Waste Management**, Divert 50%	1
	Credit 2.2	**Construction Waste Management**, Divert 75%	1
	Credit 3.1	**Resource Reuse**, Specify 5%	1
	Credit 3.2	**Resource Reuse**, Specify 10%	1
	Credit 4.1	**Recycled Content**	1
	Credit 4.2	**Recycled Content**	1
1	Credit 5.1	**Local/Regional Materials**, 20% Manufactured Locally	1
	Credit 5.2	**Local/Regional Materials**, of 20% Above, 50% Harvested Locally	1
	Credit 6	**Rapidly Renewable Materials**	1
	Credit 7	**Certified Wood**	1

6	**Indoor Environmental Quality**	Possible Points:	**15**
Y			
Y	Prereq 1	**Minimum IAQ Performance**	
Y	Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	
	Credit 1	**Carbon Dioxide** (CO_2) **Monitoring**	1
1	Credit 2	**Increase Ventilation Effectiveness**	1
	Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
	Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
1	Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
1	Credit 4.2	**Low-Emitting Materials**, Paints	1
1	Credit 4.3	**Low-Emitting Materials**, Carpet	1
	Credit 4.4	**Low-Emitting Materials**, Composite Wood	1
	Credit 5	**Indoor Chemical & Pollutant Source Control**	1
	Credit 6.1	**Controllability of Systems**, Perimeter	1
1	Credit 6.2	**Controllability of Systems**, Non-Perimeter	1
	Credit 7.1	**Thermal Comfort**, Comply with ASHRAE 55-1992	1
	Credit 7.2	**Thermal Comfort**, Permanent Monitoring System	1
	Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
1	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

3	**Innovation & Design Process**	Possible Points:	**5**
Y			
1	Credit 1.1	**Innovation in Design**: Exemplary Performance WEc3	1
1	Credit 1.2	**Innovation in Design**: Exemplary Performance EAc6	1
	Credit 1.3	**Innovation in Design**:	1
	Credit 1.4	**Innovation in Design**:	1
1	Credit 2	**LEED® Accredited Professional**	1

Figure A-2.2
LEED scorecard for Building 2, PCL Learning Centre



PCL Centennial Learning Centre
LEED® Project # 10001148
LEED Version 2 Certification Level: GOLD
9/15/06

39 Points Achieved — Possible Points: 69

Certified 26 to 32 points **Silver** 33 to 38 points **Gold** 39 to 51 points **Platinum** 52 or more points

7 Sustainable Sites — Possible Points: 14

Y			
Y	Prereq 1	**Erosion & Sedimentation Control**	
1	Credit 1	**Site Selection**	1
	Credit 2	**Urban Redevelopment**	1
	Credit 3	**Brownfield Redevelopment**	1
1	Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
1	Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
1	Credit 4.3	**Alternative Transportation**, Alternative Fuel Refueling Stations	1
1	Credit 4.4	**Alternative Transportation**, Parking Capacity	1
	Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	1
1	Credit 5.2	**Reduced Site Disturbance**, Development Footprint	1
	Credit 6.1	**Stormwater Management**, Rate and Quantity	1
	Credit 6.2	**Stormwater Management**, Treatment	1
	Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	1
1	Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof	1
	Credit 8	**Light Pollution Reduction**	1

4 Water Efficiency — Possible Points: 5

Y			
1	Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
	Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
1	Credit 2	**Innovative Wastewater Technologies**	1
1	Credit 3.1	**Water Use Reduction**, 20% Reduction	1
1	Credit 3.2	**Water Use Reduction**, 30% Reduction	1

7 Energy & Atmosphere — Possible Points: 17

Y			
Y	Prereq 1	**Fundamental Building Systems Commissioning**	
Y	Prereq 2	**Minimum Energy Performance**	
Y	Prereq 3	**CFC Reduction in HVAC&R Equipment**	
2	Credit 1.1	**Optimize Energy Performance**, 20% New / 10% Existing	2
2	Credit 1.2	**Optimize Energy Performance**, 30% New / 20% Existing	2
	Credit 1.3	**Optimize Energy Performance**, 40% New / 30% Existing	2
	Credit 1.4	**Optimize Energy Performance**, 50% New / 40% Existing	2
	Credit 1.5	**Optimize Energy Performance**, 60% New / 50% Existing	2
	Credit 2.1	**Renewable Energy**, 5%	1
	Credit 2.2	**Renewable Energy**, 10%	1
	Credit 2.3	**Renewable Energy**, 20%	1
1	Credit 3	**Additional Commissioning**	1
1	Credit 4	**Ozone Depletion**	1
	Credit 5	**Measurement & Verification**	1
1	Credit 6	**Green Power**	1

6 Materials & Resources — Possible Points: 13

Y			
Y	Prereq 1	**Storage & Collection of Recyclables**	
	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Shell	1
	Credit 1.2	**Building Reuse**, Maintain 100% of Existing Shell	1
	Credit 1.3	**Building Reuse**, Maintain 100% Shell & 50% Non-Shell	1
1	Credit 2.1	**Construction Waste Management**, Divert 50%	1
1	Credit 2.2	**Construction Waste Management**, Divert 75%	1
	Credit 3.1	**Resource Reuse**, Specify 5%	1
	Credit 3.2	**Resource Reuse**, Specify 10%	1
1	Credit 4.1	**Recycled Content**	1
1	Credit 4.2	**Recycled Content**	1
1	Credit 5.1	**Local/Regional Materials**, 20% Manufactured Locally	1
1	Credit 5.2	**Local/Regional Materials**, of 20% Above, 50% Harvested Locally	1
	Credit 6	**Rapidly Renewable Materials**	1
	Credit 7	**Certified Wood**	1

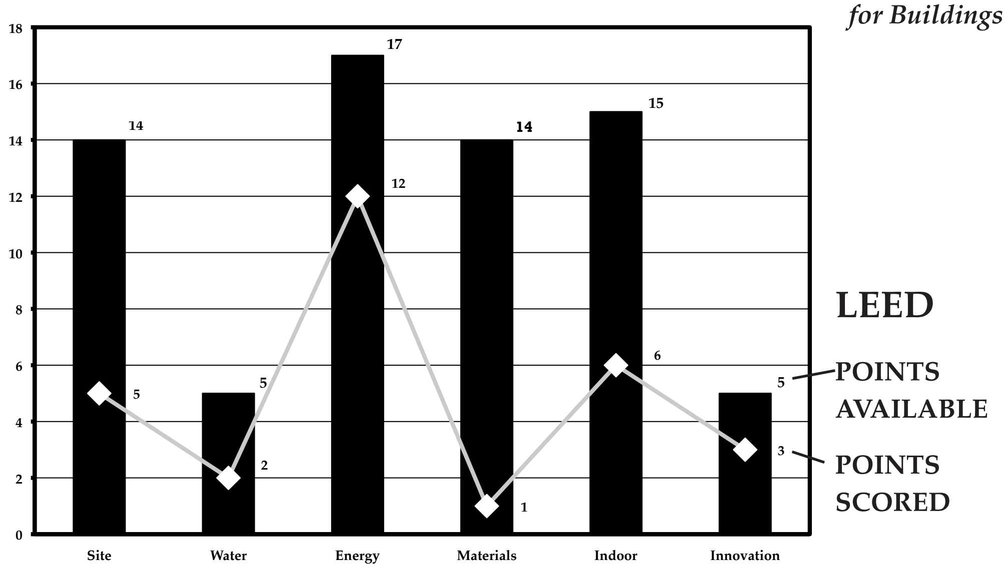
10 Indoor Environmental Quality — Possible Points: 15

Y			
Y	Prereq 1	**Minimum IAQ Performance**	
Y	Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	
1	Credit 1	**Carbon Dioxide** (CO_2) **Monitoring**	1
	Credit 2	**Increase Ventilation Effectiveness**	1
1	Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
	Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
1	Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
1	Credit 4.2	**Low-Emitting Materials**, Paints	1
1	Credit 4.3	**Low-Emitting Materials**, Carpet	1
1	Credit 4.4	**Low-Emitting Materials**, Composite Wood	1
1	Credit 5	**Indoor Chemical & Pollutant Source Control**	1
	Credit 6.1	**Controllability of Systems**, Perimeter	1
1	Credit 6.2	**Controllability of Systems**, Non-Perimeter	1
1	Credit 7.1	**Thermal Comfort**, Comply with ASHRAE 55-1992	1
1	Credit 7.2	**Thermal Comfort**, Permanent Monitoring System	1
	Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

5 Innovation & Design Process — Possible Points: 5

Y			
1	Credit 1.1	**Innovation in Design**	1
1	Credit 1.2	**Innovation in Design**	1
1	Credit 1.3	**Innovation in Design**	1
1	Credit 1.4	**Innovation in Design**	1
1	Credit 2	**LEED® Accredited Professional**	1

Figure A-2.3
Comparison of LEED rating for Buildings 1 and 2



BUILDING 1, "LOW-ENERGY"

BUILDING 2, "GREEN MATERIALS"

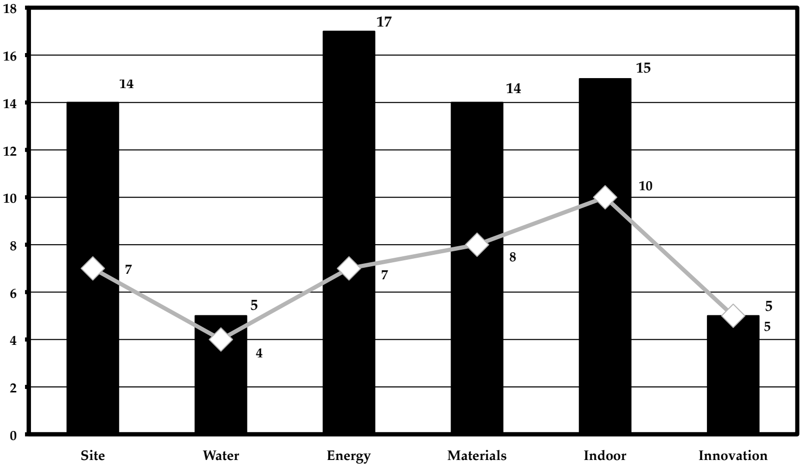
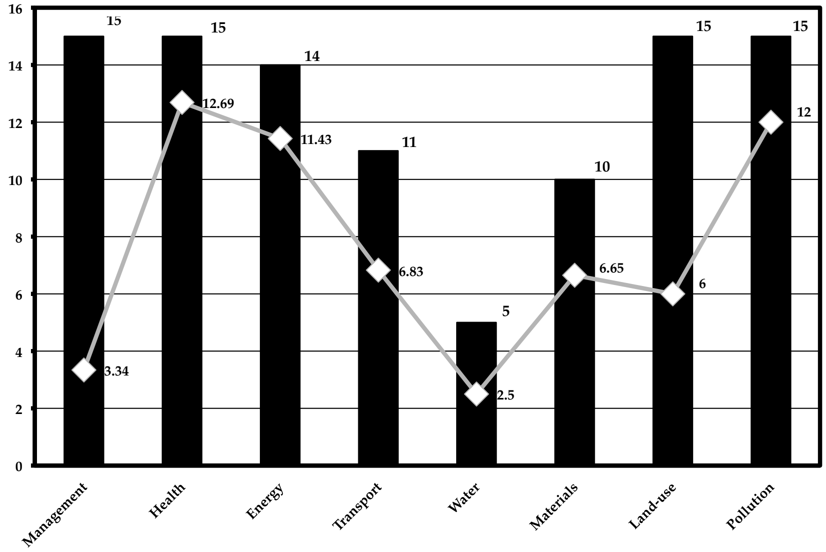
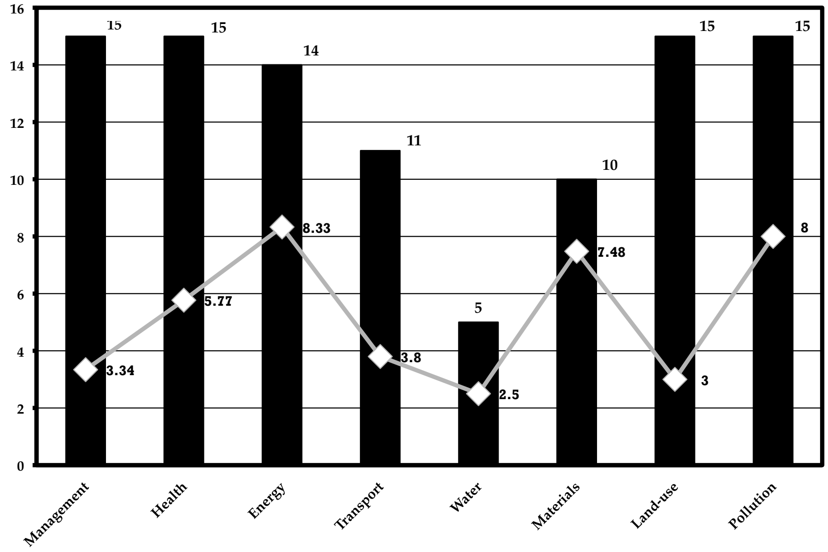


Figure A-2.4
Comparison of BREEAM rating for Buildings 1 and 2



BUILDING 1, “LOW-ENERGY”

BUILDING 2, “GREEN MATERIALS”



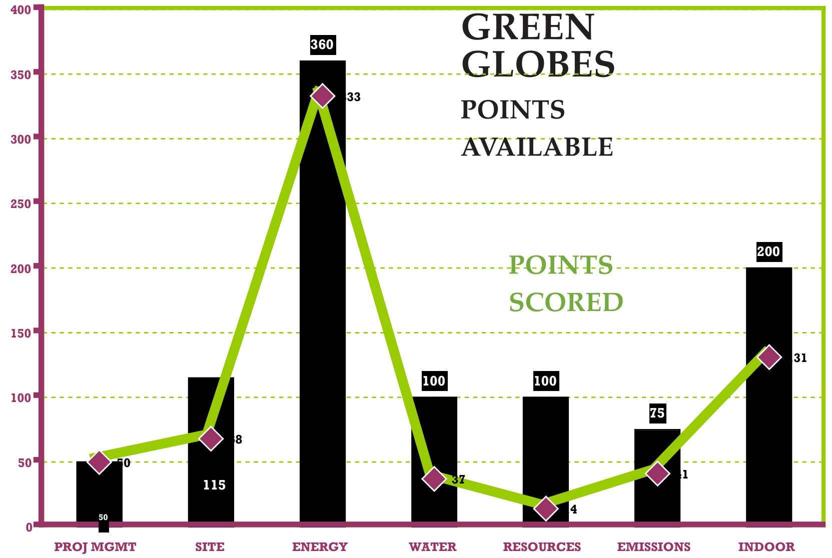
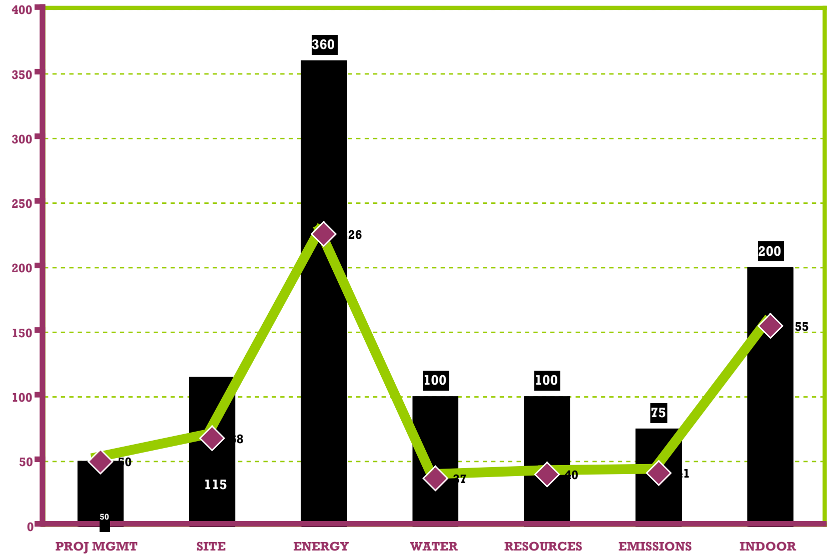


Figure A-2.5 Comparison of GREEN GLOBES rating for Buildings 1 and 2

BUILDING 1, "LOW-ENERGY"

BUILDING 2, "GREEN MATERIALS"



a3

DATA GATHERING

Five building owners in Canada provided original data from fuel bills. The following spreadsheet was developed to make the extraction of relevant figures easy and the analysis swift. In most cases, the facility manager filled in lines 1 through 24 directly; in a few instances, this was done by the researcher. The conversion factor on line C brings gas usage to equivalent kilowatt hours (ekWhr), which are added to electrical usage. The results then can be entered on the Intensometers in Chapter 3 and 4.

Figure A-3.1 (opposite) Sample calculation of energy intensity from fuel bills

Method used to calculate the energy intensity of a building, from utility bills
(sample data from School of Architecture, U Waterloo, Cambridge, ON)

		Month	**Elec. use**		**Gas use**		
			kWhr		m^3		
		1	107,701.00		2,543.17	May	
		2	118,408.00		417.58	June	
		3	137,189.00		153.85	July	
		4	106,070.00		166.41	Aug	
		5	80,737.00		1,852.44	Sep	
		6	86,049.00		8,612.26	Oct	
		7	87,853.00		10,323.41	Nov	
		8	91,744.00		14,467.84	Dec	
		9	87,038.00		20,640.53	Jan	
		10	77,867.00		19,629.54	Feb	
		11	84,092.00		11,849.31	Mar	
		12	77,787.00		8,533.77	Apr	
		13					
		14					
		15					
		16					
		17					
		18					
		19					
		20					
		21					
		22					
		23					
		24					
Total elec.	see note 1		1,142,535.00	kWhr			A
Total gas	see note 1				99,190.10	m^3	B
Factor	m^3 gas---> ekWhr				10.25	ekWhr / m^3	C
Gas as equiv	B x C				1,016,698.54	ekWhr	D
Total energy use	A + D				2,159,233.54	ekWhr	E
Floor area	from plan				7,340	m^2	F
# years of data	see note 1				1		G
Energy Intensity	E ÷ F ÷ G				**294**	**ekWhr/m^2/yr**	H

note 1: a minimum of 12 consecutive months is essential; 24 consecutive months is preferred

a4

CASE STUDY BUILDINGS - TOUR & INTERVIEW PROCESS

THE INTERVIEW PROCESS

In most cases, the following list of prompts was sent to the interviewee, between the time an appointment was made for a tour, and the day of the tour. This list of prompts is a "starter" – the interviews were kept reasonably consistent, but were not rigidly structured. For instance, where information on this list had already been published, it was not reviewed during the interview. And, where the interviewee was willing to digress, the interviewer followed, often finding very valuable insight as a result. The interviewees all commented that this procedure gave them some assurance as to what to expect, and helped them to prepare, by locating documents to be viewed during the visit (reports, drawings, etc.). The interviews were conducted in a somewhat structured, but open and relaxed manner, allowing plenty of time before and after for a walk-through with the interviewee (indoors), a walk-around (outdoors, usually alone) and photography.

Figure A-4.1
Short list of candidates for
Analysis of Case Studies

Project	Size sf	Use	Zone	Fin	Rating if LEED: C,S,G,P	Energy kWhr/m²/yr	Notes
Small (under 15,000 sf)		***14***					
Alice Turner Library, Sask	14,600	comm'y library	Prairie	1998	C-2000	301	
AUMA, Edmonton	9,600	office reno+add	NW Alberta		C		data?
Caribou Weather ME	8,380	office & ops	New Eng	2002	S	447	remote
DeptNatRes, Bathurst, NB	6,300	offices	Maritimes	2006	S	?	data?
French Wing, SocProNH Fores	11,600	office add'n	New Eng	2001	G	303	
Holyrood RCMP, Nfld.	10,100	police offices	Maritimes	2004	iGBC	167	
Lewis Center, Oberlin OH	13,600	post-sec edu	E Midwest	2000	X, TTpre03	97	
North Cariboo, Quesnel BC			Mountain		iGBC 05	143	remote
Parks Canada, Greenwich, PEI			Maritimes		iGBC		use
Science House, St. Paul MN	1,530	interpretive	W Midwest	2003	X	56	remote
SIQ Postes, AmosPlessisLac B	10,000		Quebec		CBIP		no visuals
Tompkins City SPCA, Ithaca	14,600	homey kennels	Mid-Atlant	2004		250	Xpeople
Wampanoag HQ, MthaVin, M	8,700	office, assembly	New Eng	1994		94	remote,des?
Woods Hole Research, MA	14,600	labs & offices	New Eng	2000	X	50	
Medium (15,000 sf to 100,000 sf)		***21***					
Artists for Humanity, MA	23,500	studios/gallery	New Eng	2004	P, TT2007	79	
Carl Curtis Office, Omaha, NE	68,000	office building	W Midwest	2004	G, TT**	145	remote
CBF Phillip Merrill, ChesBay	32,000	interpretive	Hot-Humid				climate
Clearview Elementary, PA	43,600	elem. school	Mid-Atlant	2002	G, iGBC	73	
Crowfoot Library, Calgary	28,000	comm'y library	Prairie	2005?	X	?	data?
Green on the Grand	23,600	office	Gt.Lakes	1996	C-2000		des?
Greyston Bakery, Yonkers, NY	23,100	bakery	Mid-Atlant	2003	TT2004	?	industrial
Heimbold VisArts, SarLaw, N	60,000	studios	Mid-Atlant	2004	C, TT2005	271	
Herm Millar C1, MI	19,100	reno'd office	E Midwest	2002	G, TT2004	271	
Hinton Govt Bldg	32,300	local govt office	NW Alberta	2001	X, C-2000	*198*	remote
Mayo School	35,500	sch/comm'y cnt	Far North	2002	C, iGBC	260	remote
MEC, Montreal	48,000	big box retail	Gt. Lakes	2003	G, iGBC05	324	retail
N Jones Fed Cthse, OH	52,200	courts & offices	E Midwest		C	225	
Nicola Valley, Merritt, BC	48,600	higher edu	Mountain	2002	C, iGBC	194	remote
PAAM, Provincetown	19,500	art gallery	New Eng	2006	S, TT2007	*88*	
Penn DEP Cambria Office, PA	36,000	office building	Mid-Atlant	2000	G, TT2000	126	des?
School of Architecture, UW	79,000	studios/offices	Gt. Lakes	2004	X	293	PlantOps
Southeast Div Sta., Edmonton	50,000	police station	NW Alberta				remote
St. John's Ambulance, Edmont	44,456	office	NW Alberta				remote
T.L. Wells Elementary	60,000	school	Gt. Lakes		S		
Wind NRG Plant & Office, MA	46,400	office & plant	New Eng	2004	G	68	JFS lecture
Large (over 100,000 sf)		***9***					
4 Times Square	1,600,000	office	Mid-Atlant	2000	X	201	except'ly L
GOC Charlottetown	187,500	office building	Maritimes	2006?	R?, iGBC05	94	
Manitoba Hydro	690,000	office	Prairie	not	tba		in construc
NoseCreek/Cardel, Calgary (	194,000	2rink,acqua,lib	Prairie	2003?	G	?	data?remote
Pavillion Lassonde	434,000	clsrms, offices	Gt. Lakes		G		data?des?
Pharmacia Bldg Q,	176,000	laboratories	E Midwest	2000	G	472	remote
ThePlazaatPPL, Allentown, PA	280,000	office building	E Midwest	2003	G	219	
SAS Canada HQ, Toronto	125,000	office	Gt. Lakes		R		
York U Computer Science	99,911	clsrms,theatre	Gt. Lakes	2001?	iGBC2000	302	cnflctdata?

PROMPTS FOR INTERVIEW DURING BUILDING TOUR

Theme #1: General Design Goals

- Apart from energy-efficiency, what were the primary goals of the project? (community / user groups / budget / other…)
- How well, in your opinion, were these goals met? (Verify cost figures published)
- Why is the building situated as it is?

Theme #2: Green Design Goals

- Why/how did "green" goals arise, for this project in particular?
- Why did your team select/not select LEED as a way of working on the "green" aspects of the building? Were there any frustrations working with/without this tool?
- Were there any compromises made, in trying to satisfy both "general" goals and the "green" goals?

Theme #3: Project Delivery

- What were the main reasons your agency selected this team of architects and engineers?
- What assistance was there from government programs?
- policies / project management / cash grants / relief from regulation
- How did the contractor perform? What specific challenges arose (re constructability) from the "green" agenda? How were these overcome?

Theme #4: Ongoing Use of the Building

- How has the building been received by:
  - its immediate neighbours?
  - the general community?
- Has there been any talk about expansion/change in the future?
- Are there complaints from occupants regarding:
  - thermal comfort? glare? air quality?
  - functional needs? access?
- Have occupants introduced their own equipment / other adaptations?

Theme #5: Ongoing Maintenance & Operation of the Building

- Is there data available regarding the actual end-use monitoring of energy use? (utility bills, third party study, …)
- How does the energy use compare with your other buildings?
- Which systems are operating differently than expected? Are there remedies to this situation being considered?

- Has anything been replaced yet? Added?

Wrap-up: If you were to be involved in another project, similar to this one, what would you do differently?

Reminders to make specific visual/sensory observations during building tour

Context
- photograph view from sidewalk/main drive, approaching main entrance
- note (ideagram) of natural and urban land-use features surrounding the site
- note general condition of neighbouring properties: occupied, well maintained?
- note and inquire about climate, as compared to near-adjacent areas (e.g. Boston vs. Cape Cod, Allentown vs. Philadelphia)

Exterior
- photograph all facades to verify % glazed area
- note evidence of deterioration of skin elements; ask about it
- photograph details of sunshades, if used
- note position of any significant shade trees

Interior
- floor-to-floor height
- quality of light in main spaces (note glare, heat)
- quality of light in work spaces (note if any devices at workstations)
- note light fixture types
- note controls on lighting
- quality of air and temperature
- whether occupants use individual comfort controls
- noise / acoustic isolation
- condition of interior surfaces
- equipment rooms: HRV, heat pumps, PV, meter panels

Documents
- R-values of: walls, roof, sub-grade
- Window specification
- size of climate control systems
- efficiency ratings of equipment
- size of renewable energy systems
- names of design team members (if not published elsewhere)

St. Gabriel’s Passionist Church Toronto, ON

Pastor Paul Cusack
St. Gabriel’s Parish
Owner/developer
Toronto, ON

Roberto Chiotti
Larkin Architect Limited
Architect
Toronto, ON

Kevin Weiss
weissbau inc.
Designer
Toronto, ON

Martin Stewart Contracting
Construction Manager
Hamilton, ON

Carruthers Wallace
Structural Engineer
Toronto, ON

Mike Godawa
Keen Engineering
Mechanical Engineer
Toronto, ON

Keen Engineering
Electrical Engineers
North Vancouver, BC

Enermodal Engineering
Energy Modelling, LEED documentation, and
Commissioning
Kitchener, ON

Ian Gray & Assoc. Ltd.
Landscape Architect
Toronto, ON

John Swallow
Swallow Acoustic Consults.
Acoustic Engineer
Mississauga, ON

Feherty and Associates Ltd.
Storm Water Management
Newmarket, ON

David Pearl
Artist
Wales, UK

SAS Canada Headquarters Toronto, ON

Jerry McDermott
Manager, Real Estate Development
SAS Institute (Canada) Ltd.
Owner/developer
Toronto, ON

David Clusiau
NORR
Architecture
Interior Design
LEED Certification
Toronto, ON

Giffels Design Build
Construction Manager
Toronto, ON

NORR
Structural Engineer
Toronto, ON

Brodie Associates
Landscape Architects
Toronto, ON

Shaheen and Peaker
Site Remediation/Geotech
Etobicoke, ON

The Lewis Center
Oberlin, OH

David Orr
Oberlin College
Owner/developer (Owner representative)
Oberlin, OH
Adrian Tuluca
Steven Winter Associates
Building systems consultant
Norwalk, CT

Kevin Burke
William McDonough
William McDonough + Partners
Architect
Charlottesville, VA

Mosser Construction, Inc.
Contractor
Fremont, OH

Lev Zetlin Associates
Mechanical engineer (Electrical, HVAC, mechanical, structural eng.)
New York, NY

John Lyle
Andropogon Associates, Ltd.
Landscape architect
Philadelphia, PA

CT Consultants, Inc.
Civil engineer
Lorain, OH

Michael Shaw
Living Technologies
Waste management consultant
(Wastewater advisor)

John Todd
Living Technologies
Waste management consultant
(Wastewater advisor)
Taos, NM

Paul Torcellini
National Renewable Energy Laboratory
Energy Evaluation
Golden, CO

Wind NRG Office & Warehouse
Hinesburg, VT

Jan and David Blittersdorf
Wind NRG Partners, LLC
Owner/developer
Hinesburg, VT

William Maclay, AIA
Jerry Bridges, Assoc. AIA, LEED-AP
Stephen Frey
William Maclay Architects and Planners
Architect
Waitsfield, VT

Andrew Shapiro
Energy Balance, Inc.
Energy consultant
Montpelier, VT

Henry Erickson
Erickson Consulting, LLC
Construction management consultant
Warren, VT

David Kirby
Bread Loaf Corporation
Contractor
Middlebury, VT

Gary Sweeny, P.E.
Engineering Ventures, Inc.
Structural engineer
Manchester, VT

Thomas Reilly
Salem Engineering, Inc.
MEP engineer
Shelburne, VT
Naomi Miller
Naomi Miller Lighting Design
Lighting designer
Troy, NY

Ian Jewkes
Krebs and Lansing Consulting Engineers
Civil engineer
Colchester, VT

Jeremy Rathbum
Salem Engineering
Commissioning agent
Shelburne, VT

Mary Jane Poynter
Efficiency Vermont
Energy consultant
Burlington, VT

Artists for Humanity EpiCenter
Boston, MA

Susan Rodgerson
Artists for Humanity, Inc.
Owner/developer
Boston, MA

James Batchelor, FAIA, LEED AP
Patricia Cornelison, AIA, LEED AP
Anthony Iacovino, AIA, LEED AP
Arrowstreet, Inc.
Architect
Somerville, MA

David Marceau
T.R. White Company, Inc.
Contractor
Boston, MA

Mark Kelley, P.E.
Building Science Engineering
Environmental building consultant
Harvard, MA

Nick Rodrigues
Artist
Boston, MA

Rene Mugnier, P.E
Rene Mugnier Associates, Inc.
Structural engineer
Cambridge, MA

Mohammed Zade
Zade Company, Inc.
Mechanical engineer
Boston, MA

Steve Garvin
Samiotes Consultants, Inc.
Civil engineer
Framingham, MA

Mark Warren, LEED AP
SEI Companies
Commissioning agent
Boston, MA

Addison Kelly
US Lighting Consultants
Lighting designer
New York, NY

Robert Carasitti, P.E.
Schirner Engineering
Code consultant
Framingham, MA
Kevin Martin, P.E.
UTS of Massachusetts, Inc.
Geotechnical engineer
Stoneham, MA

Jack Fogg
Specifications consultant
Whitinsville, MA

Gilman Ordway Building at
Woods Hole Research Center
Falmouth, MA

George Woodwell, Director
Woods Hole Research Center
Owner/developer
Woods Hole, MA

William McDonough
Mark Rylander
(Associate partner/project manager)
Kyle Copas
(Director of communications)
Jeff Sties
of:
William McDonough + Partners
Architect (Project principal)
Charlottesville, VA

John Million
TR White Company, Inc.
Contractor
Boston, MA

Marc Rosenbaum, P.E.
Energysmiths
Energy consultant
Meriden, NH

Nat Oppenheimer
Robert Silman Associates
Structural engineer
New York, NY

Robert Somers
2rw Consulting Engineers, PC
MEP engineer
Charlottesville, VA

Warren Byrd
Nelson-Byrd Landscape Architects
Landscape architect
Charlottesville, VA

David Nelson
Clanton & Associates, Inc.
Lighting designer
Boulder, CO

Mike McGrath
Holmes and McGrath, Inc.
Civil engineer
Falmouth, MA

John Kneffner
Northern Power Systems
Renewable energy systems consultant
Waitsfield, VT
John Ferguson
Ferguson Engineering
Code consultant
Clarkson, MD

Richard Vermeulen
Vermeulens Construction Consulting
Cost estimator
Unionville, ON

PAAM
Provincetown, MA

Christine McCarthy
Provincetown Art Association and Museum
Owner/developer
Provincetown, MA

Andrew Cruse, AIA, LEED
Machado and Silvetti Associates
Architect
Boston, MA

Daedalus Projects, Inc.
Client's project manager and estimator
Boston, MA

Bob Johnson
Acella Construction Corporation
Contractor for new construction
Norwell, MA

James Rogan
Paul J. Rogan Co., Inc.
Contractor for renovation
Braintree, MA

Richmond So Engineers, Inc.
Structural engineer
Cambridge, MA

Richmond So Engineers, Inc.
The Collaborative Engineers, Inc.
MEP engineer
Cambridge, MA

Michael Boucher
Michael Boucher Landscape Architecture
Landscape architect
Freeport, ME

Eric Studor
Demand Management Institute, Inc.
Energy consultant
Newton, MA

Peter Coxe
Peter Coxe Associates
Lighting designer
Marblehead, MA

Bennett & O'Reilly, Inc.
Civil engineer
Brewster, MA

Solar Design Associates
PV consultant
Harvard, MA

Collective Wisdom Corporation
Specification writer
Weston, MA

Arrowstreet, Inc.
Signage designer
Somerville, MA

GTA - Police
Vaughan, ON

Inspector Ivars Vitins
York Regional Police
Owner/occupant
Newmarket, ON

Geoffrey Brown
Carruthers Shaw & Partners Limited, Architects
Architect
Toronto, ON

Yolles Partnership Inc.
Structural engineer
Toronto, ON

Keen Engineering Co. Ltd.
Mechanical engineer
Toronto, ON

Hammershlag + Joffe Inc.
Electrical engineer
Toronto, ON

Cole Sherman Associates Ltd.
Site services engineer & landscape designers
Thornhill, ON

GTA - SAC
Cambridge, ON

Janna Levitt
Levitt Goodman Architects Ltd.
Architects
Toronto, ON

David Bowick
Blackwell Bowick Partnership Engineers
Structural engineer
Toronto, ON

(GTA - SAC cont'd)

Jerry Faubert
Keen Engineering Co. Ltd. (Stantec)
Mechanical & electrical engineer
Toronto, ON

GTA - School
Brampton, ON

Carruthers Shaw & Partners Limited, Architects
Architect
Toronto, ON

Read Jones Christoffersen Ltd.
Structural engineer
Toronto, ON

Mancini Saldan & Associates Ltd.
Mechanical & Electrical engineers
Etobicoke, ON

Graham Hess and Associates Inc.
Landscape designers
Oakville, ON

a5

eQUEST ANALYSIS - DETAIL

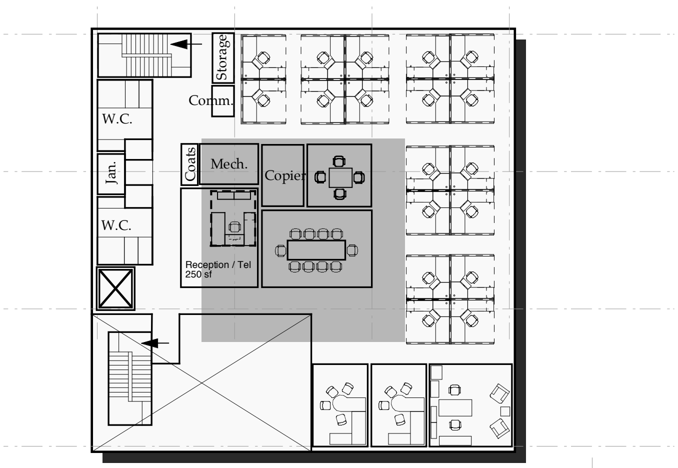
This Appendix contains back-up material relating to the Study of Design Parameters, including:

- floor plans for all types not shown in Chapter 5,
- notes on water heater sizing,
- a study of sunshades in Miami (this corresponds to the study of sunshades in Toronto in Figure 5.4.8),
- results of eQuest simulations for all 156 runs comprising Macro-matrix #1 (showing a breakdown of how energy is used),
- notes on the verification of the eQuest results, including results obtained using the MIT Design Advisor, and the NRCan Screening Tool, and
- a presentation of the results obtained by an independent researcher, with respect to the types in Macro-matrix #1.

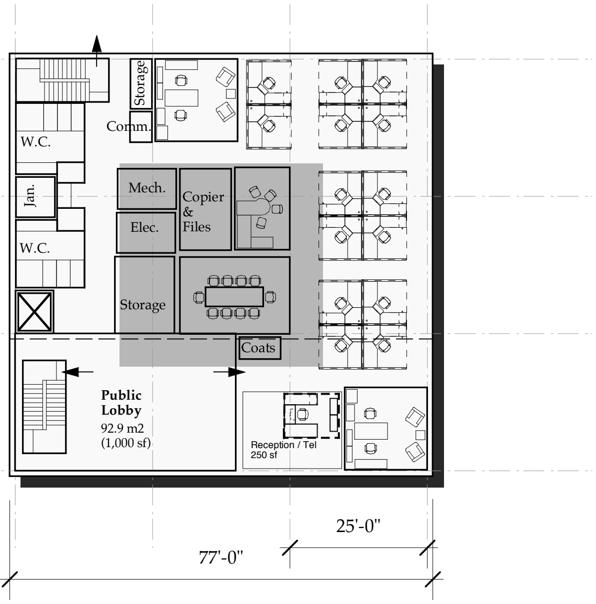
Small Office Building - SM**SQ

11,000 sf GFA, Square Plan
S20SQ, S40SQ, S60SQ
S20SQ, S40SQ, S60SQ

	sf		11,856	% of GFA	OBC occ. load
Open Office			6,068	0.512	60.7
Private Office	975	1	975	0.082	9.8
Conference	280	2	560	0.047	5.6
Copy	133	2	266	0.022	2.7
Corr/Stair/Elev	1,703	1	1,703	0.144	17.0
WC	740	1	740	0.062	7.4
Mech/Elec/Comm	272	2	544	0.046	1.8
Lobby	1,000	1	1,000	0.084	50.2
Total					155



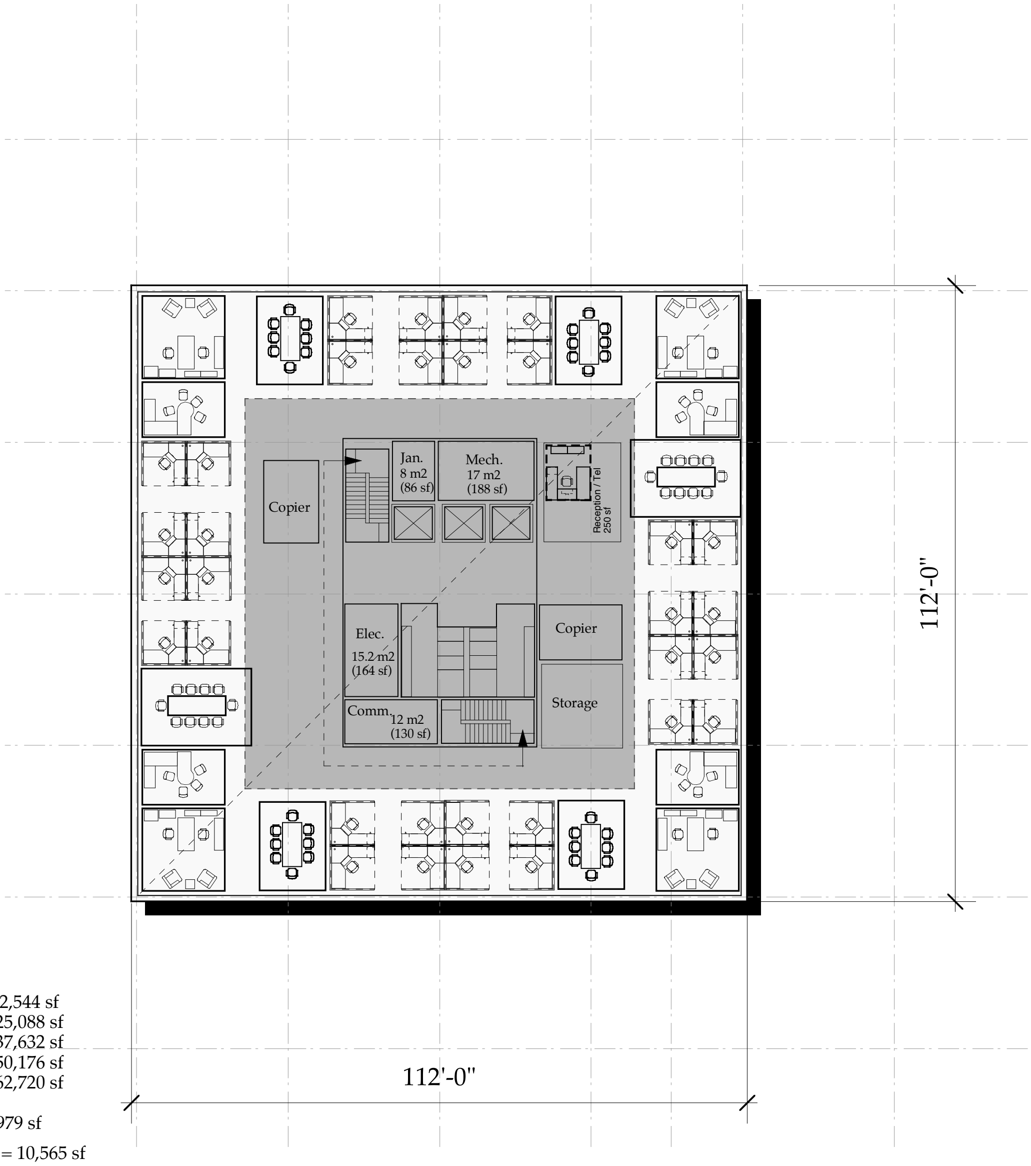
Level 2



Level 1

Medium-sized Office Building - MD**SQ

50,000 sf, , Square plan
MD20SQ, MD40SQ, MD60SQ



112' x 112' = 12,544 sf
x 2 storeys = 25,088 sf
x 3 storeys = 37,632 sf
x 4 storeys = 50,176 sf
x 5 storeys = 62,720 sf

core area = 1,979 sf

12,544 - 1979 = 10,565 sf
@ 100 sf / person,
OBC "occupant load" is 106 people,
or 53 of each sex
need 4 wcs for each sex

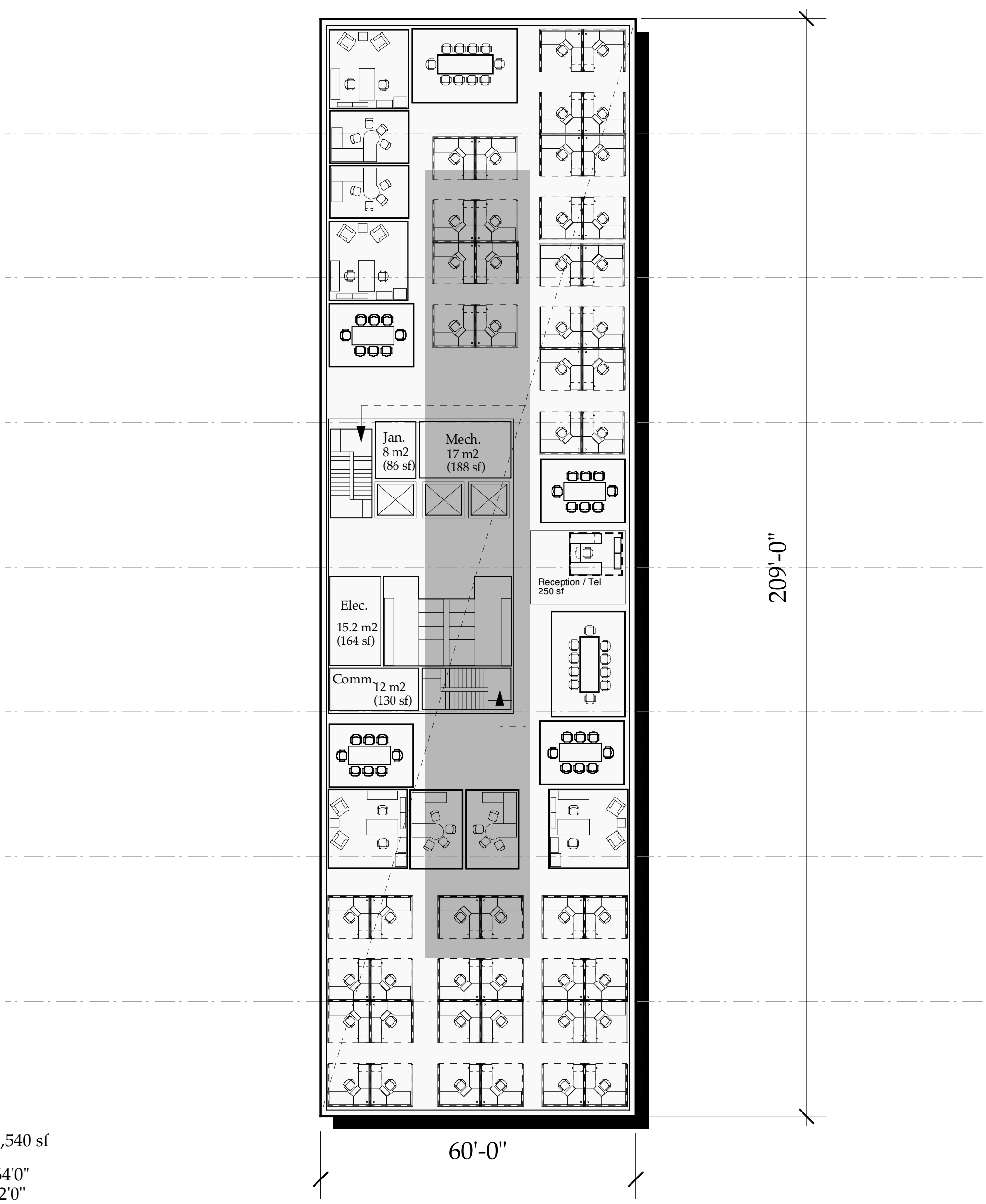
diagonal is 154'-5"
half diag. is 77'-3"
91'-4" separates 2 exit doors in design

floor-to-floor: allow 4.2 m (=13'-9";
13'0" used in eQuest models)
2.1 m: 12 risers @ 0.175
12 treads @ 0.250 = 3.0

MD-all shapes	*sf*	*flrs*	*50,176*	*% of GFA*	*OBC occ. load*
Open Office			29,050	0.579	291
Private Office	1500	4	6,000	0.12	60
Conference	1,360	4	5,440	0.108	54
Copy	300	4	1,200	0.024	12
Corr/Stair/Elev	825	4	3,300	0.066	33
WC	416	4	1,664	0.033	17
Mech/Elec/Comm/J	568	4	2,272	0.045	8
Lobby	1,250	1	1,250	0.025	63
TOTAL					537

Medium-sized Office Building - MD**NS

50,000 sf, , "Long" plan, axis of mass aligned north-south
MD20NS, MD40NS, MD60NS
MD20EW (rotated 90°), MD40EW, MD60EW

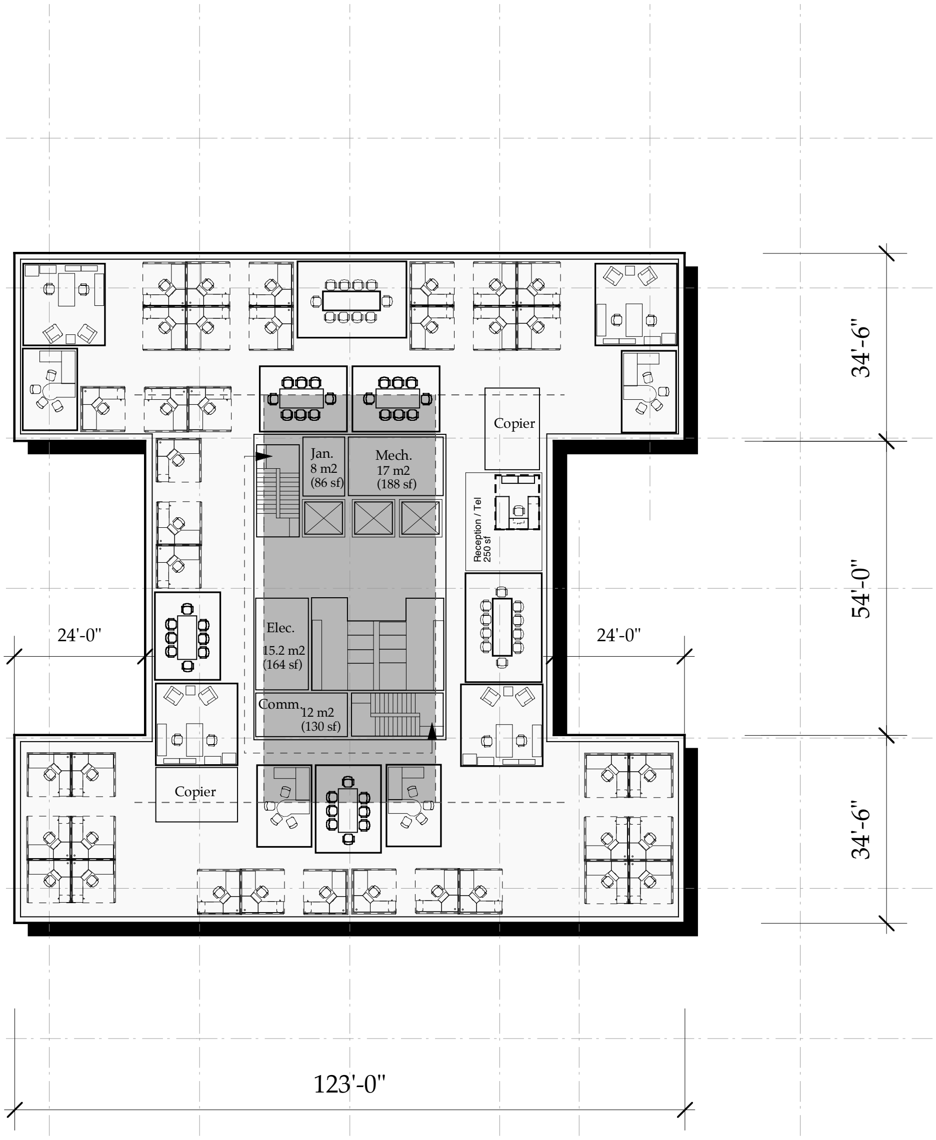


60' x 209' = 12,540 sf

diagonal is 164'0"
half diag. is 82'0"
98'3" separates 2 exits in this design**

Medium-sized Office Building - MD**HE

50,000 sf, , "H-shaped" plan, axis of wings aligned east-west
MD20HE, MD40HE, MD60HE
MD20HN (rotated 90°), MD40HN, MD60HN

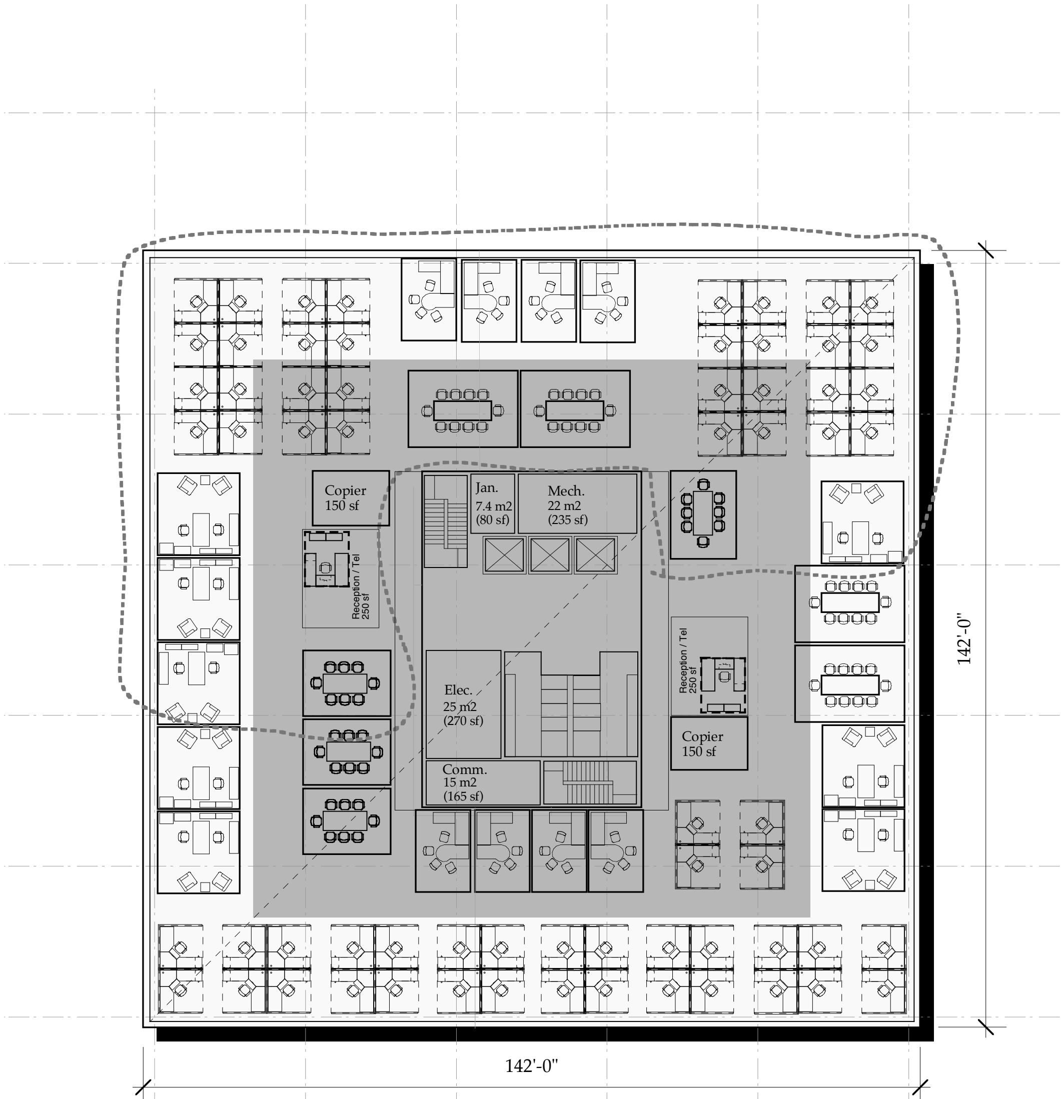


123' x 123' = 15,129 sf
2 @ 24'x 54' = 2,594 sf
floor plate = 12,535 sf

core area = same for all shapes

Large Office Building - LG**SQ

154,000 sf, Square Plan
LG20SQ, LG40SQ, LG60SQ



142'-0" x 142'-0" = 20,164 sf (1,873 m2)
x 2 storeys = 40,328 sf
x 5 storeys = 100,820 sf

(20,000-2,400) / 20,000 =>
leasable is approx. 88 % of gross (excl. ext'r wall)

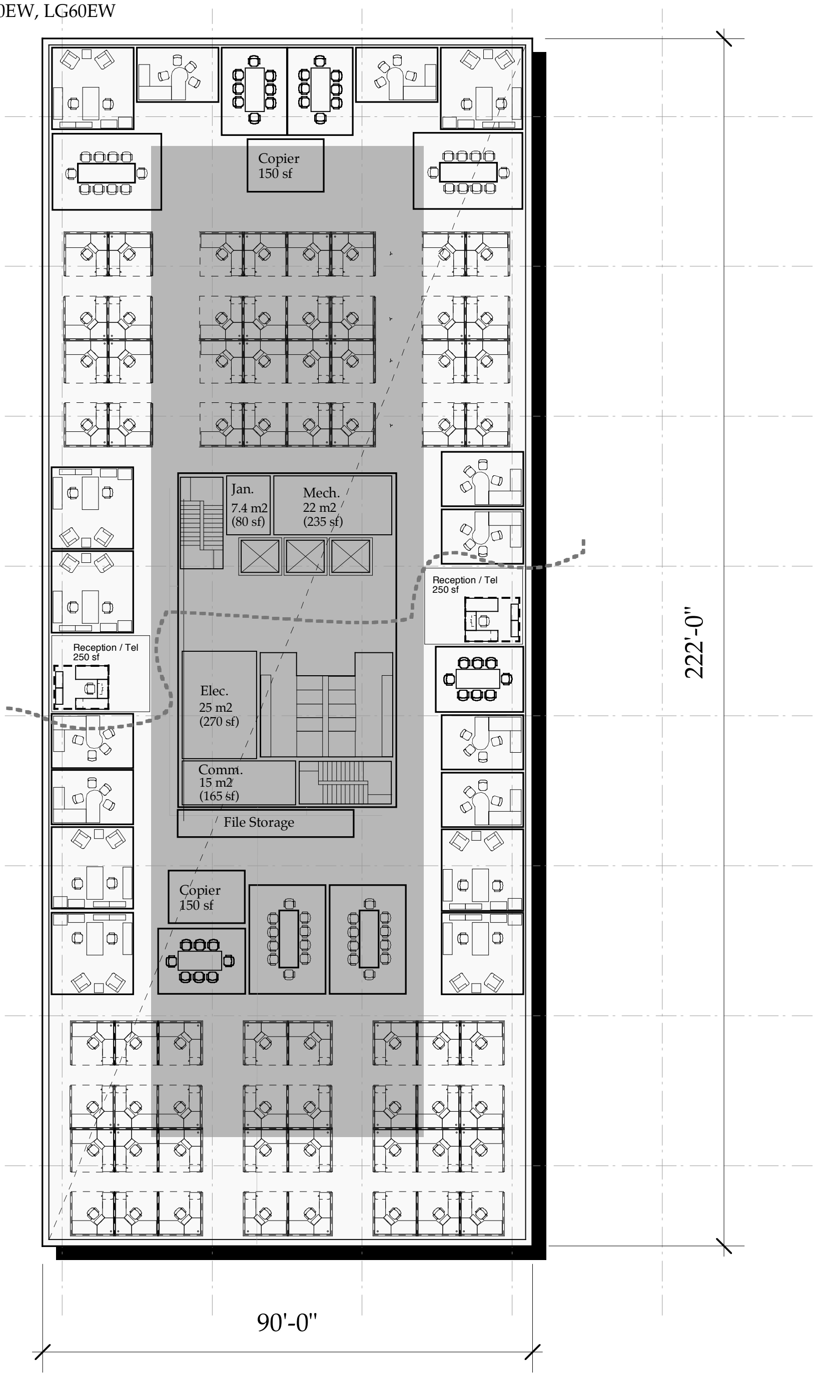
diagonal is 197'-6"; half diagonal is 98'-9"
distance between access to exits is 60' + 39' = 99'
aspect ratio of plan 1:1

max. floor-to-floor for stairs: 4.2 m (13'-9")
2.1 m: 12 risers @ 0.175 ...12 treads @0.250 = 3.0

LG-SQUARE	*sf*		*161,312*	*% of GFA*	*OBC occ. load*
OpenOffice			94,216	0.584	942
Private Office	3,000	8	24,000	0.149	240
Conference	1,920	8	15,360	0.095	154
Copy	300	8	2,400	0.015	24
Corr/Stair/Elev	1,702	8	13,616	0.084	136
WC	465	8	3,720	0.023	37
Mech/Elec/Comm	750	8	6,000	0.037	60
Lobby	2,000	1	2,000	0.012	20
TOTAL					1,613

Large Office Building - LG**NS

154,000 sf, Long Plan, axis of mass aligned north-south
LG20NS, LG40NS, LG60NS
LG20EW (rotated 90°), LG40EW, LG60EW



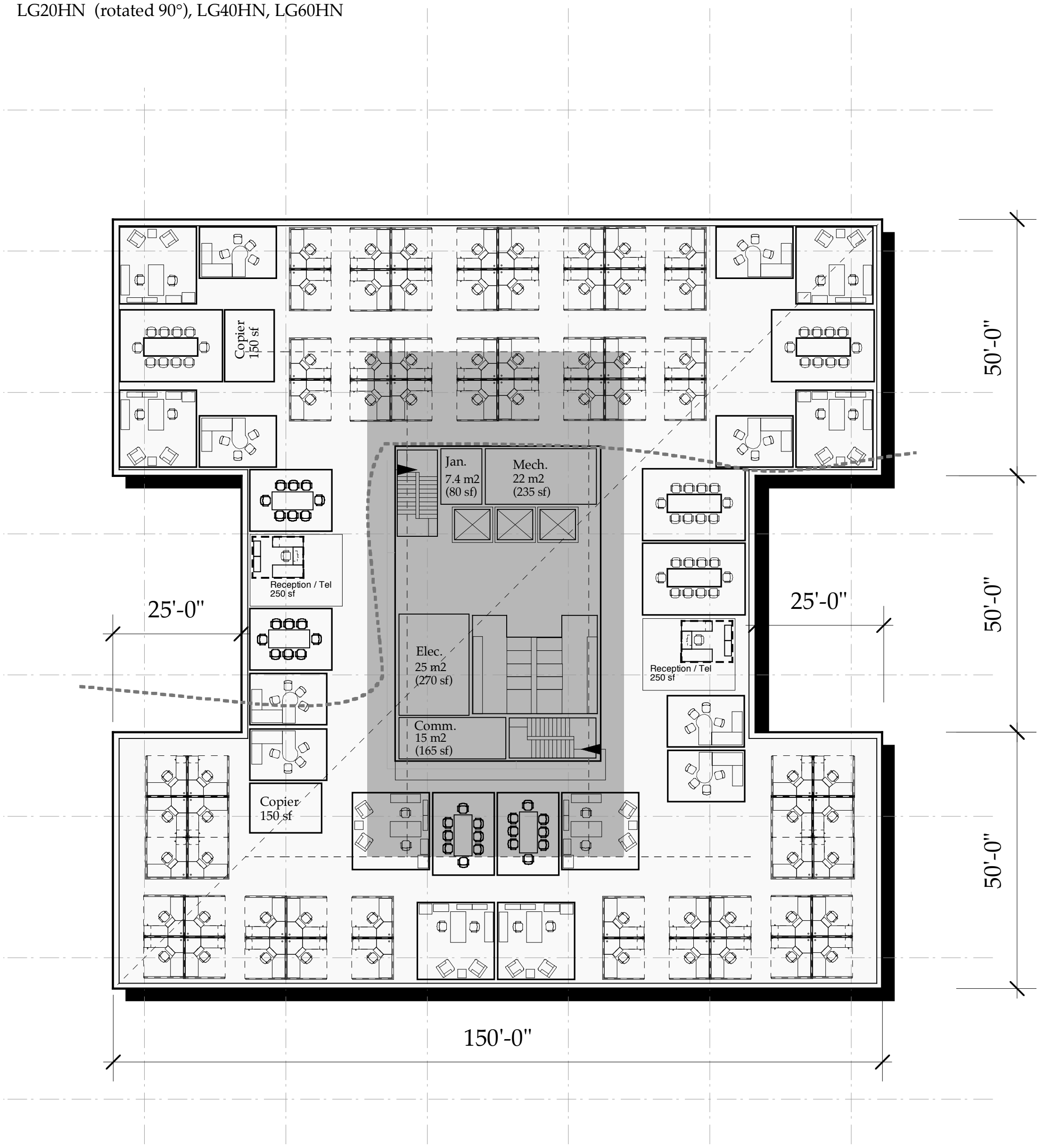
long plan is 90' x 222'
= 19,980 sf (1,856 m2)
aspect ratio of plan 2.47 : 1

diagonal is 236'-6";
half diagonal is 118'-3"
distance between access to
stairs is 60' + 39' = 99'
without "File Storage"

space allocation same as
SQ plan

Large Office Building - LG**HE

20,000 sf, "H-shaped" floor plate, axis of wings aligned east-west
LG20HE, LG40HE, LG60HE
LG20HN (rotated 90°), LG40HN, LG60HN



150' x 150' = 22,500 sf less 2 @ 25' x 50' = 2,500 sf ... 20,000 sf
diagonal of plan is 209'-8"; one half is 104'-9"
107'-6" designed, between exits

wc allocation: 20,000 - 2,460 = 17,540 sf
at 100 sf / person, occupant load is 175 people, or 88 or each sex -->
need 5 wcs for each sex

Water heater sizing

The size of water storage tanks was estimated, using the method recommended in Stein (1986, 528-530). The results from each calculation were compared to the size proposed as a default by eQuest (based on the architectural and occupancy characteristics of each building). From there, and approximate median was chosen to be used as the input for all eQuest runs. Since the heating of domestic water draws upon such a small percentage of the overall energy use profile, this exercise was done - not to attain perfect accuracy - but mainly to get a feel for what the difference between the 1986 textbook and the 2009 energy simulation software might be.

SMALL building, occupant load (OBC) = 145

Usable storage capacity, 0.6 gallons per person
Recovery capacity, 0.25 gallons per hour per person
(from Stein Figure 9.18d, p. 530)
Usable hot water must be 70% of total storage

0.6 x 145 x 1.43 = 124.41 gallons
Range of usable storage capacity is 0.2 to 1.5 => 41.47 to 311 gallons
Median is 176 gallons => say 150 gallons as between calculated size.
and median

MEDIUM building, occupant load (OBC) = 532

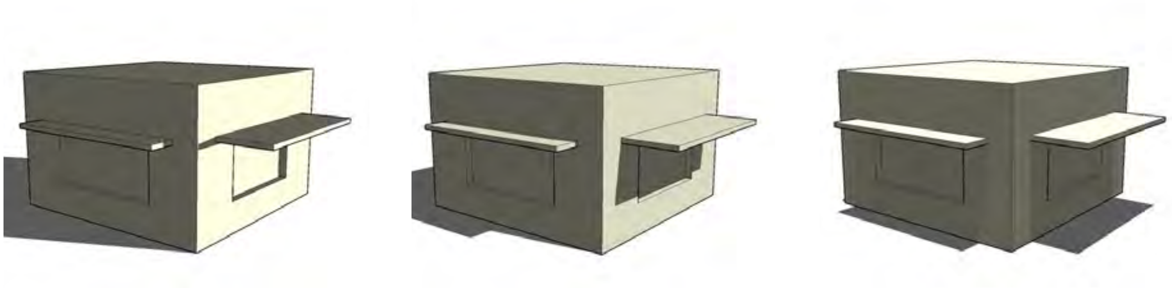
0.2 x 532 x 1.43 = 152.15 gallons
1.5 x 532 x 1.43 = 1,141.14 gallons
Median of these two is 646.65 gallons
eQuest suggests 323 => say 400 gallons as input during simulations

LARGE building, occupant load (OBC) = 966

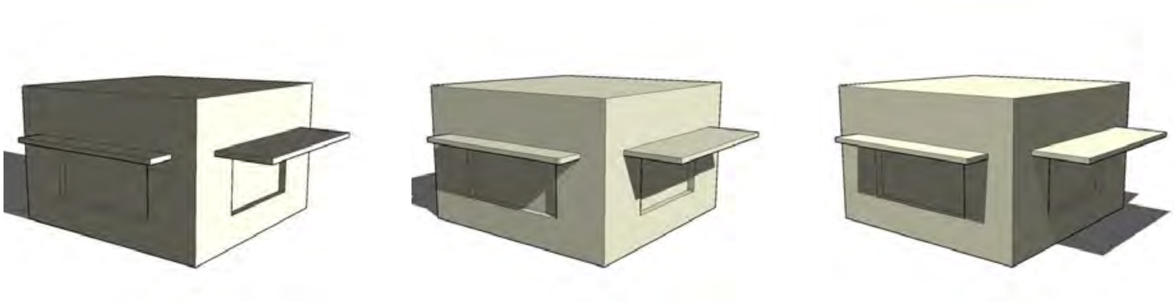
0.2 x 966 x 1.43 = 276.28 gallons
1.5 x 966 x 1.43 = 2,072.07 gallons
Median is 1,174.17 gallons
eQuest suggests 901 => say 800 gallons as input during simulations

Figure A-5.8
Effect of sunshades
in MIAMI

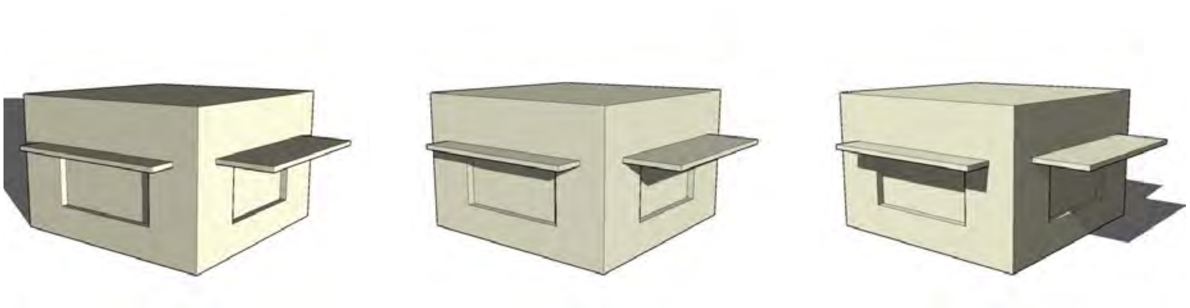
SUNRISE **9:00 AM** **NOON**



05:45 a.m.

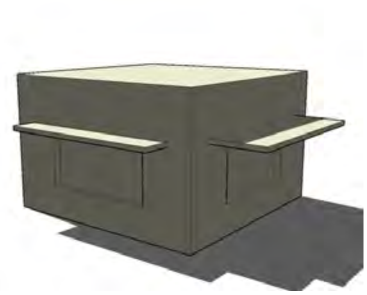


06:13 a.m.



07:08 a.m.

3:00 PM **SUNSET**

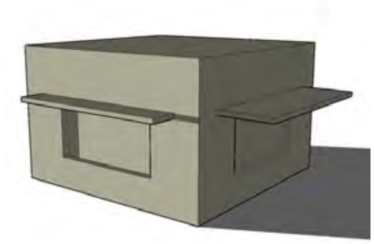


07:00 p.m.

summer solstice
21 June

06:11 p.m.

autumn equinox
21 September



05:28 p.m.

winter solstice
21 December

Figure A-5.9
Results from eQuest simulations in Macro-matrix #1

		Space Heat	Hot Water	Vent Fans	Pumps & Aux.	Misc. Equip.	Task Lights	Area Lights	Total *ekWhr/yr*
LG60HN-A	245.9	594.4	97.4	173.1	7.0	648.2	87.0	531.8	2,384.80
14,986	16	40	6	12	0	43	6	35	**159** *per* m^2
	10%	25%	4%	7%	0.3%	27%	4%	22%	% of total
LG60HE-A	246.3	584.8	97.4	174.4	7.0	648.2	87.0	531.8	2,376.80
14,986	16	39	6	12	0	43	6	35	**159** *per* m^2
	10%	25%	4%	7%	0.3%	27%	4%	22%	100%
LG60NS-A	251.3	531.5	96.5	181.6	3.9	640.4	86.1	526.5	2,322.30
14,986	17	35	6	12	0	43	6	35	**155** *per* m^2
	11%	23%	4%	8%	0.2%	28%	4%	23%	
LG60EW-A	247.7	535.0	96.5	171.5	3.9	640.4	86.1	526.5	2,307.80
14,986	17	36	6	11	0	43	6	35	**154** *per* m^2
	11%	23%	4%	7%	0.2%	28%	4%	23%	
LG60SQ-A	253.6	526.0	98.2	173.6	3.9	651.3	87.7	536.1	2,330.50
14,986	17	35	7	12	0	43	6	36	**156** *per* m^2
	11%	23%	4%	7%	0.2%	28%	4%	23%	
LG40HN-A	229.4	539.9	97.4	150.2	7.0	648.2	87.0	531.8	2,290.90
14,986	15	36	6	10	0	43	6	35	**153** *per* m^2
	10%	24%	4%	7%	0%	28%	4%	23%	
LG40HE-A	227.8	534.1	97.4	145.9	7.0	648.2	87.0	531.8	2,279.20
14,986	15	36	6	10	0	43	6	35	**152** *per* m^2
	10%	23%	4%	6%	0.3%	28%	4%	23%	
LG40NS-A	223.3	481.5	96.5	156.3	3.9	640.4	86.1	526.5	2,214.50
14,986	15	32	6	10	0	43	6	35	**148** *per* m^2
	10%	22%	4%	7%	0.2%	29%	4%	24%	
LG40EW-A	225.5	476.8	96.5	144.0	3.9	640.4	86.1	526.5	2,199.70
14,986	15	32	6	10	0	43	6	35	**147** *per* m^2
	10%	22%	4%	7%	0.2%	29%	4%	24%	
LG40SQ-A	238.0	479.0	98.2	148.6	3.9	651.3	87.7	536.1	2,242.90
14,986	16	32	7	10	0	43	6	36	**150** *per* m^2
	11%	21%	4%	7%	0.2%	29%	4%	24%	
LG20HN-A	214.7	496.0	97.4	121.4	7.0	648.2	87.0	531.8	2,203.50
14,986	14	33	6	8	0	43	6	35	**147** *per* m^2
	10%	23%	4%	6%	0.3%	29%	4%	24%	
LG20HE-A	223.1	442.7	98.1	96.1	3.9	651.3	87.7	536.1	2,139.10
14,986	15	30	7	6	0	43	6	36	**143** *per* m^2
	10%	21%	5%	4%	0.0	30%	4%	25%	
LG20NS-A	212.0	439.0	96.5	125.5	3.9	640.4	86.1	526.5	2,129.80
14,986	14	29	6	8	0	43	6	35	**142** *per* m^2
	10%	21%	5%	6%	0.0	30%	4%	25%	
LG20EW-A	208.7	438.3	96.5	120.9	3.9	640.4	86.1	526.5	2,121.20
14,986	14	29	6	8	0	43	6	35	**142** *per* m^2
	10%	21%	5%	6%	0.0	30%	4%	25%	
LG20SQ-A	223.1	442.7	98.1	96.1	3.9	651.3	87.7	536.1	2,139.10
14,986	15	30	7	6	0	43	6	36	**143** *per* m^2
	10%	21%	5%	4%	0.0	30%	4%	25%	

TYPE **m^2**	**Space Cool**	**Space Heat**	**Hot Water**	**Vent Fans**	**Pumps & Aux.**	**Misc. Equip.**	**Task Lights**	**Area Lights**	**Total** *ekWhr/yr*
LG60HN-B	265.3	912.8	97.6	215.9	7.0	648.2	87.0	531.8	2,765.50
14,986	18	61	7	14	0	43	6	35	**185** *per m^2*
	10%	33%	4%	8%	0.3%	23%	3%	19%	
LG60HE-B	260.4	910.8	97.6	211.7	7.0	648.2	87.0	531.8	2,754.50
14,986	17	61	7	14	0	43	6	35	**184** *per m^2*
	9%	33%	4%	8%	0.3%	24%	3%	19%	
LG60NS-B	267.8	825.2	96.7	229.8	3.9	640.4	86.1	526.5	2,676.40
14,986	18	55	6	15	0	43	6	35	**179** *per m^2*
	10%	31%	4%	9%	0.1%	24%	3%	20%	
LG60EW-B	251.8	855.7	96.7	200.4	3.9	640.4	86.1	526.5	2,661.40
14,986	17	57	6	13	0	43	6	35	**178** *per m^2*
	9%	32%	4%	8%	0.1%	24%	3%	20%	
LG60SQ-B	263.2	836.6	98.4	196.3	3.9	651.3	87.7	536.1	2,673.50
14,986	18	56	7	13	0	43	6	36	**178** *per m^2*
	10%	31%	4%	7%	0.1%	24%	3%	20%	
LG40HN-B	240.3	848.3	97.6	175.0	7.0	648.2	87.0	531.8	2,635.20
14,986	16	57	7	12	0	43	6	35	**176** *per m^2*
	9%	32%	4%	7%	0.3%	25%	3%	20%	
LG40HE-B	236.3	845.8	97.6	172.4	7.0	648.2	87.0	531.8	2,626.00
14,986	16	56	7	12	0	43	6	35	**175** *per m^2*
	9%	32%	4%	7%	0.3%	25%	3%	20%	
LG40NS-B	241.6	797.4	96.7	177.4	3.9	640.4	86.1	526.5	2,569.90
14,986	16	53	6	12	0	43	6	35	**171** *per m^2*
	9%	31%	4%	7%	0.2%	25%	3%	20%	
LG40EW-B	226.4	800.7	96.7	164.8	3.9	640.4	86.1	526.5	2,545.40
14,986	15	53	6	11	0	43	6	35	**170** *per m^2*
	9%	31%	4%	6%	0.2%	25%	3%	21%	
LG40SQ-B	246.6	789.5	98.4	174.5	3.9	651.3	87.7	536.1	2,588.10
14,986	16	53	7	12	0	43	6	36	**173** *per m^2*
	10%	31%	4%	7%	0.2%	25%	3%	21%	
LG20HN-B	208.0	790.9	97.6	134.7	7.0	648.2	87.0	531.8	2,505.20
14,986	14	53	7	9	0	43	6	35	**167** *per m^2*
	8%	32%	4%	5%	0.3%	26%	3%	21%	
LG20HE-B	205.9	788.4	97.6	132.9	7.0	648.2	87.0	531.8	2,498.70
14,986	14	53	7	9	0	43	6	35	**167** *per m^2*
	8%	32%	4%	5%	0.3%	26%	3%	21%	
LG20NS-B	208.8	753.5	96.7	134.2	3.9	640.4	86.1	526.5	2,450.00
14,986	14	50	6	9	0	43	6	35	**163** *per m^2*
	9%	31%	4%	5%	0.2%	26%	4%	21%	
LG20EW-B	202.7	750.6	96.7	128.5	3.9	640.4	86.1	526.5	2,435.30
14,986	14	50	6	9	0	43	6	35	**163** *per m^2*
	8%	31%	4%	5%	0.2%	26%	4%	22%	
LG20SQ-B	212.7	765.2	98.3	104.4	3.9	651.3	87.7	536.1	2,459.70
14,986	14	51	7	7	0	43	6	36	**164** *per m^2*
	9%	31%	4%	4%	0.0	26%	4%	22%	

TYPE **m^2**	**Space Cool**	**Space Heat**	**Hot Water**	**Vent Fans**	**Pumps & Aux.**	**Misc. Equip.**	**Task Lights**	**Area Lights**	**Total** *ekWhr/yr*
LG60HN-C	296.9	1,069.3	97.7	261.6	7.0	648.2	87.0	531.8	2,999.50
14,986	20	71	7	17	0	43	6	35	**200** *per m^2*
	10%	36%	3%	9%	0.2%	22%	3%	18%	
LG60HE-C	290.6	1,067.1	97.7	255.1	7.0	648.2	87.0	531.8	2,984.60
14,986	19	71	7	17	0	43	6	35	**199** *per m^2*
	10%	36%	3%	9%	0.2%	22%	3%	18%	
LG60NS-C	289.0	1,010.0	96.8	267.2	3.9	640.4	86.1	526.5	2,919.90
14,986	19	67	6	18	0	43	6	35	**195** *per m^2*
	10%	35%	3%	9%	0.1%	22%	3%	18%	
LG60EW-C	278.4	1,019.8	96.8	240.3	3.9	640.4	86.1	526.5	2,892.20
14,986	19	68	6	16	0	43	6	35	**193** *per m^2*
	10%	35%	3%	8%	0.1%	22%	3%	18%	
LG60SQ-C	288.3	1,026.0	98.5	242.8	3.9	651.3	87.7	536.1	2,934.70
14,986	19	68	7	16	0	43	6	36	**196** *per m^2*
	10%	35%	3%	8%	0.1%	22%	3%	18%	
LG40HN-C	258.3	1,043.9	97.7	206.4	7.0	648.2	87.0	531.8	2,880.20
14,986	17	70	7	14	0	43	6	35	**192** *per m^2*
	9%	36%	3%	7%	0.2%	23%	3%	18%	
LG40HE-C	253.6	1,042.1	97.7	202.2	7.0	648.2	87.0	531.8	2,869.70
14,986	17	70	7	13	0	43	6	35	**191** *per m^2*
	9%	36%	3%	7%	0.2%	23%	3%	19%	
LG40NS-C	246.0	994.2	96.8	210.2	3.9	640.4	86.1	526.5	2,804.10
14,986	16	66	6	14	0	43	6	35	**187** *per m^2*
	9%	35%	3%	7%	0.1%	23%	3%	19%	
LG40EW-C	240.8	997.3	96.8	192.7	3.9	640.4	86.1	526.5	2,784.50
14,986	16	67	6	13	0	43	6	35	**186** *per m^2*
	9%	36%	3%	7%	0.1%	23%	3%	19%	
LG40SQ-C	255.5	1,007.6	98.5	194.9	3.9	651.3	87.7	536.1	2,835.60
14,986	17	67	7	13	0	43	6	36	**189** *per m^2*
	9%	36%	3%	7%	0.1%	23%	3%	19%	
LG20HN-C	209.8	1,042.0	97.7	150.6	7.0	648.2	87.0	531.8	2,774.10
14,986	14	70	7	10	0	43	6	35	**185** *per m^2*
	8%	38%	4%	5%	0.3%	23%	3%	19%	
LG20HE-C	207.2	1,039.2	97.7	148.5	7.0	648.2	87.0	531.8	2,766.60
14,986	14	69	7	10	0	43	6	35	**185** *per m^2*
	7%	38%	4%	5%	0.3%	23%	3%	19%	
LG20NS-C	210.5	1,000.9	96.8	151.4	3.9	640.4	86.1	526.5	2,716.50
14,986	14	67	6	10	0	43	6	35	**181** *per m^2*
	8%	37%	4%	6%	0.1%	24%	3%	19%	
LG20EW-C	202.4	998.1	96.8	143.4	3.9	640.4	86.1	526.5	2,697.60
14,986	14	67	6	10	0	43	6	35	**180** *per m^2*
	8%	37%	4%	5%	0.1%	24%	3%	20%	
LG20SQ-C	211.3	1,022.8	98.5	116.7	3.9	651.3	87.7	536.1	2,728.40
14,986	14	68	7	8	0	43	6	36	**182** *per m^2*
	8%	37%	4%	4%	0.1%	24%	3%	20%	

TYPE **m²**	**Space Cool**	**Space Heat**	**Hot Water**	**Vent Fans**	**Pumps & Aux.**	**Misc. Equip.**	**Task Lights**	**Area Lights**	**Total** *ekWhr/yr*
LG60HN-D	312.3	1,649.5	98.0	317.0	7.0	648.2	87.0	531.8	3,650.80
14,986	21	110	7	21	0	43	6	35	**244** *per m²*
	9%	45%	3%	9%	0.2%	18%	2%	15%	
LG60HE-D	300.1	1,652.2	98.0	307.1	7.0	648.2	87.0	531.8	3,631.40
14,986	20	110	7	20	0	43	6	35	**242** *per m²*
	8%	45%	3%	8%	0.2%	18%	2%	15%	
LG60NS-D	302.9	1,601.5	97.1	304.4	3.9	640.4	86.1	526.5	3,562.90
14,986	20	107	6	20	0	43	6	35	**238** *per m²*
	9%	45%	3%	9%	0.1%	18%	2%	15%	
LG60EW-D	295.5	1,570.1	97.1	290.0	3.9	640.4	86.1	526.5	3,509.70
14,986	20	105	6	19	0	43	6	35	**234** *per m²*
	8%	45%	3%	8%	0.1%	18%	2%	15%	
LG60SQ-D	291.6	1,618.1	98.8	276.5	3.9	651.3	87.7	536.1	3,564.10
14,986	19	108	7	18	0	43	6	36	**238** *per m²*
	8%	45%	3%	8%	0.1%	18%	2%	15%	
LG40HN-D	264.0	1,628.2	98.0	255.0	7.0	648.2	87.0	531.8	3,519.20
14,986	18	109	7	17	0	43	6	35	**235** *per m²*
	8%	46%	3%	7%	0.2%	18%	2%	15%	
LG40HE-D	251.2	1,653.9	98.0	234.9	7.0	648.2	87.0	531.8	3,512.00
14,986	17	110	7	16	0	43	6	35	**234** *per m²*
	7%	47%	3%	7%	0.2%	18%	2%	15%	
LG40NS-D	256.6	1,585.3	97.1	244.7	3.9	640.4	86.1	526.5	3,440.60
14,986	17	106	6	16	0	43	6	35	**230** *per m²*
	7%	46%	3%	7%	0.1%	19%	3%	15%	
LG40EW-D	252.6	1,549.3	97.1	236.0	3.9	640.4	86.1	526.5	3,392.00
14,986	17	103	6	16	0	43	6	35	**226** *per m²*
	7%	46%	3%	7%	0.1%	19%	3%	16%	
LG40SQ-D	251.9	1,599.3	98.8	226.2	3.9	651.3	87.7	536.1	3,455.20
14,986	17	107	7	15	0	43	6	36	**231** *per m²*
	7%	46%	3%	7%	0.1%	19%	3%	16%	
LG20HN-D	209.8	1,639.2	98.0	189.0	7.0	648.2	87.0	531.8	3,410.00
14,986	14	109	7	13	0	43	6	35	**228** *per m²*
	6%	48%	3%	6%	0.2%	19%	3%	16%	
LG20HE-D	200.6	1,660.0	98.0	176.2	7.0	648.2	87.0	531.8	3,408.90
14,986	13	111	7	12	0	43	6	35	**227** *per m²*
	6%	49%	3%	5%	0.2%	19%	3%	16%	
LG20NS-D	204.1	1,602.3	97.1	180.7	3.9	640.4	86.1	526.5	3,341.10
14,986	14	107	6	12	0	43	6	35	**223** *per m²*
	6%	48%	3%	5%	0.1%	19%	3%	16%	
LG20EW-D	201.4	1,560.9	97.1	177.1	3.9	640.4	86.1	526.5	3,293.40
14,986	13	104	6	12	0	43	6	35	**220** *per m²*
	6%	47%	3%	5%	0.1%	19%	3%	16%	
LG20SQ-D	207.0	1,610.7	98.8	171.9	3.9	651.3	87.7	536.1	3,367.40
14,986	14	107	7	11	0	43	6	36	**225** *per m²*
	6%	48%	3%	5%	0.1%	19%	3%	16%	

TYPE **m²**	**Space Cool**	**Space Heat**	**Hot Water**	**Vent Fans**	**Pumps & Aux.**	**Misc. Equip.**	**Task Lights**	**Area Lights**	**Total** *ekWhr/yr*
MD60HN-A	84.6	257.6	36.6	64.1	7.0	202.8	27.0	167.7	847.48
4,662	18	55	8	14	2	43	6	36	**182** *per m²*
	10%	30%	4%	8%	0.8%	24%	3%	20%	
MD60HE-A	83.4	257.5	36.6	62.9	7.0	202.8	27.0	167.7	844.82
4,662	18	55	8	13	2	43	6	36	**181** *per m²*
	10%	30%	4%	7%	0.8%	24%	3%	20%	
MD60NS-A	85.4	239.8	36.6	68.6	3.9	202.0	27.0	167.7	830.97
4,662	18	51	8	15	1	43	6	36	**178** *per m²*
	10%	29%	4%	8%	0.5%	24%	3%	20%	
MD60EW-A	82.1	229.9	36.6	59.9	3.9	202.0	27.0	167.7	809.19
4,662	18	49	8	13	1	43	6	36	**174** *per m²*
	10%	28%	5%	7%	0.5%	25%	3%	21%	
MD60SQ-A	82.5	223.5	36.6	59.2	3.9	201.1	27.1	167.8	801.65
4,662	18	48	8	13	1	43	6	36	**172** *per m²*
	10%	28%	5%	7%	0.5%	25%	3%	21%	
MD40HN-A	76.9	233.1	36.6	53.0	7.0	202.8	27.0	167.7	804.15
4,662	16	50	8	11	2	43	6	36	**172** *per m²*
	10%	29%	5%	7%	0.9%	25%	3%	21%	
MD40HE-A	75.9	232.9	36.6	52.0	7.0	202.8	27.0	167.7	801.89
4,662	16	50	8	11	2	43	6	36	**172** *per m²*
	9%	29%	5%	6%	0.9%	25%	3%	21%	
MD40NS-A	76.6	219.0	36.6	55.9	3.9	202.0	27.0	167.7	788.78
4,662	16	47	8	12	1	43	6	36	**169** *per m²*
	10%	28%	5%	7%	0.5%	26%	3%	21%	
MD40EW-A	75.4	218.7	36.6	50.7	3.9	202.0	27.0	167.7	782.12
4,662	16	47	8	11	1	43	6	36	**168** *per m²*
	10%	28%	5%	6%	0.5%	26%	3%	21%	
MD40SQ-A	76.0	206.0	36.6	49.8	2.9	201.1	27.1	167.8	768.2
4,662	16	44	8	11	1	43	6	36	**165** *per m²*
	10%	27%	5%	6%	0.4%	26%	4%	22%	
MD20HN-A	70.5	211.8	36.6	41.6	7.0	202.8	27.0	167.7	764.94
4,662	15	45	8	9	2	43	6	36	**164** *per m²*
	9%	28%	5%	5%	0.9%	27%	4%	22%	
MD20HE-A	68.5	211.5	36.6	41.0	7.0	202.8	27.0	167.7	762.07
4,662	15	45	8	9	2	43	6	36	**163** *per m²*
	9%	28%	5%	5%	0.9%	27%	4%	22%	
MD20NS-A	67.5	202.0	36.6	42.8	3.9	202.0	27.0	167.7	749.52
4,662	14	43	8	9	1	43	6	36	**161** *per m²*
	9%	27%	5%	6%	0.5%	27%	4%	22%	
MD20EW-A	70.9	201.0	36.6	40.4	3.9	202.0	27.0	167.7	749.43
4,662	15	43	8	9	1	43	6	36	**161** *per m²*
	9%	27%	5%	5%	0.5%	27%	4%	22%	
MD20SQ-A	69.2	191.7	36.6	39.9	3.9	201.1	27.1	167.8	737.22
4,662	15	41	8	9	1	43	6	36	**158** *per m²*
	9%	26%	5%	5%	0.5%	27%	4%	23%	

TYPE **m^2**	**Space Cool**	**Space Heat**	**Hot Water**	**Vent Fans**	**Pumps & Aux.**	**Misc. Equip.**	**Task Lights**	**Area Lights**	**Total** *ekWhr/yr*
MD60HN-B	92.0	372.3	36.7	78.9	7.0	202.8	27.0	167.7	984.37
4,662	20	80	8	17	2	43	6	36	**211** *per m^2*
	9%	38%	4%	8%	0.7%	21%	3%	17%	
MD60HE-B	90.6	371.3	36.7	77.2	7.0	202.8	27.0	167.7	980.30
4,662	19	80	8	17	2	43	6	36	**210** *per m^2*
	9%	38%	4%	8%	0.7%	21%	3%	17%	
MD60NS-B	93.9	348.6	36.7	85.2	3.9	202.0	27.0	167.7	965.07
4,662	20	75	8	18	1	43	6	36	**207** *per m^2*
	10%	36%	4%	9%	0.4%	21%	3%	17%	
MD60EW-B	87.6	339.3	36.7	72.9	3.9	202.0	27.0	167.7	937.16
4,662	19	73	8	16	1	43	6	36	**201** *per m^2*
	9%	36%	4%	8%	0.4%	22%	3%	18%	
MD60SQ-B	87.5	331.0	36.7	71.8	3.9	201.1	27.1	167.8	926.78
4,662	19	71	8	15	1	43	6	36	**199** *per m^2*
	9%	36%	4%	8%	0.4%	22%	3%	18%	
MD40HN-B	81.7	346.9	36.7	62.4	7.0	202.8	27.0	167.7	932.20
4,662	18	74	8	13	2	43	6	36	**200** *per m^2*
	9%	37%	4%	7%	0.8%	22%	3%	18%	
MD40HE-B	79.0	345.4	36.7	61.2	7.0	202.8	27.0	167.7	926.76
4,662	17	74	8	13	2	43	6	36	**199** *per m^2*
	9%	37%	4%	7%	0.8%	22%	3%	18%	
MD40NS-B	80.8	327.9	36.7	66.4	3.9	202.0	27.0	167.7	912.44
4,662	17	70	8	14	1	43	6	36	**196** *per m^2*
	9%	36%	4%	7%	0.4%	22%	3%	18%	
MD40EW-B	80.4	327.8	36.7	59.2	3.9	202.0	27.0	167.7	904.88
4,662	17	70	8	13	1	43	6	36	**194** *per m^2*
	9%	36%	4%	7%	0.4%	22%	3%	19%	
MD40SQ-B	79.1	313.1	36.7	57.8	3.9	201.1	27.1	167.8	886.47
4,662	17	67	8	12	1	43	6	36	**190** *per m^2*
	9%	35%	4%	7%	0.4%	23%	3%	19%	
MD20HN-B	68.6	324.3	36.7	45.9	7.0	202.8	27.0	167.7	879.99
4,662	15	70	8	10	2	43	6	36	**189** *per m^2*
	8%	37%	4%	5%	0.8%	23%	3%	19%	
MD20HE-B	68.2	322.3	36.7	45.2	7.0	202.8	27.0	167.7	876.85
4,662	15	69	8	10	2	43	6	36	**188** *per m^2*
	7%	33%	4%	5%	0.7%	21%	3%	17%	
MD20NS-B	71.1	311.1	36.7	47.4	3.9	202.0	27.0	167.7	866.97
4,662	15	67	8	10	1	43	6	36	**186** *per m^2*
	8%	36%	4%	5%	0.4%	23%	3%	19%	
MD20EW-B	67.7	309.5	36.7	44.2	3.9	202.0	27.0	167.7	858.70
4,662	15	66	8	9	1	43	6	36	**184** *per m^2*
	8%	36%	4%	5%	0.5%	24%	3%	20%	
MD20SQ-B	68.0	298.8	36.7	43.5	3.9	201.1	27.1	167.8	846.77
4,662	15	64	8	9	1	43	6	36	**182** *per m^2*
	8%	35%	4%	5%	0.5%	24%	3%	20%	

TYPE **m^2**	**Space Cool**	**Space Heat**	**Hot Water**	**Vent Fans**	**Pumps & Aux.**	**Misc. Equip.**	**Task Lights**	**Area Lights**	**Total** *ekWhr/yr*
MD60HN-C	106.2	409.1	36.8	97.1	7	202.8	27	167.7	1,053.70
4,662	23	88	8	21	2	44	6	36	**226** *per m^2*
	10%	39%	3%	9%	0.7%	19%	3%	16%	
MD60HE-C	104.1	409.6	36.8	94.6	7	202.8	27	167.7	1,049.50
4,662	22	88	8	20	2	44	6	36	**225** *per m^2*
	10%	39%	4%	9%	0.7%	19%	3%	16%	
MD60NS-C	109.1	386	36.8	105.7	3.9	202	27	167.7	1,038.30
4,662	23	83	8	23	1	43	6	36	**223** *per m^2*
	11%	37%	4%	10%	0.4%	19%	3%	16%	
MD60EW-C	99.5	382.9	36.8	88.9	3.9	202	27	167.7	1,008.80
4,662	21	82	8	19	1	43	6	36	**216** *per m^2*
	10%	38%	4%	9%	0.4%	20%	3%	17%	
MD60SQ-C	98.5	377.5	36.8	87.4	3.9	201.1	27.1	167.8	999.98
4,662	21	81	8	19	1	43	6	36	**214** *per m^2*
	10%	38%	4%	9%	0.4%	20%	3%	17%	
MD40HN-C	90.4	400.5	36.8	74.9	7.0	202.8	27.0	167.7	1,007.10
4,662	19	86	8	16	2	44	6	36	**216** *per m^2*
	9%	40%	4%	7%	0.7%	20%	3%	17%	
MD40HE-C	87.1	400.7	36.8	73.1	7.0	202.8	27.0	167.7	1,002.10
4,662	19	86	8	16	2	44	6	36	**215** *per m^2*
	9%	40%	4%	7%	0.7%	20%	3%	17%	
MD40NS-C	90.2	381.5	36.8	80.5	3.9	202.0	27.0	167.7	989.66
4,662	19	82	8	17	1	43	6	36	**212** *per m^2*
	9%	39%	4%	8%	0.4%	20%	3%	17%	
MD40EW-C	88.2	382.6	36.8	70.6	3.9	202.0	27.0	167.7	978.85
4,662	19	82	8	15	1	43	6	36	**210** *per m^2*
	9%	39%	4%	7%	0.4%	21%	3%	17%	
MD40SQ-C	85.8	372.4	36.8	68.7	3.9	201.1	27.1	167.8	963.44
4,662	18	80	8	15	1	43	6	36	**207** *per m^2*
	9%	39%	4%	7%	0.4%	21%	3%	17%	
MD20HN-C	70.9	401.5	36.8	52.3	7.0	202.8	27.0	167.7	965.94
4,662	15	86	8	11	2	43	6	36	**207** *per m^2*
	7%	42%	4%	5%	0.7%	21%	3%	17%	
MD20HE-C	70.1	400.7	36.8	51.4	7.0	202.8	27.0	167.7	963.40
4,662	15	86	8	11	2	43	6	36	**207** *per m^2*
	7%	42%	4%	5%	0.7%	21%	3%	17%	
MD20NS-C	73.9	387.2	36.8	54.6	3.9	202.0	27.0	167.7	953.17
4,662	16	83	8	12	1	43	6	36	**204** *per m^2*
	8%	41%	4%	6%	0.4%	21%	3%	18%	
MD20EW-C	69.4	385.1	36.8	50.2	3.9	202.0	27.0	167.7	942.05
4,662	15	83	8	11	1	43	6	36	**202** *per m^2*
	7%	41%	4%	5%	0.4%	21%	3%	18%	
MD20SQ-C	69.3	376.2	36.8	49.2	3.9	201.1	27.1	167.8	931.37
4,662	15	81	8	11	1	43	6	36	**200** *per m^2*
	7%	40%	4%	5%	0.4%	22%	3%	18%	

TYPE m^2	**Space Cool**	**Space Heat**	**Hot Water**	**Vent Fans**	**Pumps & Aux.**	**Misc. Equip.**	**Task Lights**	**Area Lights**	**Total** *ekWhr/yr*
MD60HN-D	110.8	616.4	37.0	110.8	7.0	202.8	27.0	167.7	1,279.50
4,662	24	132	8	24	2	44	6	36	**274** *per m^2*
	9%	48%	3%	9%	0.5%	16%	2%	13%	
MD60HE-D	106.7	617.2	37.0	108.1	7.0	202.8	27.0	167.7	1,273.50
4,662	23	132	8	23	2	44	6	36	**273** *per m^2*
	8%	48%	3%	8%	0.5%	16%	2%	13%	
MD60NS-D	112.1	586.8	37.0	120.9	3.9	202.0	27.0	167.7	1,257.40
4,662	24	126	8	26	1	43	6	36	**270** *per m^2*
	9%	47%	3%	10%	0.3%	16%	2%	13%	
MD60EW-D	104.9	579.8	37.0	101.7	3.9	202.0	27.0	167.7	1,224.00
4,662	23	124	8	22	1	43	6	36	**263** *per m^2*
	9%	47%	3%	8%	0.3%	17%	2%	14%	
MD60SQ-D	101.7	570.8	37	99.5	3.9	201.1	27	167.8	1,208.70
4,662	19	121	8	17	1	43	6	36	**259** *per m^2*
	7%	48%	3%	7%	0.3%	17%	2%	14%	
MD40HN-D	92.0	606.4	37.0	87.8	7.0	202.8	27.0	167.7	1,227.60
4,662	20	130	8	19	2	44	6	36	**263** *per m^2*
	7%	49%	3%	7%	0.6%	17%	2%	14%	
MD40HE-D	90.4	606.8	37.0	85.6	7.0	202.8	27.0	167.7	1,224.30
4,662	19	130	8	18	2	44	6	36	**263** *per m^2*
	7%	50%	3%	7%	0.6%	17%	2%	14%	
MD40NS-D	97.1	581.7	37.0	94.6	3.9	202.0	27.0	167.7	1,211.00
4,662	21	125	8	20	1	43	6	36	**260** *per m^2*
	8%	48%	3%	8%	0.3%	17%	2%	14%	
MD40EW-D	89.8	580.8	37.0	82.8	3.9	202.0	27.0	167.7	1,191.00
4,662	19	125	8	18	1	43	6	36	**255** *per m^2*
	8%	49%	3%	7%	0.3%	17%	2%	14%	
MD40SQ-D	86.3	566.2	37.0	80.1	3.9	201.1	27.0	167.8	1,169.30
4,662	19	121	8	17	1	43	6	36	**251** *per m^2*
	7%	48%	3%	7%	0.3%	17%	2%	14%	
MD20HN-D	70.9	610.1	37.0	63.4	7.0	202.8	27.0	167.7	1,186.00
4,662	15	131	8	14	2	44	6	36	**254** *per m^2*
	6%	51%	3%	5%	0.6%	17%	2%	14%	
MD20HE-D	70.0	609.2	37.0	62.0	7.0	202.8	27.0	167.7	1,182.80
4,662	15	131	8	13	2	44	6	36	**254** *per m^2*
	6%	52%	3%	5%	0.6%	17%	2%	14%	
MD20NS-D	74.1	591.1	37.0	66.4	3.9	202.0	27.0	167.7	1,169.30
4,662	16	127	8	14	1	43	6	36	**251** *per m^2*
	6%	51%	3%	6%	0.3%	17%	2%	14%	
MD20EW-D	69.3	587.3	37.0	60.3	3.9	202.0	27.0	167.7	1,154.50
4,662	15	126	8	13	1	43	6	36	**248** *per m^2*
	6%	51%	3%	5%	0.3%	17%	2%	15%	
MD20SQ-D	68.6	573.1	37.0	58.9	3.9	201.1	27.0	167.8	1,137.40
4,662	15	123	8	13	1	43	6	36	**244** *per m^2*
	6%	50%	3%	5%	0.3%	18%	2%	15%	

TYPE m^2	**Space Cool**	**Space Heat**	**Hot Water**	**Vent Fans**	**Pumps & Aux.**	**Misc. Equip.**	**Task Lights**	**Area Lights**	**Total** *ekWhr/yr*
SM60NS-A	22.4	89.4	10.8	16.8	2.6	40.0	5.1	37.4	224.41
1,102	20	81	10	15	2	36	5	34	**204** *per* m^2
	10%	40%	5%	7%	1.2%	18%	2%	17%	
SM60EW-A	22.0	88.2	10.9	15.7	2.6	41.0	5.7	37.8	223.94
1,102	20	80	10	14	2	37	5	34	**203** *per* m^2
	10%	39%	5%	7%	1.2%	18%	3%	17%	
SM60SQ-A	22.1	87.0	13.3	15.8	2.6	40.6	5.7	37.9	225.01
1,102	20	79	12	14	2	37	5	34	**204** *per* m^2
	10%	39%	6%	7%	1.2%	18%	3%	17%	
SM40NS-A	19.9	83.0	10.8	14.6	2.6	39.7	5.1	37.4	213.04
1,102	18	75	10	13	2	36	5	34	**193** *per* m^2
	9%	39%	5%	7%	1.2%	19%	2%	18%	
SM40EW-A	18.9	84.5	10.8	13.2	2.6	39.7	5.1	37.4	212.26
1,102	17	77	10	12	2	36	5	34	**193** *per* m^2
	9%	40%	5%	6%	1.2%	19%	2%	18%	
SM40SQ-A	18.6	90.4	11.3	13.2	2.6	38.5	4.6	37.1	216.30
1,102	17	82	10	12	2	35	4	34	**196** *per* m^2
	9%	42%	5%	6%	1.2%	18%	2%	17%	
SM20NS-A	16.4	78.6	10.8	10.8	2.6	40.0	5.1	37.4	201.70
1,102	15	71	10	10	2	36	5	34	**183** *per* m^2
	8%	39%	5%	5%	1.3%	20%	3%	19%	
SM20EW-A	16.6	78.7	10.8	10.3	2.6	40.0	5.1	37.4	201.57
1,102	15	71	10	9	2	36	5	34	**183** *per* m^2
	8%	39%	5%	5%	1.3%	20%	3%	19%	
SM20SQ-A	16.8	77.7	13.3	10.4	2.6	40.6	5.7	37.9	205.02
1,102	15	70	12	9	2	37	5	34	**186** *per* m^2
	8%	38%	7%	5%	1.3%	20%	3%	18%	

TYPE **m^2**	**Space Cool**	**Space Heat**	**Hot Water**	**Vent Fans**	**Pumps & Aux.**	**Misc. Equip.**	**Task Lights**	**Area Lights**	**Total** *ekWhr/yr*
SM60NS-B	25.1	122.0	10.9	21.1	2.6	40.0	5.1	37.4	264.13
1,102	23	111	10	19	2	36	5	34	**240** *per m^2*
	10%	46%	4%	8%	1.0%	15%	2%	14%	
SM60EW-B	24.0	121.2	10.9	19.3	2.6	40.0	5.1	37.4	260.50
1,102	22	110	10	18	2	36	5	34	**236** *per m^2*
	9%	47%	4%	7%	1.0%	15%	2%	14%	
SM60SQ-B	24.4	118.7	13.4	19.5	2.6	40.6	5.7	37.9	262.69
1,102	22	108	12	18	2	37	5	34	**238** *per m^2*
	9%	45%	5%	7%	1.0%	15%	2%	14%	
SM40NS-B	20.4	114.1	10.9	17.0	2.6	39.7	5.1	37.4	247.15
1,102	19	104	10	15	2	36	5	34	**224** *per m^2*
	8%	46%	4%	7%	1.1%	16%	2%	15%	
SM40EW-B	19.9	114.0	10.9	15.6	2.6	39.7	5.1	37.4	245.16
1,102	18	103	10	14	2	36	5	34	**222** *per m^2*
	8%	46%	4%	6%	1.1%	16%	2%	15%	
SM40SQ-B	20.1	112.7	11.0	15.8	2.6	40.6	5.7	37.9	246.29
1,102	18	102	10	14	2	37	5	34	**223** *per m^2*
	8%	46%	4%	6%	1.1%	16%	2%	15%	
SM20NS-B	17.4	109.8	10.9	11.9	2.6	40.0	5.1	37.4	235.04
1,102	16	100	10	11	2	36	5	34	**213** *per m^2*
	7%	47%	5%	5%	1.1%	17%	2%	16%	
SM20EW-B	16.7	109.7	10.9	11.2	2.6	40.0	5.1	37.4	233.53
1,102	15	100	10	10	2	36	5	34	**212** *per m^2*
	7%	47%	5%	5%	1.1%	17%	2%	16%	
SM20SQ-B	17.1	107.9	13.4	11.4	2.6	40.6	5.7	37.9	236.52
1,102	15	98	12	10	2	37	5	34	**215** *per m^2*
	7%	46%	6%	5%	1.1%	17%	2%	16%	

TYPE **m^2**	**Space Cool**	**Space Heat**	**Hot Water**	**Vent Fans**	**Pumps & Aux.**	**Misc. Equip.**	**Task Lights**	**Area Lights**	**Total** *ekWhr/yr*
SM60NS-C	29.7	128.5	10.9	26.2	2.6	40.0	5.1	37.4	280.28
1,102	27	117	10	24	2	36	5	34	**254** *per m^2*
	11%	46%	4%	9%	0.9%	14%	2%	13%	
SM60EW-C	28.1	128.2	10.9	23.8	2.6	40.0	5.1	37.4	275.99
1,102	25	116	10	22	2	36	5	34	**250** *per m^2*
	10%	46%	4%	9%	0.9%	15%	2%	14%	
SM60SQ-C	22.5	128.5	11.0	23.8	2.6	40.6	5.7	37.9	278.42
1,102	28	117	10	22	2	37	5	34	**253** *per m^2*
	8%	46%	4%	9%	0.9%	15%	2%	14%	
SM40NS-C	23.2	126.4	10.9	20.7	2.6	39.7	5.1	37.4	265.93
1,102	21	115	10	19	2	36	5	34	**241** *per m^2*
	9%	48%	4%	8%	1.0%	15%	2%	14%	
SM40EW-C	22.3	126.2	10.9	18.8	2.6	39.7	5.1	37.4	262.95
1,102	20	115	10	17	2	36	5	34	**239** *per m^2*
	8%	48%	4%	7%	1.0%	15%	2%	14%	
SM40SQ-C	22.5	125.6	10.6	19.0	2.6	40.6	5.7	37.9	264.38
1,102	20	114	10	17	2	37	5	34	**240** *per m^2*
	9%	47%	4%	7%	1.0%	15%	2%	14%	
SM20NS-C	18.4	130.0	10.9	13.7	2.6	40.0	5.1	37.4	258.04
1,102	17	118	10	12	2	36	5	34	**234** *per m^2*
	7%	50%	4%	5%	1.0%	16%	2%	14%	
SM20EW-C	17.5	129.9	10.9	12.7	2.6	40.0	5.1	37.4	256.03
1,102	16	118	10	12	2	36	5	34	**232** *per m^2*
	7%	51%	4%	5%	1.0%	16%	2%	15%	
SM20SQ-C	17.8	130.2	11.0	13.0	2.6	40.6	5.7	37.9	258.69
1,102	16	118	10	12	2	37	5	34	**235** *per m^2*
	7%	50%	4%	5%	1.0%	16%	2%	15%	

TYPE **m^2**	**Space Cool**	**Space Heat**	**Hot Water**	**Vent Fans**	**Pumps & Aux.**	**Misc. Equip.**	**Task Lights**	**Area Lights**	**Total** *ekWhr/yr*
SM60NS-D	29.0	190.3	10.9	32.0	2.6	40.0	5.1	37.4	347.29
1,102	26	173	10	29	2	36	5	34	**315** *per m^2*
	8%								
SM60EW-D	27.2	189.6	11.0	28.5	2.6	40.0	5.1	37.4	341.37
1,102	25	172	10	26	2	36	5	34	**310** *per m^2*
	8%								
SM60SQ-D	27.8	193.4	11.0	29.5	2.6	40.6	5.7	37.9	348.39
1,102	25	175	10	27	2	37	5	34	**316** *per m^2*
	8%								
SM40NS-D	25.2	188.5	10.9	25.0	2.6	39.7	5.1	37.4	334.34
1,102	23	171	10	23	2	36	5	34	**303** *per m^2*
	8%								
SM40EW-D	23.6	187.8	11.0	22.5	2.6	39.7	5.1	37.4	329.51
1,102	21	170	10	20	2	36	5	34	**299** *per m^2*
	7%								
SM40SQ-D	20.8	188.3	13.6	20.2	2.6	40.1	5.7	37.9	329.09
1,102	19	171	12	18	2	36	5	34	**299** *per m^2*
	6%								
SM20NS-D	17.8	197.0	11.4	17.1	2.6	38.4	4.6	37.0	325.9
1,102	16	179	10	16	2	35	4	34	**296** *per m^2*
	5%								
SM20EW-D	17.6	191.7	11.0	15.9	2.6	40.0	5.1	37.4	321.17
1,102	16	174	10	14	2	36	5	34	**291** *per m^2*
	5%								
SM20SQ-D	16.0	188.8	11.0	14.9	2.6	40.6	5.7	37.9	317.42
1,102	14	171	10	14	2	37	5	34	**288** *per m^2*
	5%								

Figure A-5.10a Summary of inputs to MIT Design Advisor

Constants	Variables
1 ***Climate:***	
Toronto, Ontario, Canada	
2 ***Occupancy: Office Building***	
Schedule: 7 a.m. - 7 p.m., lights always on	
Person density: 0.075 people/m2 (sim OP)	
Lighting: 750 lux, “fine work”	
Equipment: 15 W/m2, “office med-high”	
3 ***Ventilation systems:***	Vent’n rates:
mech. cooling & heating	A: 5 ł/s/person
Indoor temps: 78 max, 68 min (defaults)	D: 40 ł/s/person
Max. r.h. 60%	(roughly 9x)
4 ***Thermal mass:***	
high mass, exposed concrete slab floor	
5 ***Building geometry:***	
entire floor (4 facades + core)	
well-mixed air between zones	
Building orientation:	
side a = e-w dim.; side b = n-s dim.	
	dims. vary as in orig. types
6 ***Typical room properties***	
room dims: 10’ wide, 15’ deep, 9’ high	
primary façade oriented: east	
7 ***Windows:***	
overhang: none	
type: all fixed	
blinds/shading: none	
	w-w-r 20%, 40%, 60%
	A-triple/D-double glazed
	A-high perf/D-clear
8 ***Wall description:***	A- R-36/D- R-8 (entered)

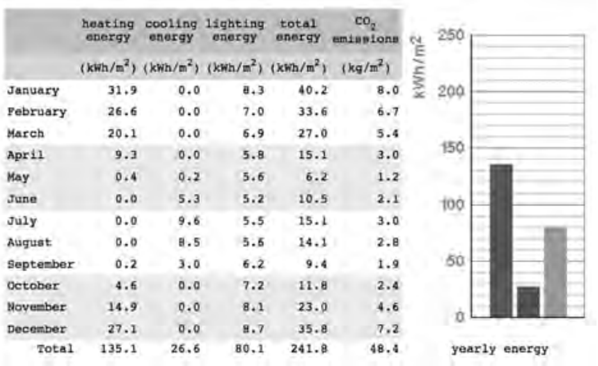
VERIFICATION OF EQUEST RESULTS

To put the results from eQuest into perspective, comparisons were made to results obtained using two other simulators - both of which are on-line tools with relatively simple inputs. MIT Design Advisor and the NRCan Screening Tool are intended to help students and practitioners make swift simulations during the earliest stages of design.

The expectation was that each simulator would return slightly different absolute values, because it uses slightly different inputs. Still, the values were expected to lie within a consistent range across the Macro-matrix. Further, the general conclusions - regarding the power of the various design parameters - ought not to change, regardless of which simulator was used.

Verification #1: Simulate selected types using the online tool "MIT Design Advisor"

The online tool MIT Design Advisor, version 1.0, is intended to help a designer improve upon the indoor comfort and energy use of a conceptual design, using inputs that require minimal technical expertise and can be entered within 5 minutes. Major assumptions built into the background of the simulator, as well as procedures used to validate its results are outlined on its website.*



	heating energy (kWh/m²)	cooling energy (kWh/m²)	lighting energy (kWh/m²)	total energy (kWh/m²)	CO_2 emissions (kg/m²)
January	31.9	0.0	8.3	40.2	8.0
February	26.6	0.0	7.0	33.6	6.7
March	20.1	0.0	6.9	27.0	5.4
April	9.3	0.0	5.8	15.1	3.0
May	0.4	0.2	5.6	6.2	1.2
June	0.0	5.3	5.2	10.5	2.1
July	0.0	9.6	5.5	15.1	3.0
August	0.0	8.5	5.6	14.1	2.8
September	0.2	3.0	6.2	9.4	1.9
October	4.6	0.0	7.2	11.8	2.4
November	14.9	0.0	8.1	23.0	4.6
December	27.1	0.0	8.7	35.8	7.2
Total	135.1	26.6	80.1	241.8	48.4

Figure A-5.10b
Sample output MD40EW-C, from MIT Design Advisor

In order to obtain a good comparison without excess labour; rather than repeating all 156 types, a representative 36 types, lying along the diagonal line within Macro-matrix #1, from LG20SQ-A to SM60NS-D were simulated. The inputs resembled those used in eQuest runs as closely as possible, given the range available in MIT Design Advisor (see Figure A-5.10a). MIT Design Advisor can simulate only rectangular plan forms, and a limited range of alternate building orientations; glass is assumed to be distributed evenly across all facades.

Outputs are both graphic and numeric (see one sample in the inset in Figure A-5.10b).

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*For instance, inputs used TMY2 weather data and outputs for a range of scenarios (not explicit) have been validated against the US DOE's Energy Plus software. See FAQ at: http://www.designadvisor.mit.edu/design, accessed 21-27 May, 2009

Figure A-5.11a Summary of inputs to NRCan Screening Tool for New Building Design

	Constants	Variables
Location:	Toronto, Ontario	
More than one occupancy type?	NO	
Configuration		
Building type:	Office, large	
Floor area:	varies	SM 1,100 m^2 MD 4,660 m^2 LG 14,860 m^2
Primary heating sys.:	elec. (var. vol.)	
Utility rates:	\$0.035 per kWh \$8.50 per kW \$11 per GJ net gas \$0.00 per l. oil/propane	
Building Shell		
w-w-r:	varies	20%, 40%, 60%
ø/a U_{SI}:	varies	A 1.21; B 1.99; C 1.93; D 3.17
window SC:	varies	A 0.35; B 0.53; C 0.72; D 0.84
ø/a R_{SI} wall:	varies	A 6.24; B 4.23; C 2.99; D1.38
ext'r wall area:	SQ:	S 744; M 2,164; L 5,488 m^2
	NS & EW:	S 802; M 2,599; L 6,029 m^2
roof type:	"all other" (not "attic", not "trusses & joists")	
R_{SI} roof:	varies	A 8.33; B 5.81; C 3.35; D 0.87
ext'r roof area:	varies	S 550; M 1,165; L 1,858 m^2
Mechanical Systems		
htg. efficiency:	100%	
min. outside air	0.4 liter/sec./m2	
DCV type:	none	
% outside air DCV-cntrld:	0%	
% floor area cooled:	100%	
cooling efficiency:	3.5 COP = EER 8.5	(nb: NRCan ref bldg COP 5.2)
outdoor air econo'r:	Yes	
exh. air ht. recov. effic'y:	0%	
dom. water htg. fuel:	electical	
dom. water htg. effic'y:	100%	
dom. water htg. savings:	0%	
variable speed fans?	Yes	
Lighting		
avg. ltg. density:	14 W/m2	
controls:	none	
Process Loads		
avg. p. load density:	16 W/m2	
% saved by elec'y:	0%	

Verification #2: Simulate selected types using the online "Screening Tool for New Building Design" *

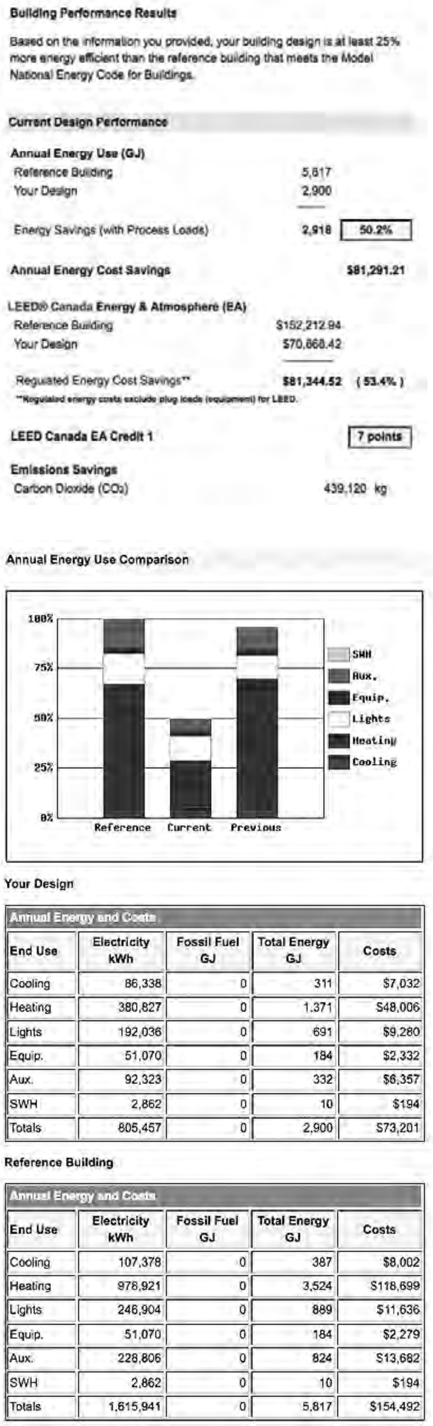
This online tool estimates the energy performance of a schematic design, relative to Canada's Model National Energy Code for Buildings and NRCan's "established rules". However, neither the assumptions built into the simulator nor the validation processes are made available to the user.

The same types simulated with MIT Design Advisor were to be simulated using the NRCan Screening Tool. Again, the inputs most closely resembling those used in eQuest were selected from available options in the Screening Tool (see Figure A-5.11a). However, the Screening Tool does not allow alternative building orientations to be tested at all; this limited the number of types tested here to 24, rather than 36. Plan shape is interpreted from other inputs (including building gross floor area, overall exterior wall area, and roof area). Like MIT Design Advisor, the Screening Tool does not allow testing of window orientation.

Outputs are both graphic and numeric, and include an appraisal of the potential of the design to earn points under the LEED rating system's Energy and Atmosphere Credit EA1 (see Figure A-5.11b).

When testing the "-D" enclosure, the software returned a non-sensical result: a number so high that it was meaningless. This is perhaps due to the Screening Tool's expectation that the design in question would not use the parameters that define the "Market" or "-D" enclosure, which fall slightly below OBC 2009 minimums. Because this result was difficult to interpret, the runs made with the Screening Tool were further limited to 18 in number. Nevertheless this seemed to be enough to observe the trends in the results (see Figure A-5.12).

Figure A-5.11b
Sample output, MD40EW-A and MD40EW-C, from NRCan Screening Tool



Building Performance Results

Based on the information you provided, your building design is at least 25% more energy efficient than the reference building that meets the Model National Energy Code for Buildings.

Current Design Performance

Annual Energy Use (GJ)

Reference Building	5,617	
Your Design	2,900	
Energy Savings (with Process Loads)	2,918	50.2%
Annual Energy Cost Savings		**$81,291.21**

LEED® Canada Energy & Atmosphere (EA)

Reference Building	$152,212.94	
Your Design	$70,868.42	
Reguated Energy Cost Savings**	**$81,344.52**	**(53.4%)**

**Regulated energy costs exclude plug loads (equipment) for LEED.

LEED Canada EA Credit 1	7 points

Emissions Savings

Carbon Dioxide (CO₂)	439,120 kg

Annual Energy Use Comparison

Your Design

Annual Energy and Costs

End Use	Electricity kWh	Fossil Fuel GJ	Total Energy GJ	Costs
Cooling	86,338	0	311	$7,032
Heating	380,827	0	1,371	$48,006
Lights	192,036	0	691	$9,280
Equip.	51,070	0	184	$2,332
Aux.	92,323	0	332	$6,357
SWH	2,862	0	10	$194
Totals	805,457	0	2,900	$73,201

Reference Building

Annual Energy and Costs

End Use	Electricity kWh	Fossil Fuel GJ	Total Energy GJ	Costs
Cooling	107,378	0	387	$8,002
Heating	978,921	0	3,524	$118,699
Lights	246,904	0	889	$11,636
Equip.	51,070	0	184	$2,279
Aux.	228,806	0	824	$13,682
SWH	2,862	0	10	$194
Totals	1,615,941	0	5,817	$154,492

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* available at http://screen.nrcan.gc.ca, accessed 22-27 May, 2009.

Figure A-5.12
Comparison of results obtained using MIT Design Advisor, NRCan Screening Tool and eQuest

MIT Des. Adv.				NRCan Screening					eQuest			
A	B	C	D	A	B	C	D		A	B	C	D
210	218	253	300	282	450	733	x	SM60NS	204	240	254	315
208	211	246	294	z	z	z	xz	SM60EW	203	236	250	310
211	211	246	292	276	426	687	x	SM60SQ	204	238	253	316
213	199	233	274	170	232	327	x	MD40NS	193	224	241	303
212	193	228	270	z	z	z	xz	MD40EW	193	223	239	299
215	193	227	267	163	215	297	x	MD40SQ	194	224	240	299
215	185	222	264	120	145	178	x	LG20NS	183	213	234	294
215	184	221	262	z	z	z	xz	LG20EW	183	212	232	291
216	184	220	261	121	143	174	x	LG20SQ	186	215	235	288

Macro-matrix #1

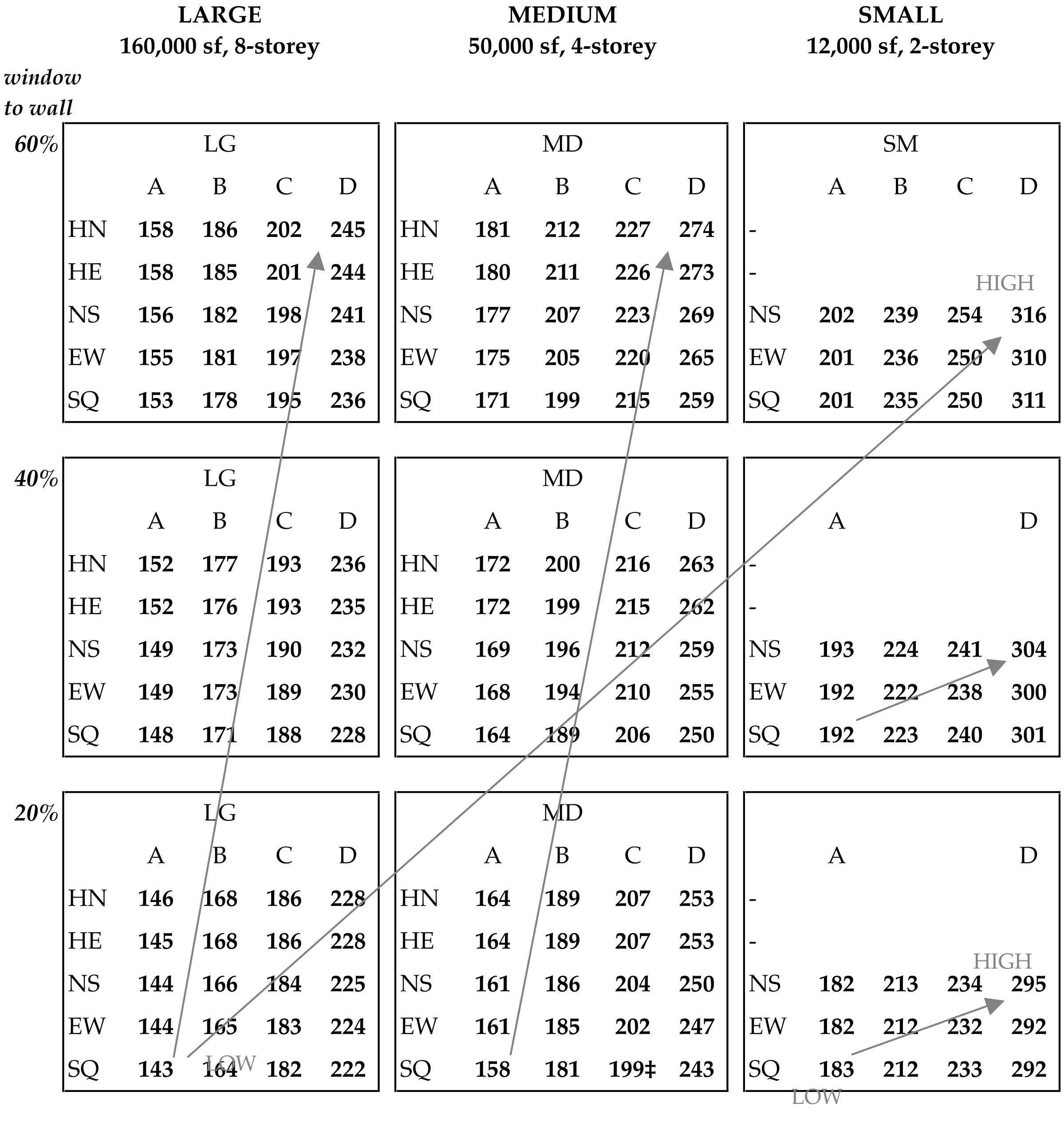
Similar trends seen in the results from other tools

The key diagram, at the lower left, of Figure A-5.12, shows the sectors of Macro-matrix #1, from which the building types were selected, for the verification runs. The main panel in Figure A-5.12 presents the results obtained using MIT Design Advisor and the NRCan Screening Tool, in comparison to those obtained using eQuest.

Comparing the pattern of results obtained via MIT Design Advisor to the pattern obtained via eQuest confirms that changing only the form of a building, from a square plan to a long slender one, has little impact on energy intensity. This is true for the small, medium and large buildings. In both MIT Design Advisor and eQuest, all buildings that were spun on their axis - that is the NS and EW variations - performed similarly in both solar orientations. This effect also was consistent in the buildings with small, medium, and large gross floor areas. The impact of the enclosure type (comparing any -D type to the -B type on the same horizontal line) was estimated at roughly the same magnitude by both simulators. One anomaly, in the results from MIT Design Advisor, is the increased energy-intensity in the -A types, relative to the -B types, in the MD and LG buildings (noted in red figures).

Comparing the pattern of results obtained via the NRCan Screening Tool to the pattern obtained via eQuest tells a similar story, with a few key differences. Building orientation could not be tested in the Screening Tool (this is the reason for the ‘z’ entry). The impact of varying the enclosure is exaggerated, relative to the eQuest results, particularly in the small building. Also, a greater difference in energy-intensity between one building size and another also is suggested. Nevertheless, the results obtained via the NRCan Screening Tool consistently show very little impact from varying the form of the floor plan, and significantly more impact from varying the enclosure.

Figure A-5.13
Verification of eQuest results, by an independent researcher



	LARGE **160,000 sf, 8-storey**	**MEDIUM** **50,000 sf, 4-storey**	**SMALL** **12,000 sf, 2-storey**

window to wall

60%

LG

	A	B	C	D
HN	**158**	**186**	**202**	**245**
HE	**158**	**185**	**201**	**244**
NS	**156**	**182**	**198**	**241**
EW	**155**	**181**	**197**	**238**
SQ	**153**	**178**	**195**	**236**

MD

	A	B	C	D
HN	**181**	**212**	**227**	**274**
HE	**180**	**211**	**226**	**273**
NS	**177**	**207**	**223**	**269**
EW	**175**	**205**	**220**	**265**
SQ	**171**	**199**	**215**	**259**

SM

	A	B	C	D
-				
-				
NS	**202**	**239**	**254**	**316**
EW	**201**	**236**	**250**	**310**
SQ	**201**	**235**	**250**	**311**

40%

LG

	A	B	C	D
HN	**152**	**177**	**193**	**236**
HE	**152**	**176**	**193**	**235**
NS	**149**	**173**	**190**	**232**
EW	**149**	**173**	**189**	**230**
SQ	**148**	**171**	**188**	**228**

MD

	A	B	C	D
HN	**172**	**200**	**216**	**263**
HE	**172**	**199**	**215**	**262**
NS	**169**	**196**	**212**	**259**
EW	**168**	**194**	**210**	**255**
SQ	**164**	**189**	**206**	**250**

	A			D
-				
-				
NS	**193**	**224**	**241**	**304**
EW	**192**	**222**	**238**	**300**
SQ	**192**	**223**	**240**	**301**

20%

LG

	A	B	C	D
HN	**146**	**168**	**186**	**228**
HE	**145**	**168**	**186**	**228**
NS	**144**	**166**	**184**	**225**
EW	**144**	**165**	**183**	**224**
SQ	**143**	**164**	**182**	**222**

MD

	A	B	C	D
HN	**164**	**189**	**207**	**253**
HE	**164**	**189**	**207**	**253**
NS	**161**	**186**	**204**	**250**
EW	**161**	**185**	**202**	**247**
SQ	**158**	**181**	**199‡**	**243**

	A			D
-				
-				
NS	**182**	**213**	**234**	**295**
EW	**182**	**212**	**232**	**292**
SQ	**183**	**212**	**233**	**292**

RESULTS OBTAINED, BY ANOTHER RESEARCHER, USING EQUEST

As a final check on the use of eQuest for this study, the whole experiment was replicated by an independent researcher, working at a remote location. The author of this study, Researcher A had developed all of the inputs, and documented them, before seeking the assistance of Researcher B.*

Researcher B received the following documents from Researcher A: floor plans of all building types, three sheets of inputs (summary, space allocation and climate control, Figures 5.1.6, 5.1.12, and 5.1.13), the details of the enclosure types (Figures 5.1.6, 5.1.8, and 5.1.9), the wall sections and elevations (Figure 5.1.10), and an empty Macro-matrix #1 in which to enter the results. Researcher B used her own computer, and independently-installed versions of both eQuest and the relevant weather files.

Both researchers began simulating the small building, and compared results for the nine SM-A and nine SM-D types. A few anomalies helps to identify "sticky" points of data entry, such as window dimensions and WWR. After a few re-iterations of the first 18 building types, both researchers were able to obtain consistent outputs.

The two researchers then completed all of the remaining runs independently, without comparing any results until the entire series was completed. Figure A-5.13 shows the results obtained by Researcher B. These compare very closely to the results obtained by Researcher A, which are shown in Figure 5.3.2.

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*for more on the potential and limitations of energy-simulation software, including a discussion on passive ventilation strategies, see Brittany Hanam, 2010 "Development of an open-source hourly energy modelling software tool" (working title) M.Sc. (Civ. Eng.), University of Waterloo.