THE TRANSITION TO A CHLORINE-FREE ECONOMY

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ABSTRACT

In April of 1992, the International Joint Commission (IJC), a United States-Canadian agency that monitors environmental quality in the Great Lakes, called for the phasing out of chlorine as an industrial feedstock. The IJC had concluded that, based on a review of the scientific evidence, the health of humans was in danger due to persistent toxic chlorinated compounds found in the environment. The IJC and the task force went on to recommend a comprehensive transition planning process in order to implement the phase-out of industrial chlorine in an orderly and planned manner.

In spite of almost a decade of deliberation, the conclusions and recommendations of the IJC were strongly criticized by industry, and received only limited support from the Canadian and U.S. governments. Industry and government advanced alternative approaches that were far less sweeping and were based on traditional pollution control strategies. The comprehensive transition planning process as envisioned by the IJC has not been implemented and, because of funding concerns, the IJC's ability to pursue the toxic substance issue is being constrained.

Although the approaches currently being pursued by government and industry will lead to some reductions in toxic chemical emissions, these approaches fail to address the unique problems of persistent and bioaccumulative substances. Traditional pollution control strategies will not prevent the accidental release of toxic substances during the production, application and disposal of chlorine-based products. Once released, these toxic byproducts do not readily break down in the environment. They slowly accumulate—adding to the increasing load of toxins found in virtually all human and animal tissue around the globe. The IJC's recommendations, which are focused on eliminating the source of the problem, is a more prudent approach to addressing the unique problems of persistent and bioaccumulative substances.

Furthermore, industry's claim that a transition to a chlorine-free economy is too expensive appears to be unfounded. In this thesis, two applications—polyvinyl chloride pipe and perchloroethylene solvent—were examined to evaluate industry's claim. It was determined that, although there are some differences in cost-performance, chlorine-free alternatives compare favorably to chlorine-based products. The cost-performance differences that do exist appear to be manageable.

In order to move the transition process forward, government needs to firmly establish its commitment to eliminating the industrial use of chlorine. Then, rather than applying a comprehensive planning approach, government needs to establish appropriate phase-out timelines and develop market-based instruments which will provide industry with the incentives to implement the transition. The timelines must provide industry with enough time to: (1) obtain a return on chlorine-based investments, (2) develop chlorine-free business strategies, and (3) assist affected employees.

The details and innumerable business decisions concerning a transition to a chlorine-free economy should be left to the marketplace. This is because adapting to change is business-as-usual in competitive industries. Industry is constantly responding and adapting to new customer requirements, initiatives from competitors, and new technologies. Industry's flexibility, innovativeness, and responsiveness are powerful tools that can be applied to implement a transition to a chlorine-free economy. Market-based instruments established by the government, in consultation with industry, will provide the signals and incentives to move the transition process forward.

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PROBLEM STATEMENT

In April of 1992, the International Joint Commission (IJC), a United States-Canadian agency that monitors environmental quality in the Great Lakes, called for the phasing out of chlorine as an industrial feedstock. The IJC had concluded that, based on a review of the scientific evidence, the health of humans was in danger due to persistent toxic chlorinated compounds found in the environment (IJC Sixth Biennial Report 1992).

The International Joint Commission (IJC)

The IJC's call to phase out the industrial use of chlorinated compounds was unprecedented in its scope. Of the estimated 60,000 to 70,000 of commercially available chemicals, over 15,000 contain chlorine. A phasing out of all chlorinated compounds would eliminate approximately 25% of the chemicals in commerce (Ehrenfield et al., 1993).

After making this sweeping recommendation, the IJC was strongly criticized by industry and received only limited support from the U.S. and Canadian governments. A brief history of the IJC, and the developments that lead to its recommendation will put the IJC's position and the response from government and industry into context.

The IJC was created in 1914 as an independent agency to oversee the 1909 Boundary Waters Treaty between Canada and the U.S. The purpose of the treaty was to address issues such as the flow and use of boundary waters shared between the two countries. The treaty also stipulated that neither country could pollute boundary waters to the detriment of the other side. The members of the IJC were appointed to their positions by the Canadian and the U.S. governments.

In 1972, Canada and the United States negotiated the Great Lakes Water Quality Agreement (GLWQA). The IJC was assigned the task of overseeing the implementation of the GLWQA. A Water Quality Board and a Science Advisory Board for Great Lakes Water Quality were established to assist the IJC in this task. The IJC's main role was and is to monitor and assess the progress made by governments with respect to the agreement and to recommend what needs to be done in order to achieve the agreement objectives. The IJC is not a regulatory body. It can only make recommendations. The federal governments ultimately decide whether or not to act upon the IJC's recommendations.

During the 1960s, the main issue in the Great Lakes was eutrophication caused by excessive phosphorous and nitrogen loadings. In the 1970s, as a result of the GLWQA, there was a great deal of action by both the U.S. and Canadian governments to reverse the eutrophication problem mainly by reducing phosphorous loadings from municipal waste treatment plants and industries in the Great Lakes. There was also a growing awareness of the presence of persistent toxic substances in the Great Lakes. This awareness lead to an expansion of the GLWQA in 1978, which shifted the focus from eutrophication to the control and elimination of toxic substances. The expanded agreement stated that the discharge of toxic substances in toxic amounts was prohibited, and the discharges of any or all persistent toxic substances were to be virtually eliminated. A toxic substance was defined as a substance which can cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological deformities in any organism or its offspring, or which can become poisonous after concentration in the food chain or in combination with other substances. Persistent toxic substances were defined as any toxic substance with a half-life in water of greater than eight weeks (Durnil 1995).

This new emphasis on toxic substances complemented existing water pollution control legislation such as the U.S. Clean Water Act, the Canadian Fisheries Act, and the Environmental Protection Act in Ontario. It resulted in substantial improvements in the control of toxic substances such as cyanide and heavy metals during the 1980s. Although there was substantial progress, the unique problems of persistent toxic substances were still not generally understood.

This situation began to change in the late 1980s and early 1990s as a result of a number of factors. One of these was the publication of a book called *Great Lakes, Great Legacy* (Colborn et al. 1990) by The Conservation Foundation and The Institute for Research on Public Policy. The work for this book was directed by Dr. Theo Colborn who brought together scientists from many disciplines to evaluate the issue of persistent toxic substances. Dr. Colborn and other scientists suspected that these substances were acting as endocrine disrupters in the environment. Dr. Colburn has continued her work in this area with the recent publication of a book titled *Our Stolen Future* (Colborn et al. 1997).

Another factor which raised the priority of persistent toxics was increased pressure from the public. Environmental groups and the public had become more organized during the 1980s and early 1990s and began to demand action to address the pollution that was adversely affecting all species in the ecosystem. At the IJC's Fifth Biennial Meeting held in Hamilton in 1989, various groups and individual citizens made these demands very clear. It was obvious from the Fifth Biennial Meeting and subsequent meetings that the idea of zero discharge was a high priority in the mind of the public. And although the IJC supported the zero discharge philosophy, it was public pressure that initiated a series of roundtables on this subject over the next two years. The IJC followed up with the creation of the Virtual Elimination Task Force in 1990. The objective of the task force was to develop a strategy that would virtually eliminate persistent toxics in the Great Lakes.

The IJC also pursued its own review of the toxics issue through the Council of Great Lakes Research Managers. This council brought top researchers together to examine evidence concerning the effects of persistent toxics. An important result of this work was the adoption of the weight-of-evidence approach in order to reach conclusions regarding persistent toxics in the ecosystem (Durnil 1995).

This approach is necessary because it could take many years to obtain conclusive scientific evidence that will resolve the competing claims concerning persistent toxics. With the weight-of-evidence approach, policy-makers would assess all of the available data concerning epidemiological criteria for causality. These criteria would include: (1) whether the exposure precedes the effect, (2) whether there is a consistent association between a contaminant and damage, and (3) whether the association is plausible in light of understood biological mechanisms. Rather than definitive proof based on controlled laboratory experiments, conclusions are drawn in a manner similar to a doctor diagnosing a patient. The weight-of-evidence approach may lead to the conclusion that hormone-disrupting chemicals such as dioxins and furans are linked to testicular cancer, falling sperm counts, and learning disabilities in children (Colborn et al. 1997).

Although this approach is less rigorous than traditional science, it is justified because of the magnitude of the potential threat to human health and the environment. If all that were at stake were the survival of a few gull colonies, it would make sense to wait for compelling scientific evidence. However, based on the serious worldwide trends in human health that are being observed, postponement of action is highly imprudent (Colborn et al. 1997).

The weight-of-evidence approach was publicly advanced by the IJC during the Sixth Biennial Meeting in Traverse City, Michigan in 1991. It was at this meeting that the IJC made the unprecedented recommendation to sunset chlorine as an industrial feedstock.

The IJC's controversial recommendation was based on the premise that traditional ideas regarding pollution assimilation, management, and end-of-pipe control were simply inappropriate in dealing with persistent toxics. For example, assimilation assumes that there is some safe ambient level of toxins that can be measured and controlled. However, with the bioaccumlative nature of persistent toxics, there may be no safe level. In fact, it is possible that existing ambient levels are already above the calculated or observed "no effect" levels.

The IJC pointed out that persistent toxics defy traditional end-of-pipe regulatory solutions. Accidental releases, inappropriate applications, the ability to migrate among media, and the ability to travel via many pathways make persistent toxins difficult to manage and control. The IJC and the task force concluded that a new approach was needed because traditional regulatory approaches would not solve the problem (IJC Virtual Elimination Task Force 1993).

The IJC and the task force also believed that cooperative, roundtable discussions among all stakeholders—industry, environmentalists, public and government were required to solve the problem. They recommended the development of a transitional planning model by creating:

> "a comprehensive process to restrict, phase out and eventually ban the manufacture, generation, use, transport, storage, discharge and disposal of a persistent toxic substance. [In the Sixth Biennial Report, the IJC pointed out that] Sunsetting may require consideration of the manufacturing processes and products associated with a chemical's production and use, as well as the chemical itself, and realistic yet finite time frames to achieve the virtual elimination of the persistent toxic substance." (Durnil 1995, 64)

It is important to note that, although industry was invited to the meetings and roundtables, which lead to IJC's recommendations, industry representation was limited. However, when industry realized the magnitude of what the IJC was proposing, they quickly became major participants. Industry representation grew substantially at the IJC's Seventh Biennial Meeting in 1993.

During the Seventh Biennial Meeting, the IJC continued to support their earlier recommendations and those of the task force. They also suggested that all chemicals, new and in use, should be subjected to the concept of reverse onus. They challenged industry to conduct environmental audits of their procurement, production and marketing activities in relation to the Great Lakes Water Quality Agreement. They further recommended that industry develop corporate environmental policies that would include the concept of sustainable development (Durnil 1995).

The Chlorine Controversy

Although industry responded with a number of positive initiatives, the idea of sunsetting chlorine remains far from being accepted. Instead of supporting a transition planning process to eliminate chlorine, industry has challenged the IJC's conclusions and recommendations and is advocating programs such as Responsible Care® to manage and control persistent toxics.

Industry stakeholders claim that the dangers described by the IJC are exaggerated and that the transition costs are enormous and unnecessary (Chlorine Chemistry Council 1996). Although industry concedes that some chlorinated toxins must be eliminated from environment, the industry's approach to the problem is very different from the IJC's. The IJC wants to eliminate chlorine as a fundamental industrial feedstock—removing, at the source, the basic building block of chlorinated toxins. The industry prefers to focus on better management through programs such as Responsible Care®, and to apply more effective emission control technologies. And rather than treating chlorine as a single class, industry would prefer a chemical-by-chemical screening to identify and eliminate only the most harmful compounds (Rampy 1995).

These two approaches are based on very different philosophies. The IJC's recommendation is based on the application of a pollution prevention strategy aimed at eliminating the source of pollutants. This approach would require alterations to many industrial processes and would likely lead to changes in the market positions of a number of large companies. The industry's approach, on the other hand, is based on a traditional strategy that emphasizes end-of-pipe solutions and improved management practices. Industry's strategy also maintains the status quo of existing applications and of industry market positions.

Industry's decision to resist rather than to embrace transitional planning has meant that few of the recommendations made by the IJC over the past decade have been implemented. At the Eighth Biennial Meeting in 1995, the IJC pointed out that recent cutbacks in regulation, enforcement and funding could jeopardize future progress to clean up the Great Lakes (Durnil 1995).

In the face of industry resistance and fiscal realities, the U.S. and Canadian governments have chosen more modest goals concerning persistent toxics. Their policy directions follow the recommendations of several research groups who have made proposals that are much less sweeping than the IJC and are more in line with industry's point-of-view.

For example, in June of 1994, the Michigan Environmental Science Board (MESB) outlined a number of findings and conclusions that recommended a slower, more cautious approach. The MESB concluded that "The mere presence of chlorine in a chemical compound does not mean that the compound is predisposed to be a toxic substance which could cause harm to humans or to the environment." In other words, chlorine should not be treated as a single class to be managed and controlled. Some of the MESB's findings and recommendations supporting this view are listed below:

- Toxic compounds currently known to be persistent and bioaccumulative should be vigorously controlled.

- Grouping of chemical substances for regulatory purposes on the basis of physical, chemical and biological characteristics is scientifically defensible, whereas grouping by a single property (e.g., contains chlorine) is perceived to be inadequate. Consequently, for the purpose of regulatory control, persistent toxic chlorinated and non-chlorinated compounds released to the environment can be treated as a group.

- An elimination proposal using a priority system addressing health, economic and other societal factors over a period of up to 30 years is reasonable for known and suspected harmful chlorinated compounds or processes.

- Some non-persistent chlorinated compounds, including certain volatile organic solvents, can produce toxic effects at high exposures. However, the ability of non-persistent chlorinated compounds to produce long-term health effects such as cancer, neurological damage or reproductive deficits as a result of lower environmental exposures is not considered convincing at this time (Kent, 1995).

The Texas Institute for Advancement of Chemical Technology (TIACT) advocates a similar position by noting that:

> "Two opposed positions have been taken by various groups with respect to the use of chlorine and chlorinated chemicals. One approach is to take action against chlorine and the entire class of chlorinated chemicals on the

> basis of both real and perceived risk and without regard for either economic impacts or the loss of known benefits of the targeted class of chemicals. The other approach is to judge each chemical on a chemical-by-chemical basis—considering the scientific data on toxicity and adverse effects as well as the risks and benefits of each chemical." (Holland 1995, 1)

TIACT considers a total ban on the industrial use of chlorine to be a "simplistic method which cannot be justified on a risk/benefit basis." TIACT also point out that the chemical-by-chemical approach needs to be complemented with the development of rapid screening procedures to deal with the huge number of chlorinated compounds that need to be tested (Holland 1995).

The Chlorine Chemistry Council (CCC), which is the chlorine industry's primary voice, also supports the idea of taking action on classes of chemicals. They also advocate the use of a high priority screening system to remove low-risk compounds from the screening process. The CCC has produced a list of principles that they believe should be considered when evaluating classes of chemicals defined as persistent, toxic and bioaccumulative (PTBs):

- not all PTBs contain chlorine
- criteria for PTB should be based on valid science
- action on PTBs should address those present at levels of real concern
- address most serious risks first
- focus on release not use
- reductions should focus on feasibility—don't chase the last molecule (Rampy 1995).

In Canada, Environment Canada's policy contains a number of elements which are similar to the approaches described above. A summary of Environment Canada's Toxic Substances Management Policy (TSMP) policy is outlined below:

> "The Policy presents a management framework based on two key objectives: virtual elimination from the environment of toxic substances that are persistent, bioaccumulative, and primarily the result of human activity (Track 1), and life-cycle management of other toxic substances and substances of concern to prevent or minimize their releases into the environment (Track 2). The Policy commits the federal government to identify candidate substances for virtual elimination from the environment and to consult the public in the decision process. The federal government will engage stakeholders

> involved in the generation or use of confirmed Track 1 substances in order to propose domestic and international actions to protect the Canadian environment from these substances." (Canada Gazette 1997)

Again, this policy supports a chemical-by-chemical approach rather than the elimination of chlorine as an industrial feedstock.

THESIS OBJECTIVES

After almost a decade of analysis and discussion, the conclusions and recommendations put forward by the IJC have been strongly criticized by industry and have received weak support from the Canadian and U.S. governments. Although Environment Canada has initiated studies and roundtables to evaluate the social and economic impacts of transition, the transition planning process as envisioned by the IJC is not moving forward. The objective of this thesis is to examine the obstacles that are preventing the implementation of this planning process and to explore other approaches that might be more applicable.

Some of the questions that will be explored include: What are the strategic and economic issues that cause industry to defend the status quo rather than to participate in the IJC's process? What impact does science, public pressure, and the availability of alternatives have on the decision making process and on the positions taken by industry?

Industry has claimed that there will be severe economic consequences if chlorinated compounds are phased-out. This claim is used to defend industry's position concerning the precautionary principle, the weight-of-evidence approach, and its proposed solutions to the persistent toxic problem. Is industry's economic argument valid? Is modern society's infrastructure so dependent on chlorine that it is impossible to transition to alternatives? Are studies that claim that there are chlorine-free alternatives to virtually every chlorine-based product valid? Is industry's approach, which advocates better management and control through programs such as Responsible Care®, valid?

As part of its Chlorinated Substances Action Plan, Environment Canada is studying the social and economic implications of a transition to chlorine-free alternatives. A first draft of this study, *A Technical and Socio-Economic Evaluation of the Use of Products Derived from Chlor-Alkali Industry*, was released in July 1996. Environment Canada's approach is to bring industry, environmental groups, academe, and government together in roundtables—an approach much like the cooperative planning process proposed by the IJC. However, the atmosphere at these sessions suggests that a cooperative transition process is highly unlikely. Companies that supply chlorine-based products have simply not accepted the idea that a phase-out of chlorinated substances is either necessary or inevitable.

In addition to a lack of consensus on an ultimate goal to sunset chlorine, there may be other issues that impede transition planning. These may include: (1) the sheer number of chlorine-based applications, suppliers, and associated companies, (2) the complicated cost-performance and business case arguments advanced by competing suppliers (chlorine-based and chlorine-free), (3) the uncertainty in predicting economic outcomes, (4) the self-interest of competing companies, (5) the confidential nature of industry costs, revenues, and business strategies, and (6) reduced government funding.

With all of these obstacles to transition planning, should other approaches be considered? Should there be less emphasis on central planning and more emphasis on markets to accomplish the transition? If government demonstrated its resolve to sunset chlorine and then set realistic timetables by product group, would industry and the market rise to the challenge to cost-effectively implement a transition process?

The hypothesis of this thesis is that a market-oriented approach is a more effective, less costly, and faster approach to transition than the comprehensive, centrally planned, multi-stakeholder approach envisioned by the IJC. This hypothesis assumes that industry and other stakeholders would provide input concerning timetables and the appropriate economic tools to generate market signals (e.g. green taxes). It also assumes that this input would be provided with the understanding that governments are firmly committed to eliminating the industrial use of chlorine. The need for firm government commitment is based on the premise that clear guidelines and unambiguous goals are required in order to reduce business uncertainty and to motivate companies to develop business strategies based on a chlorine-free economy. The thesis further hypothesizes that once the timetables and tools are established, market forces would address the countless implementation issues that will occur during the transition process. During the transition, the need for government resources would be minimal and would mainly be focused on monitoring.

This approach is based on the observation that successful companies in competitive industries are adaptable, innovative, and responsive to change. Companies in competitive industries constantly evolve their strategies and products due to emerging technology, aggressive competition, expanding or declining markets, and new customer demands. If the appropriate market signals were in place, would successful companies not respond to opportunities to increase their business in a growing market for chlorine-free products? Would it not be more appropriate to leave the transition to a chlorine-free economy in the hands of organizations that can deal with change in the most cost-effective manner?

Because business leaders tend to trust technology and markets, would this approach not be more acceptable to industry? Participating in a comprehensive planning process with government is not a normal business practice, especially when the issues involve market share, business strategies and competitors. Planning should be restricted to establishing broad guidelines. This means setting realistic timetables and devising tools that send the appropriate market signals. The implementation details should be worked out by industry and market forces.

This thesis will explore the questions outlined above in order to determine whether a market-oriented approach is more appropriate than a comprehensive planning approach.

METHODOLOGY

To examine the issues surrounding the chlorine controversy and the transition process, two chlorine-based products were chosen as case studies: (1) polyvinyl chloride (PVC) pipe used in the construction industry and, (2) perchloroethylene (PCE) used in the dry cleaning industry. Data for this study was gathered from a number of sources including:

1) Participation and attendance at workshops organized by government and environmental groups to debate the chlorine issue
2) Interviews with industry representatives
3) Review of current scientific and economic studies on the chlorine issue
4) Historical review of debates and transition processes for other chlorine-based products (e.g. chlorofluorocarbons (CFCs), alachlor, etc.)

It is important to provide a brief sketch of the author's background in order to establish a value framework for the thesis. As we will see later, in an examination of previous debates involving chlorine-based products, when there is a high degree of uncertainty, value frameworks strongly influence the interpretation of data and subsequent conclusions.

The author's background includes seventeen years as an employee in two large, multi-national corporations (General Electric and Hewlett-Packard) followed by nine years as a management consultant. The author's consulting assignments are primarily with large, multi-national corporations (e.g. ABB, Alfa Laval, Agfa, Digital Equipment, Hewlett-Packard, Honeywell, IBM, Kodak, Nortel, Westinghouse, and Xerox).

LESSONS FROM THE RECENT PAST

The issues and arguments being raised over chlorine are not new. Many products that were once viewed positively were subsequently banned or restricted.

When polychlorinated biphenyls (PCBs) were discovered, toxicity tests did not identify any hazardous effects. The characteristics of being nonflammable and extremely stable motivated the Swann Chemical Company (later part of Monsanto Chemical Company) to quickly move into production. The pesticide dichloro-diphenyl-trichloro-ethane (DDT) was once considered a major breakthrough in the fight against malaria, a disease that caused untold suffering for millions of people. Paul Muller, the developer of DDT, was awarded the Nobel Prize for his work. Thomas Midgley Jr. developed chlorofluorocarbons (CFCs) in response to the demand for a safer alternative to the toxic and flammable chemicals used as coolants in refrigerators. He received the Priestly Prize, chemistry's highest award, for his work on the development of this product (Colburn, Dumanoski, and Myers 1997). Only later, when the negative impacts of each of these chemicals became apparent, did people act to have them banned.

Many of the issues and arguments that were raised prior to the banning of these and other chemicals are strikingly similar to those being raised today in the debate concerning chlorine. In order to provide a context for the current debate, we will review the issues and arguments that were raised during two past controversies involving the herbicide alachlor and CFCs.

Alachlor

The following summary of the alachlor controversy is based mainly on work done by Brunk, Haworth, and Lee (1991).

In Canada the debate over alachlor began on February 5, 1985, when the Canadian Minister of Agriculture canceled the registration of this herbicide that had been used by Canadian corn and soybean farmers for nearly 16 years. The impetus to take this decision came from the Health Protection Branch (HPB) of Health and Welfare Canada and was based on new studies which indicated that alachlor induced cancerous tumors in laboratory rats and mice during long-term feeding trials.

After the cancellation announcement, Monsanto Canada Inc., the manufacturer of alachlor, immediately launched an appeal. The Minister of Agriculture responded by setting up a Review Board to consider Monsanto's appeal. Almost three years later, on November 13, 1987, the Review Board submitted its final report to the Minister of Agriculture, recommending that the registration of alachlor be reinstated. The Minister, however, did not implement this recommendation and alachlor remains unregistered for sale in Canada.

The alachlor issue was also debated in the U.S. after concerns were raised by the U.S. Environmental Protection Agency (EPA). However, in the U.S., Monsanto's views prevailed. Alachlor was allowed to remain in the market with a number of relatively minor restrictions (Fagin and Lavelle 1996).

The arguments that were presented at the Canadian Review Board demonstrated the inability of science and risk assessment to provide clear direction for policy makers. Although science and risk assessment were supposed to provide unbiased data in order to support rational decisions, they were woefully inadequate in achieving this goal. Because of scientific uncertainty and different value frameworks, opposing parties came to very different conclusions based on virtually identical data.

At every juncture in the debate decisions were made regarding what data was acceptable, what data was correct, and what values were to be placed on human life and economics. The value frameworks of the participants influenced the decisions at each of these junctures. The participants included Ciba-Geigy, Monsanto, farm groups and environmentalists. During the debate Ciba-Geigy and Monsanto mostly countered each other's claims regarding the toxicity of their products. Farm groups were mainly concerned with the economic consequences of banning alachlor and other herbicides. Environmentalists argued that safety should take precedent over economic benefits.

Although the Review Board attempted to approach the controversy in a scientific manner, the process was essentially a political debate among different value frameworks, different moral positions, different conceptions of society, different attitudes toward technology and different views of risk.

One example of how different values influenced conclusions was in the determination of expected exposure rates. The HPB's calculation of exposure rates was based on the assumptions that: (1) the level of exposure to herbicide applicators should not be amortized over a total lifetime, (2) that protective clothing would not be worn or would, in come cases, be ineffective, and (3) that alachlor would be absorbed by the skin at near 100% rates. HPB believed that these were reasonable or even best-case assumptions. Monsanto and the Review Board, on the other hand, viewed these assumptions as worst-case and unreasonable. As a result, each group came to very different conclusions when estimating exposure rates.

Value assumptions were apparent in attitudes toward technology. The Review Board had a very positive view of technology's ability to solve human problems. This bias translated into an assumption that it was acceptable to apply technology but it was unacceptable to oppose technology unless it was proven to be harmful. If harm cannot be proven, interference or regulation was seen as unjustified.

The value assumptions concerning government regulations and risk were also exposed during the debate. The Review Board took the position that government action was justified only if there was compelling evidence that human health was being adversely affected. Monsanto believed that it was up to the government to prove that alachlor was harmful and not up to Monsanto to prove that it was safe. In other words, Monsanto's position was that it is better to accept the risk that some harmful products might enter the environment in order to ensure that no safe products are banned. Opponents to this view believed that it was better to accept the risk that some safe products might be banned in order to ensure that no unsafe products enter the environment.

In the U.S., the concept that government must prove that an agricultural chemical is unsafe is entrenched in the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). In the U.S. this meant that the EPA had to show that the risk of alachlor was unreasonable. Although Monsanto conceded that alachlor was a carcinogen, it was able to spend millions of dollars on studies which showed that the alternatives were: (1) less effective and just as dangerous, (2) that the cost of a ban would be tremendous, and (3) that the danger to farmers was less than EPA had estimated. These studies provided enough uncertainty that the proposed ban was not implemented (Fagin and Lavelle 1996).

With regard to the use of risk-benefit analysis, Agriculture Canada pointed out that this analytical tool tends to cover up or skew uncertainties. Agriculture Canada noted that risk-benefit analysis excludes social values that are just as valid and important as economics. In other words, the risks that society is willing to bear cannot be solely determined from a simple evaluation based on risk-benefit.

Environmentalists supported Agriculture Canada's view that it was better to err on the side of safety rather than on the side of economic benefits. Environmentalists were also opposed to the use of risk-benefit to determine risk acceptability. They pointed out that Canadian legislation allowed government to ban a herbicide simply by showing that there is a risk. There is no requirement to weigh this risk against economic benefits.

The Review Board, on the other hand, believed that there were clear and substantial benefits that should be weighed against alachlor's risk and that it was inappropriate to consider safety alone. However, when applying risk-benefit analysis, the tendency was to give more weight to the "factual" economic benefits while ignoring the uncertain health risks.

Opposing value assumptions were also clearly visible with regard to economics. Several Monsanto witnesses claimed that chemical weed control is essential in order for Canada to compete in the world agricultural market. These witnesses did not point out that this need was created by the fact that competitors to Canadian farmers were allowed to use these chemicals. The Review Board agreed with Monsanto's position and was supported by farm representatives who testified that alachlor or metolachlor (Ciba-Geigy's equivalent to alachlor) were essential to Canada's competitive position in international markets. And although the farm representatives indicated that they were concerned about the health risks to farmers, their testimony did not indicate that this was a priority.

Throughout the hearings, uncertainty affected every argument and conclusion. There was uncertainty concerning the data, the interpretation of the data, the methods to follow, and the conclusions to be drawn. As a result, no question could be answered with a high level of confidence. In spite of this uncertainty and lack of conclusive evidence, judgements were made and conclusions were drawn.

Even if the participants had attempted to make value-free judgements by insisting on statistically compelling evidence, there would always be the possibility that unknown risks were being assumed because compelling scientific evidence was not available. Scientific evidence can provide important information in the decision making process. However, can science shed light on the estimation of risk when there is a great deal of uncertainty?

The reality of the risk assessment process is that human judgement dominates in the face of uncertainty. Different value frameworks result in different interpretations of the uncertainties in the database. The tools of risk assessment and risk-benefit analysis cannot be relied upon to provide clear direction for policy makers.

There is no reason to believe that the comprehensive, multi-stakeholder planning process envisioned by the IJC could avoid the issues faced by participants in the alachlor review. The chlorine controversy has many of the same elements of scientific and economic uncertainty. The result is that value frameworks strongly influence opinions and conclusions. It is highly unlikely that a cooperative transition process could be developed under these conditions.

Chlorofluorocarbons (CFCs)

In 1928, Thomas Midgley Jr. developed CFCs in response to the need for a safe coolant in refrigerators. The two coolants being used at the time were sulfur dioxide and ammonia, which were considered dangerous because of their toxicity and flammability. CFCs were considered far superior and were produced for over forty years before scientists began to realize the potential harm these chemicals could have on the stratospheric ozone layer (Colborn, Dumanoski, and Myers 1996).

As awareness of the ozone problem grew, a spirited debate began to unfold. The characteristics of the debate were influenced by economic self-interest, scientific uncertainty, technological limitations, and political timidity (Benedict 1991).

Economic self interest played a dominant role in the debate. At first, the international chemical industry denied any connection between declining stratospheric ozone and increasing sales of CFCs. The response of the industry was to quickly mobilize research and public relations efforts in order to cast doubt on the theory that CFCs might be destroying the ozone layer (Dotto and Schiff 1978). The Alliance for Responsible CFC Policy, was formed in order to consolidate and communicate industry's position that CFCs were safe. The Alliance consisted of about 500 U.S. producer and user companies. The group warned of serious economic dislocation if CFCs were banned and it pointed out that the available scientific information did not demonstrate any actual risk from using CFCs (Benedict 1991).

As scientific evidence began to confirm that the threat was real, industry began to change strategies. Rather than denying the existence of the problem and risking international regulations, industry competitors attempted to influence the debate to their advantage. As a result, the Montreal Protocol negotiations had more to do with sorting out competitive advantages between E. I. Du Pont de Nemours & Co. (Du Pont) and European companies, than with solving an environmental problem (MacKenzie 1988).

At the time of the debate, Du Pont's main European competitor was Imperial Chemical Industries (ICI), the largest manufacturing company in Britain and one of the world's largest producers of CFCs. ICI strongly opposed any form of international regulation. ICI's position was supported by the British DoE who believed that the scientific case against CFCs was weak. ICI was particularly concerned about a proposal for an international ban on CFC aerosols. This proposal would have had serious implications for ICI because 80% of their production was for aerosol applications. In the U.S., aerosols represented only 50% of manufacturing production (Ehrenfeld et al. 1993).

The U.S. CFC industry was plagued with problems of overcapacity and low profit margins. U.S. companies were indignant about the competitive advantage that their European competitors had gained as a result of blocking regulations in the 1970s. When the U.S. EPA proposed a freeze on non-aerosol uses of CFCs, U.S. industry argued that domestic regulatory action should be avoided in order to maintain a level playing field in the international CFC market (Benedick 1991).

As scientific evidence and public pressure continued to grow, the U.S. industry eventually concluded that the ozone controversy was not going to disappear and decided to cooperate in the search for a solution. In 1986 the industry made an unexpected announcement by recommending additional scientific research, end-use conservation of CFC, development of alternatives, and the establishment of reasonable production limits. Informally some U.S. business representatives indicated that they would support a freeze on CFC production while others were even prepared to accept substantial cuts—as long as adequate time was allowed for the development of substitutes (Benedict 1991).

There were several factors that may have caused industry to change its position. One possible factor was that some customers were already switching to CFC alternatives. For example, Johnson Wax announced in June 1975 that it would phase-out CFCs in response to pressure from consumers, environmental groups, and state regulators (Dotto and Schiff 1978).

Du Pont may have supported this position for a number of reasons: (1) a sense of environmental responsibility, (2) a fear of future lawsuits from people with skin cancer, and (3) the immense sum ($1 billion in the 1990s) that Du Pont needed to spend in order to shift their production facilities to hydrochlorofluorocarbon (HCFC) substitutes. A government-sponsored ban was essential in order to protect the market for these higher-cost substitutes (Cairncross 1992). However, it is important to note that the substitutes for CFCs were not developed as a result of the ban. The major producers had developed these substitutes several decades earlier, but had put these products on the shelf because they could not compete with CFCs (Ehrenfeld et al. 1993).

Another factor that may have contributed to industry's shift in attitude was the realization that there would be no great economic hardship as a result of the transition to HCFCs. In fact, the transition to HCFCs would increase margins substantially. Much of the negotiations focused on ensuring that none of the six global CFC producing companies gained a competitive advantage over the others as a result of the transition to these substitutes (Ehrenfeld et al. 1993).

The CFC debate was also characterized by scientific uncertainty. Industry argued that because of scientific uncertainty it was prudent to delay action in order to avoid severe economic consequences. Environmentalists argued that because of scientific uncertainty it was prudent to act immediately in order to prevent a potential disaster.

The scientific uncertainties led to a vehement debate among researchers. After scientists had discovered the potential threat of CFCs to stratospheric ozone, there were several years of intense debates within the scientific community (Dotto and Schiff 1978). U.S. scientists believed that there was enough information to understand the basic chemical processes leading to ozone depletion. The British, on the other hand, emphasized the uncertainties and pointed out that all of the estimates varied by as much as 100% (Ehrenfeld et al. 1993).

There was also scientific uncertainty regarding the threat to human health. Most scientists agreed that there was a link between ultraviolet radiation and skin cancer. However, scientists did not agree that recent increases in skin cancer were linked to a decrease in the ozone layer. It was pointed out that skin cancers take decades to develop. Therefore, any decreases in ozone would have been too recent to account for the increase in skin cancers during the 1970s and 1980s. Some people speculated that the increase might have been caused by changes in life-style resulting in more exposure to the sun. People who were opposed to regulations used these uncertainties to undermine attempts to regulate CFCs (Benedict 1991).

The debate was also characterized by technological limitations. Measurements of the ozone layer over a thirty-year period had not demonstrated any statistically significant loss. Seasonal fluctuations of ozone over Antarctica were considered an anomaly that could not be explained by the ozone-depletion theory. Based on existing models, scientists predicted that there would be no significant loss of ozone due to CFCs for at least two decades (Benedict 1991).

Because of scientific uncertainties and technological limitations there were no clear choices or compelling evidence during the debate. Politicians initially chose a cautious approach by maintaining the status quo rather than initiating change that could lead to unpredictable political and economic consequences.

However, as the public became more aware of the ozone situation, political positions began to change. The public's influence on politicians was clearly seen in the contrasting situations in the U.S. and in Europe. In the U.S., ozone-depletion captured the public's imagination and was featured prominently in the media. In Europe, closer-to-home problems such as acid rain, chemical spills, and the 1986 Chernobyl nuclear power plant accident took precedence over the ozone problem. These contrasting public perceptions likely contributed to the different U.S. and European positions during the negotiations to ban CFCs (Benedict 1991).

A key observation of the CFC transition process was that the tremendous economic dislocations predicted by the industry did not materialize. In fact, the transition to non-CFC alternatives in some applications such as circuit board cleaning in the electronics industry occurred much faster than expected.

The rapid changeover in the electronics industry may be attributed to a number of factors that include:

- the cost-performance of non-CFC alternatives was superior to CFCs
- suppliers (flux manufacturers) who produced related products for the CFC-based cleaning process quickly developed new products
- the electronics industry is characterized by high levels of innovation and rapid change
- formation of industry groups to efficiently disseminate information on alternative technologies
- high levels of competition forced all companies to follow the lead of early adapters who promoted themselves as being "green" (Ehrenfeld et al. 1993)

The changeover to non-CFC alternatives proceeded at a slower pace in other industries such as automobiles. The slower response in this industry was likely due to longer design lead times and more complex engineering issues (Ehrenfeld et al. 1993). Although the phase-out of CFCs in new automobiles was achieved at a slower rate, the disastrous economic consequences did not materialize. The changeover in older automobiles is still an issue because of the high cost to replace old air conditioning systems. However, automobiles are eventually replaced. The existing stock of CFC based automobiles will eventually be taken out of the environment

POLYVINYL CHLORIDE (PVC) PIPE

Many of the characteristics of the PVC debate are similar to those observed during the CFC and alachlor debates. The first similarity is the wide gulf that exists among the stakeholders, especially between environmental groups and industry. These opposing forces are applying strategies that are very similar to past environmental debates.

Both sides argue that their assertions are based on science, but because of uncertainty, there is no compelling evidence to prove either position with absolute confidence. The result is a never-ending series of claims and counter claims with no consensus in sight. Some of the arguments used by stakeholders favoring the elimination of PVC and the industrial use of chlorine are summarized below:

- The environmental threat from PVC is based on its link to the formation of polychlorinated-dibenzo-dioxins (PCDDs or dioxins) and polychlorinated-dibenzo-furans (PCDFs or furans), that have known health effects on animals, and are suspected as human carcinogens (Ehrenfeld et al. 1993). Dioxin is known to be toxic to humans and animals in extremely low doses, producing devastating effects on the immune, endocrine and reproductive systems. In February 1997, the International Agency for Research on Cancer (IARC) classified dioxin as a known human carcinogen. Once released into the environment, dioxin is virtually impossible to remove (Environment News Service 1997).

- Although the end products of PVC are relatively inert and non-toxic, toxic substances are released into the environment during their manufacture and disposal (IJC 1993). For example, the beginning of the PVC manufacturing cycle requires a feedstock product called vinyl chloride monomer (VCM) which is a known carcinogen (CanTox 1994). And when PVC is incinerated at the end of its life cycle, dioxins and furans are produced from incomplete combustion (IJC 1993).

- The VCM manufacturing process generates dioxins and furans as byproducts (IJC 1993). These byproducts are toxic, bioaccumulative, persistent, and have no known safe levels (Muldoon and Jackson 1994).

- PVC products are manufactured with a wide range of characteristics for a variety of applications. The product attributes are acquired by adding various chemicals to alter the product's strength, flexibility, and response to temperature. When PVC is disposed in landfills, these additive chemicals can leach out especially if organic solvents are present (IJC 1993).

- Very little, if any, dioxins or furans can be found in samples of human tissues frozen over 100 years ago. Likewise, silt samples deposited in lakes during the same time period show almost none of these chemicals. This suggests that most dioxins and furans found today are relatively new and are derived from synthetic chemicals (Schechter 1992). Although organochlorines are not known to occur naturally in tissues of people, hundreds of industrial organochlorines are now accumulating in human tissues (IJC 1989).

- PVC is difficult to recycle back to its original use because of the wide range of chemical additives. Recycling PVC products would require that they be sorted into hundreds of different categories. Because of this, only a small fraction of total PVC production is recycled. This small fraction is usually down-cycled into products that are less valuable than the original (Hileman 1993). Also, recycling does not remove most toxic chemicals. These chemicals are passed on to new products and to the people who handle them (Zero Toxic Alliance 1997).

- When PVC is disposed of in an incinerator, the chlorine is transformed into hydrogen chloride and chlorinated products of incomplete combustion. These products include hexachlorobenzene, PCBs, dioxins and furans (IJC 1993). According to the Physicians for Social Responsibility (PSR) and the Environmental Working Group (EWG), chlorinated plastics are the reason that medical waste incinerators have been cited by the U.S. Environmental Protection Agency (EPA) as a leading source of dioxins and dioxin-like chemicals. These chemicals are produced when certain chlorinated plastics such as PVC are disposed in hospital incinerators. These plastics are used in many hospital products such as IV bags, tubing, gloves and packaging materials (Environment News Service 1997).

- Even the most modern and efficient incinerators emit traces of dioxins and furans (Steingraber 1997).

- When fires erupt in buildings containing PVC products, a full range of toxic substances are produced as a result of incomplete combustion. These substances include dioxins, furans, phthalates, heavy metals, and other additives (IJC 1993).

- Alternatives to PVC are readily available. For example, pipe and fittings can be manufactured from copper, steel, or non-chlorine based plastics (IJC 1993).

- In January 1996 the Danish Environmental Protection Agency released a report linking PVC production, manufacture, use and disposal with endocrine disruption, reproductive disorders, immune system suppression and a variety of cancers (Zero Toxic Alliance 1997).

- In November 1995, the Swedish Parliament initiated steps toward a PVC ban. The government concluded that PVC should be phased out as quickly as possible (Zero Toxic Alliance 1997). The government then set up a Chemical Committee to review Swedish policies. This committee is reviewing the hazards of PVC throughout its entire lifecycle (Costner 1997).

- More than 200 communities in Germany and Austria have banned the use of PVC construction materials in public buildings (Zero Toxic Alliance 1997).

- Large retail chains and supermarkets in Germany have virtually eliminated PVC packaging. Switzerland, the Netherlands and Australia are also phasing out PVC packaging (Zero Toxic Alliance 1997).

Opposing forces respond that these assertions are exaggerated and that the toxic byproducts created in the manufacture and disposal of chlorine-based products can be controlled by better management and technology. Their claims and counterclaims are listed below:

- Chlorine compounds are found throughout the natural world and are produced by many plants and animals. Naturally occurring chlorine compounds are found in the blood, skin and teeth of human beings. These compounds play a vital role in digestive processes in the form of hydrochloric acid and enable white blood cells to fight off infections (Chlorine Chemistry Council 1996).

- Although VCM is highly toxic, VCM emissions have been reduced by over 99 percent since the 1970s. The 1976 EPA standard for VCM within five miles of a PVC plant is 1 ppb (one part per billion) and the EPA has set a goal of zero VCM in drinking water. PVC production is moving toward a closed loop process with almost all activities taking place within contained vessels (Vinyl Institute 1993).

- PVC manufacturing sites are far from being "dioxin factories" as Greenpeace claims. In 1992, PVC manufacturer Norsk Hydro produced 1 billion pounds of VCM (2% of worldwide production) and generated only 3.2 grams of dioxin byproduct. To put this amount in perspective, the Inspectorates of Public Health for Environmental Protection estimates that the air emissions of dioxin from all sources in the Netherlands was 484 grams in 1991 (Carroll 1994).

- PVC is highly stable and extremely resistant to the aggressive chemical environment found in landfills. When PVC decomposes under these conditions, only tiny amounts of plasticizers (additives) are released. Furthermore, the most common plasticizers have been thoroughly researched and do not present cause for concern to consumers (Vinyl Institute 1993). Other research such as a study from the Chalmers University of Technology in Sweden, concluded that rigid PVC would not degrade in landfill. Furthermore, when plasticizer levels have decreased to a certain level there is no further degradation (British Plastics Federation 1997).

- With today's technology and standards, PVC can be recycled. As an example, the USCAR automotive disassembly plant located in Highland Park, Michigan plans to recycle PVC wire harnesses, side moldings, instrument panels, and armrests from U.S. cars (Ontario Business Journal 1994). For the industry as a whole, about 1% of total vinyl production is being recovered in the form of packaging. The Vinyl Institute is aiming for a recovery rate of 25% but it does concede that the economics of PVC recycling will be difficult to overcome (Hileman 1993).

- Dioxin production in incinerators depends on operating conditions not on the amount of PVC (Vinyl Institute 1993). Trials in Würzberg, Germany, and at the South East London Combined Heat & Power (SELCHP) plant in the UK demonstrated that the presence or absence of PVC in the Municipal Solid Waste (MSW) stream made no difference to the quantities of dioxin produced. Furthermore, in the largest study of its kind, The American Society of Mechanical Engineers also found that it was the operating conditions of the incineration plant that determined dioxin production rather than the quantity or source of the chlorine entering the incinerator (British Plastics Federation 1997).

- PVC outlasts and outperforms many traditional materials. Also, because 50 percent of its base polymer comes from common salt, it is much preferred to materials that rely 100 percent on petrochemical feedstocks, or to those that deplete forests or ore reserves (Vinyl Institute 1993).

- Carbon monoxide is the main killer in fires. Following two fires that recently took place in German warehouses where postconsumer PVC waste and other plastic wastes were being stored, the dioxin and furan levels were measured and found to be less than the background after the fire (Hileman 1993). One of these warehouses located in the German town of Lengerich, contained 500 tonnes of PVC products. The North Rhine Westfalia (NRW) Department of the Environment investigations concluded that dioxin levels did not increase appreciably in the vicinity of the fire (British Plastics Federation 1997).

- PVC is being used to construct sturdy, low-cost housing in the U.S. and developing nations. Using PVC as a wood substitute in siding, doors, floors and windows saves natural resources. PVC pipe liners also help to extend the life of aging water systems by 50 to 100 years, saving millions of dollars in repair costs (Chlorine Chemistry Council 1996).

- There is no evidence of dioxins posing a serious risk to public health. The intake level of dioxins is several orders of magnitude below those that would lead to adverse health affects (British Plastics Federation 1997).

- Suggestions that certain chemicals in the environment have estrogenic effects are often based on anecdotal evidence. Additional research is required to study what, if any, impact these chemicals have (Buzzelli 1996).

- The Swedish government has made no official commitment to the phasing out of PVC. The Swedish government did commission its Environmental Protection Agency (Naturvårdsverket) and its National Chemicals Inspectorate (KemI) to examine the waste management of PVC. The findings of these organizations' studies (reported in June 1996) confirmed that there were absolutely no grounds for the phasing out of PVC. The Naturvårdsverket consider it acceptable to recycle PVC, and confirm that reducing the amount of PVC in incinerators will not reduce the formation of dioxins. While KemI's report did suggest the reduction in use of some specific PVC additives, it has reserved a recommendation on phthalate plasticisers until a full EU risk assessment program has been completed (British Plastics Federation 1997).

- When pressed by Greenpeace to limit the use of PVC, Viersen [a German municipality] sent a questionnaire to the then 101 authorities which Greenpeace claimed had placed a ban on PVC. The results showed that of the 64 authorities that responded, 23 had no PVC bans, 10 had bans, 27 had partial restrictions and 4 bans had since been rescinded. Therefore, Greenpeace's most recent figure of 200 German authorities should be treated with caution (British Plastics Federation 1997).

The main point in the arguments made by opponents of PVC is that production and disposal of PVC creates byproducts that are toxic, persistent, and bioaccumulative. These byproducts are now ubiquitous in the environment and are approaching levels in human beings that may have serious health consequences. They claim that "end-of-pipe" control is not the solution. The solution is to eliminate the critical component in the production of the toxins—chlorine. By banning chlorine as an industrial feedstock, the source of chlorinated toxins will be eliminated. They also point out that there are alternatives for almost every PVC-based product.

The main point of the arguments made by the supporters of PVC is that although the production and disposal of PVC does create toxic, persistent, and bioaccumlative byproducts, these byproducts can be controlled through better management and control. They point out that PVC and other chlorine-based products are essential to today's modern society.

Without conclusive or compelling scientific evidence, this debate will continue without resolution. The situation is very similar to the alachlor debate where consensus was impossible because of scientific uncertainty and different value frameworks. The weight-of-evidence approach being advocated by the IJC is required in order to resolve the issues.

The PVC Pipe Industry

PVC represents the largest use of industrial chlorine. In 1994, PVC consumed 34% of global chlorine production. The chlorine industry projects that by 2010, PVC's share of chlorine usage will grow to 55%.

PVC is used in a wide range of applications but the largest volume application is pipe, conduit, duct and fitting products. In 1993, 139 kT of PVC or 31% of the total volume of PVC was used to produce these products in Canada. In the U.S. (1986), pipe and fittings represented 47.2% of total PVC consumption while in Western Europe (1986), this category represented 26.89% (Ehrenfeld et al.). The following table lists the major pipe products, their consumption of PVC in Canada (1993), and the chlorine-free alternatives:

Table 1: Consumption of PVC Resin by Pipe Application

Application	PVC Resin (kT)	%	Alternatives
Watermain	40	28.8	Ductile iron, HDPE
Sewer	51	36.7	Concrete, HDPE
Drainage	11	7.9	HDPE, Concrete
Drain Waste and Vent (DWV)	6	4.3	ABS
Electrical ducting / conduit, industrial, other	31	22.3	HDPE
Total	**139**	**100.0**	

Note: HDPE (High Density Polyethylene Plastic)
ABS (Acrylonitrile-Butadiene-Styrene Plastic)

As this table shows, alternatives to PVC pipe and fittings are available for virtually every application. Some of these alternatives were used long before the invention of PVC and others, such as non-chlorinated plastics, can be enhanced to meet PVC application specifications. The major applications listed in the table are briefly described below.

Watermain and Sewer Applications

Since the 1960s, when PVC pipe first entered the Canadian market, its market share has risen from 13% (1976) to 75% (1993). PVC dominates small diameter applications in the Watermain and Sewer product category. For large diameter applications, ductile iron and concrete are used more frequently. Spiral ribbed galvanized steel pipe is also used as an alternative to PVC in Watermain and Sewer applications. This product is marketed as a rigid, lightweight material with flow characteristics similar to smooth interior wall pipes.

High-density polyethylene (HDPE) has a relatively minor share (2%) in Watermain and Sewer applications. This is due primarily to different marketing strategies employed for PVC and HDPE. The initial target markets for PVC were municipal infrastructures. HDPE, on the other hand, was initially sold to the chemical process and mining industries.

Drainage and Construction Applications

In Drainage applications, PVC competes primarily with HDPE. PVC is typically used for building drainage while corrugated HDPE is commonly used for farm and road drainage. Concrete and galvanized steel are also used in these applications.

The dominant product for Drain Waste and Venting (DWV) applications is acrylonitrile-butadiene-styrene (ABS) although PVC is gaining market share. Fire codes demand that copper and iron be used in plumbing applications in apartments and commercial buildings.

For wire protection (electrical and telecommunications), PVC is dominant for both conduit (above ground) and duct (below ground). For industrial applications and natural gas distribution, HDPE is the dominant product.

Cost Performance Comparison

The arguments as to which products have superior cost performance are complex and inconclusive. In forums such as Environment Canada's workshop: "A Technical and Socio-Economic Evaluation of Options to the Use of Products Derived from the Chlor-Alkali Industry (February 1997)", competing suppliers argue convincingly that their respective products are either equal to, or better than the competition.

It is difficult to sort through these arguments in order to determine if either product has a compelling advantage. The wide range of application conditions and an obvious supplier bias make comparisons difficult. One approach to this problem is to solicit the opinions of people who actually purchase and apply these products. The opinions of users will likely provide a more unbiased view of cost and performance.

In order to understand this end-user perspective, interviews were conducted at a large mechanical contracting company (Sutherland & Schultz). This company has annual sales revenues of over $50 million, employs over 500 people, and is one of the largest mechanical contractors in Ontario. Most of the company's customers are in the industrial, commercial, and government segments. Residential customers represent a minor portion of the business. Fifty percent of the company's business is new construction and 50% is retrofit and service.

PVC pipe and fittings form a substantial portion of the company's total material costs. A company representative in middle management (Dave Elder) estimated that PVC pipe represented at least 10% of this total. He also said that the company used other types of pipe including copper, black malleable steel, galvanized steel, glass, and stainless steel. The type of pipe chosen for a particular job is based on cost, building and construction codes, and customer specifications. The applications for various types of pipe were described by the company representative in Table 2 below:

Table 2: Pipe Applications in the Construction Industry

Type of Pipe	Application
Stainless Steel	distribution of corrosive chemicals, industrial applications such as chemical plants; requires welded joints
Galvanized Steel	building water distribution
Copper	building water distribution
Black Malleable Steel	natural gas and hot water distribution
Glass	distribution of acids, industrial chemical applications
PVC	water distribution (especially drainage), non-exposed natural gas

ABS (acryonitrile-butadiene-styrene) and PE (polyethylene) are used infrequently except in specialized applications. The main advantage of ABS and PE is that they can be coiled or curved.

In many cases, the choice of pipe is determined solely on building and construction standards. For example, building codes require black malleable steel pipe for natural gas distribution where the pipe is exposed to potential mechanical damage. PVC is not allowed in this application because of its low mechanical strength. Galvanized steel is also not allowed because metal flakes from the inside walls of galvanized steel pipe can damage gas burners in heating units.

For natural gas distribution in underground applications, where pipe is protected from mechanical damage, PVC is used almost exclusively. Its advantages over metal pipe are lower cost, easier installation, and resistance to corrosion.

In cases where building codes allow contractors to choose among alternatives, the choice of pipe is based on: (1) cost of installation labor, (2) cost and availability of installation equipment, (3) cost of pipe and, (4) customer preferences.

For example, in an application where pipe needs to be hung from the ceiling of an industrial plant, a number of factors would be considered. One of these factors is installation. Because of its light weight, PVC pipe might require only one person for the installation. The heavier alternative, metal pipe, might require two people. On the other hand, because PVC has less strength, a support bracket might be required every five feet. With metal pipe, a support bracket might be required every fifteen feet. Also, PVC joints can be installed quickly and simply using solvent and glue. Metal pipe joints require threading equipment for steel or soldering equipment for copper. All of these factors influence the type of pipe that would be used for the application.

Another important factor when selecting pipe is customer preference. A customer may prefer metal rather than PVC in order to reduce the risk of mechanical damage. Essentially, the incremental cost for metal pipe is considered an "insurance policy" against potential mechanical damage.

In electrical conduit applications, PVC is preferred over metal because it is non-conductive and the tightly sealed joints are waterproof. This is especially advantageous in food processing plants where equipment must be washed down frequently.

Because PVC is inert, it is also preferred in chemical distribution applications. These applications usually require a superior quality PVC that can withstand higher temperatures and pressures. This top-of-the-line PVC, called CPVC, has a continuous rating of 82°C and 100 psi.

There are many other rules-of-thumb and practices that the construction industry uses when selecting pipe. In Canada's cottage country, for example, PVC is typically not used in exposed applications because porcupines will chew through this material. PVC is also a poor choice for extremely high or low temperature applications unless more expensive products such as CPVC are used. Clear PVC is useful in applications where a customer wants a visual confirmation that liquid is flowing in the pipe. Steel pipe is almost always required for very large diameter applications (e.g. 48 inch) because it is much stronger than PVC or CPVC.

Overall, the use of PVC pipe is on the rise because of its cost advantage. This cost advantage is demonstrated in Table 3 which shows the price of 100 feet of two-inch pipe made from a variety of materials.

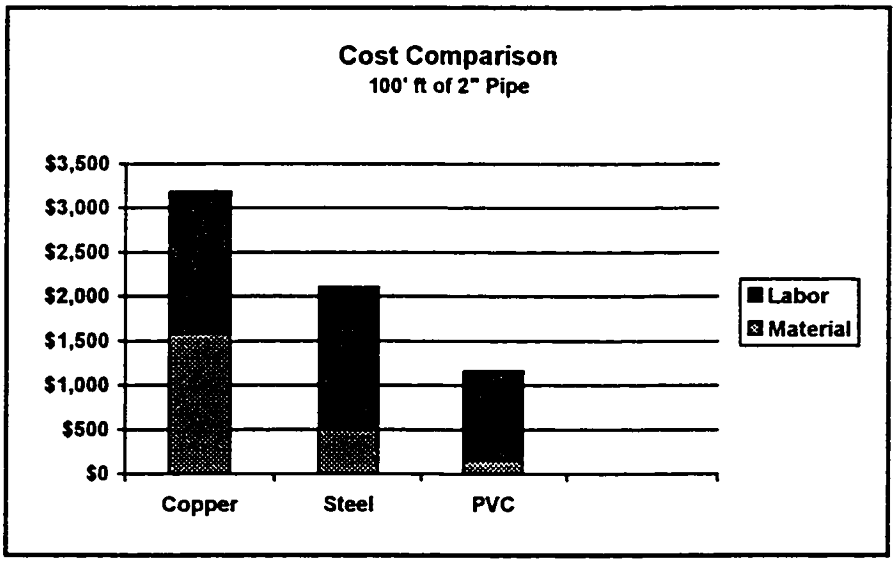
Table 3: Price of Two-Inch Pipe by Material Type

Pipe Material	Price (per 100 ft.)
Copper	$1,581.48
Galvanized Steel	$ 874.61
PE (high pressure)	$ 644.07
Black Malleable Steel	$ 504.28
PE (low pressure)	$ 454.42
ABS	$ 241.29
PVC	$ 161.38

Because of low cost, the manager who was interviewed said that the industry uses as much PVC as all other pipe combined. With regard to recycling pipe, the manager said that copper is always recycled because of its high value; steel pipe is often recycled; PVC is never recycled. The manager said that he did not know of any company that accepted PVC pipe for recycling.

The relative differences in installation and material costs of PVC vs. metal pipe is shown in Chart 1. This chart compares the typical material and labor costs to install 100 feet of two-inch pipe using copper, black malleable, and PVC pipe material.

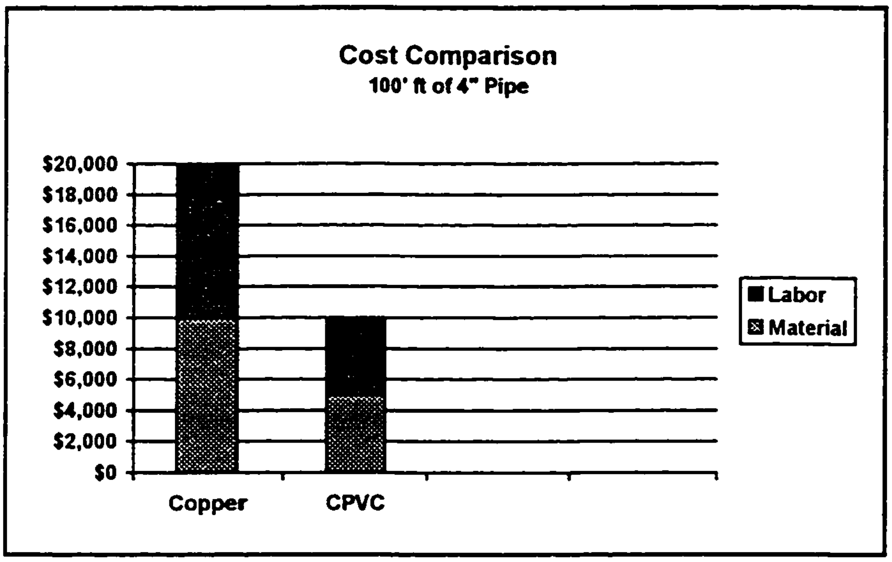
Chart 1: Cost Comparison of Pipe and Installation (2" Pipe)



As this chart shows, the material cost for black malleable steel is about three times as high as PVC while the material cost for copper is almost ten times as high. The labor cost to install copper or steel pipe is 60% higher than PVC. This is because PVC joints require a simple application of solvent, glue and a fitting. Copper joints require soldering while steel joints require threading.

There is also a large cost differential for large diameter pipe in spite of the fact that CPVC, which is required for large diameter applications, is much more expensive than standard PVC. With a four inch pipe diameter application, the choice is usually between CPVC and copper. Copper is preferred over steel because it is easier to solder joints than to thread or weld. A cost comparison of CPVC and copper for a 100 foot run of four inch pipe is shown in Chart 2.

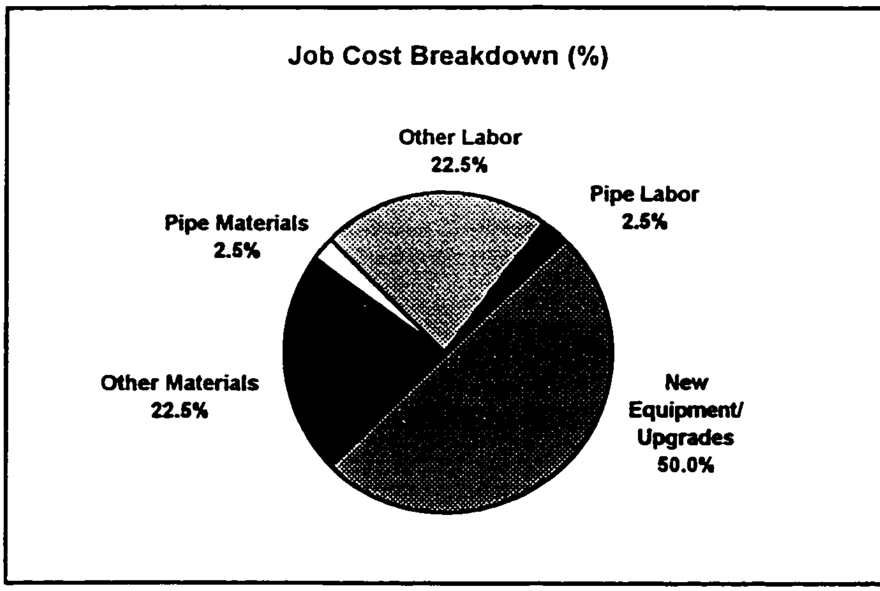
Chart 2: Cost Comparison of Pipe and Installation (4" Pipe)



As Chart 2 demonstrates, both the material and labor costs of copper are twice as high as those of CPVC. The difference in labor cost is due, again, to the fact that CPVC joints can be made using solvents and glue. Soldering large diameter copper pipe is a demanding task that requires highly skilled people.

To determine the total impact of alternative pipe materials, one must consider all of the costs in relation to the total job cost. Although conditions can vary widely at each site, a number of typical jobs were averaged to determine the relative impact. The jobs examined were industrial projects which involved new equipment installations, equipment upgrades, expansions, etc. The average cost breakdown for these jobs is shown in Chart 3.

Chart 3: Average Job Cost Breakdown (%)



As shown in Chart 3, the pipe and pipe installation costs represent a relatively small portion of the total job cost. The cost of pipe and pipe installation would have to increase dramatically in order to have a significant impact on total cost.

Pipe materials are specified by either the customer or by the contractor's engineering staff. The specifications must adhere to building codes that define minimum standards in terms of material application, design and use. Very few companies will risk the use of unapproved materials because of potential liabilities and penalties.

Metal pipe is approved for most applications because it was used before PVC was introduced. Non-chlorinated plastic pipe such as ABS and PE are approved only for certain applications. Although the performance of ABS and PE could be enhanced by using additives or corrugation to meet building code standards, these enhancements would increase their already high price (Ehrenfeld et al.). Manufacturers of ABS and PE have no incentive to seek approvals or to produce equivalent products knowing that they will be unable to compete on price.

In an industry as competitive as construction, material selection is almost always based on the lowest cost that will meet building code standards. Higher priced alternatives are typically used only when owners or end-users specify them. Simply approving the use of higher priced alternatives would, therefore, have no impact on the use of PVC pipe.

From a contractor's point-of-view, it does not matter what material is approved or specified as long as all competitors use the same material. If a high cost alternative is required, the material and labor costs are simply passed along to the customer.

These findings are similar to those reported by other researchers. For example, in a study completed by the Massachusetts Institute of Technology (MIT), researchers reported that:

> "(a) While PVC displays important strength properties, which are unavailable in other materials, the strength characteristics of those materials can be enhanced (through adding fillers or through ribbed construction, etc.). Furthermore, some materials possess other performance characteristics that outperform PVC.
>
> (b) While PVC has a significant cost advantage over rival materials, it is not necessarily an excessive advantage and may be a manageable one" (Ehrenfeld et al. 1993, 128)

The MIT study also pointed out that the technology required to manufacture pipe from PVC or from other plastics is essentially the same. Therefore, a transition to non-chlorinated polymers will not require substantial re-tooling investments for pipe manufacturers.

Greenpeace also reached similar conclusions regarding chlorine-free alternatives to PVC pipe:

> "Alternatives to PVC in plumbing and drainage applications include: concrete, earthenware, stoneware, steel, cast iron and copper. Alternative plastics include PE-X (cross-linked polyethylene), HDPE and polypropylene (PP). PVC underground and sewage systems can be replaced by concrete, nodular graphite iron and earthenware pipes. These materials have a longer service life than PVC but they are 20% to 30% more expensive. However, the materials cost is of less importance in underground ductwork, since the earthwork (excavating, laying ducts, etc.) accounts for the largest share of total costs." (Greenpeace 1997, 28)

In conclusion, there are readily available alternatives to PVC for almost all pipe applications. Although there are performance and cost differences, it appears that these are manageable. End-users may be forced to pay higher costs but, in the applications examined, these costs appear to be small relative to total costs.

It should also be pointed out that the cost-performance issues are based on current technology. A fundamental belief of a market based transition process is that the various competitors will view cost-performance differences as opportunities. A declining market for PVC pipe is a growing market for chlorine-free alternatives. Growing markets provide incentives to invest in technology improvements to address cost performance issues.

It should also be pointed out that opponents on both sides of the debate argue that cost performance numbers may not be comparable. PVC supporters claim that the price of alternative materials do not include externalized costs such as the environmental degradation due to increased mining activities. They also point out that PVC's basic raw material is salt, one of the most common compounds on earth, while alternative chlorine-free products require increased consumption of dwindling natural resources.

Organizations such as Greenpeace counter this argument with their own list of externalized costs associated with PVC. Greenpeace points out that the following costs are borne by society but are created by the PVC industry:

- environmental, health and occupational impacts due to persistent pollution during production of chlorine, EDC, VCM, PVC and its additives
- subsidized electricity prices paid by the chlor-alkali industry [in reference to Australian industry]
- public health and environmental impacts from accidental fires and additional firefighting equipment costs and damages to public and private property
- environmental and health impacts from leachates and additives migration
- cost of incinerator upgradings and maintenance
- environmental and health impact from incineration emissions and slag/ash waste disposal
- cost of landfill space for this non-biodegradable product
- cost of providing recycling services (Greenpeace 1997)

One of the approaches that has been advocated to resolve these two opposing claims is life cycle analysis. However, life cycle analysis, like risk-benefit analysis, is filled with uncertainties and value judgements that make it difficult to obtain undisputed conclusions. Past studies comparing disposable diapers to cloth diapers or paper cups to washable cups have been controversial and inconclusive. Some of the problems encountered with life cycle analysis include: 1) assigning costs and weightings to environmental impacts which have different values for different people, 2) deciding where to draw the line to establish total impact, and 3) gathering process information from private companies who consider this information proprietary (Warmer Bulletin 1995).

Although the life cycle approach does raise important questions, the uncertainties and value judgements inherent in the approach make it an ineffective tool for decision-making. The findings in a life cycle analysis should therefore be considered one piece of evidence in a weight-of-evidence approach. Life cycle analysis alone will not produce compelling evidence to guide decision-makers.

Impediments to Transition

Industry Resistance

The main opposition to a phase-out of chlorine and PVC are the producers who have made large investments to manufacture and market these products. However, it is important to put this opposition in context with the many other companies who are also part of the industry stakeholder group. There are a wide variety of stakeholders who are involved with meeting the application need for pipe. They include:

- chloro-alkali producers (in Canada, Dow Chemical, ICI Canada, Canadian Occidental, PPG Canada, Avenor, St. Anne Chemicals, Canso Chemicals)
- EDC and VCM producers (in Canada, primarily Dow Chemical)
- PVC resin producers (in Canada, The Geon Co., Imperial Oil)
- suppliers of raw materials used to manufacture chlorine-free pipe products (Noranda, Stelco, Dofasco, non-chlorinated polymer suppliers, etc.)
- manufacturers of PVC pipe (in Canada, IPEX, Royal Plastics Ltd.)
- manufacturers of chlorine-free pipe (Canada Pipe Co. for ductile iron and many manufacturers of PE and concrete alternatives)
- distributors of pipe (many wholesalers/dealers companies, etc.)
- installers of pipe (many contracting companies and end-users)
- developers (residential/commercial/industrial building developers, municipalities, etc.)

Each of these stakeholders has a different perspective on how critical PVC pipe is to their business. For example, from the contracting company's perspective, the choice of pipe is irrelevant as long as all competitors are obliged to use the same material. Distributors of pipe have the same perspective. Distributors will provide whatever type of pipe their customers demand. End-users might be concerned with the higher cost of alternatives, but these costs need to be compared to the total job. And as we have seen, pipe and pipe installation cost is a relatively small component in total job cost for many applications.

Stakeholders such as the manufacturers and suppliers of raw materials for non-chlorinated pipe such as metal, PE, HDPE, etc. would likely support a phase-out of PVC pipe. They would gain market share at the expense of their rivals who supply chlorinated materials.

Manufacturers of PVC pipe would likely oppose a transition to alternatives. However, their opposition may not be as strong as the raw material suppliers (chlorine, EDC, VCM, and PVC resin suppliers) because many PVC pipe manufacturing companies can produce PVC as well as non-chlorinated plastic pipe made from chlorine-free polymers. Nonetheless, a transition to chlorine-free alternatives will involve some costs and risks for pipe manufacturers. Competitors will look for any possible advantage during a transition. The major manufacturers would likely prefer the status quo while the smaller manufacturers would likely see a transition as an opportunity to gain market share.

The companies who are involved at the front-end of the PVC pipe manufacturing process—the raw material (chlorine, EDC, VCM) and PVC resin manufacturers—have the most to lose and would be expected to exert the greatest opposition. These are companies that have made huge investments in PVC technology. Much of this technology can only be used to produce PVC because a PVC plant cannot be converted to produce other polymers.

The suppliers of the front-end raw materials are dominated by a small number of large global companies. This situation is not unlike the CFC market where a handful of global companies produced most of the world's output. However, unlike the CFC situation, PVC suppliers may not be able to maintain their market shares during a transition to alternatives. During the transition from CFCs to HCFCs the suppliers were able to maintain their market positions by switching production to alternative products. In the case of PVC, the alternative materials are from different industries. It may be difficult for the major industry suppliers to maintain their current levels of business as they transition to chlorine-free products. The Dow Chemical Company (Dow) may already be acting to address this issue. In 1996, Dow formed a number of acquisitions and alliances to expand their non-chlorinated plastics business. These included entry into the global polypropylene business through technology licensing agreements, the acquisition of a controlling interest in Estireno do Nordeste (EDN) a Brazilian polystyrene manufacturer, and entry into the PET business via acquisition of an 80 percent share in Enichem's INCA International SpA subsidiary (Dow Plastics Newscenter 1996).

The response from those companies who have the most to lose is similar to any company faced with a competitive challenge—resources are marshaled in order to develop appropriate responses that will influence public opinion, employees, customers and policy makers. Initiating and responding to competitive challenges is business-as-usual in all competitive industries.

In some sectors of the chemical industry such as pesticides, observers have noted that "bad press, ugly lawsuits, and regulatory wars are all part of the price of doing business—so much so that pesticide companies routinely spend far more money on marketing and regulatory issues than on actually manufacturing their products" (Fagin and Lavelle 1996, 190). It should be pointed out, however, that manufacturing costs are a small percentage of total costs for a wide range of businesses, not just the pesticide sector of the chemical industry. Nonetheless, the key point is that successful companies are adept at deflecting competitive threats.

For example, during the 1960s and 1970s, public opinion of Dow Chemical was at a low point because of : (1) Dow's participation in the development and production of chemical weapons, (2) challenges from environmentalists, and (3) lawsuits from veterans who were exposed to one of Dow's products, Agent Orange. In spite of this negative image, Dow was able to turn the situation around with an advertising campaign that positioned Dow's products and technology as helping to feed the world's starving children (Fagin and Lavelle 1996). Through this marketing campaign, Dow was able to deflect a great deal of criticism and pressure.

This ability to manage adverse public opinion is especially important because of liability issues. If chemical companies acknowledged the adverse health effects of some of their products, they would open the door to huge liability costs (Fagan and Lavelle 1996).

In order to manage and control adverse publicity, industry often relies on associations. Industry associations, such as the Chlorine Chemistry Council (CCC) are ideal organizations to respond to threats from environmentalists and the general public. Associations allow industry to leverage their combined resources and to ensure that their messages to the press, public, and government are well articulated and consistent. During the CFC debate, an industry association called the Alliance for Responsible CFC Policy was formed in order to respond to pressure to eliminate CFCs.

Although associations are useful organizations that can provide industry with a strong and consistent voice in environmental debates, they can impede constructive communications when their sole mandate is to protect the status quo. How can a comprehensive, planned transition process move forward when the objective of a key stakeholder is to maintain the status quo?

Industry's commitment to business-as-usual can be seen in the size of the association budgets. In the case of chlorine, industry can justify substantial budgets to protect the huge investments in chlorine and PVC technology. The budget for the CCC has risen substantially in response to growing environmental pressures:

> "In 1994, corporate contributions to the Chlorine Chemistry Council's (CCC) budget for public relations and research totaled $ 12 million-up from $ 2 million in 1992. The CCC is the chlorine industry's lobbying and public relations coalition. The CCC has hired not one but two public relations firms to help shield dioxin polluters from the American people. Occidental Petroleum's president and CEO, J. Roger Hirl, promises that the chlorine industry could contribute "ten times" the current level of people and resources to the CCC if they need it to fight the campaign to stop dioxin exposure." (Gibbs 1995, 277-278)

These sums of money are huge compared to the resources that many chlorine-free product suppliers are able to marshal in order to promote their alternatives. Moreover, suppliers of chlorine-free products, even larger companies, are sometimes reluctant to promote their alternatives too strongly in public. This is because they do not want to upset large potential customers who are currently purchasing chlorinated products. These large customers may prefer the status quo as much as the chlorine industry because they may have to pay higher prices for alternative products (Beaton 1997).

Associations such as the CCC respond to criticism by focusing on the positive attributes of the chlorine industry. The CCC reminds the public and policy makers of the many contributions made by their industry—drinking water, pharmaceuticals, and countless everyday products used in modern society. The CCC also raises the issues of risk and scientific uncertainty in response to environmental challenges. The value frameworks that were observed in the alachlor debate are very apparent in the CCCs comments concerning chlorine:

> "Clifford T. Howlett, managing director of the Chlorine Chemistry Council (CCC) advises that "The first step is to make sure that regulatory decisions focus on real risks, not hypothetical or "politically correct" ones. Sound science, not politics, must be at the root of our environmental policies." He also points out that other steps to "improve our environment without going broke in the process," should include:
> - Using sound science in a risk-based decision process to prioritize pollution prevention efforts
> - Applying the same cost-benefit principles to all regulatory actions
> - Recognizing that reducing pollution is good business and that progress has and can be made through voluntary industry initiatives
> - Encouraging cooperative efforts between government and industry, such as environmental audit privilege legislation that has been passed by 19 states
> - Making certain that environmental policies are good for the economy's health as well as our own" (Flynn 1996)

The CCC also emphasizes the economic uncertainties of a chlorine ban in order to defend the industry:

> "A chlorine ban would cause widespread job losses and economic disruptions. Plants producing chlorine chemicals and plants dependent on chlorine would be forced to close. Nearly 45 percent of all industries use chlorine or its co-products and every industry uses products that are produced with chlorine. Almost 40 percent of US jobs and income are in some way dependent on chlorine. A chlorine ban would leave many chlorine users without alternatives. Others would have to switch to more expensive, less effective alternative products and processes. The products of many US manufacturing plants would become less competitive in US and world markets. The result: plant closures and jobs lost to foreign production." The CCC goes on to say that "Through higher prices and less effective products, consumers would bear the cost of developing and producing alternatives. Costs are estimated to exceed $90 billion annually, all in the naïve hope of finding risk-free alternatives." (Chlorine Chemistry Council 1996)

The accuracy of the $90 billion cost is difficult to confirm. One would suspect that it is a worse case scenario because of uncertainties in the analysis. The value-framework of the industry would likely produce a number that would tend to err on the conservative side.

This has certainly happened in the past. For example, during the acid rain controversy, when electrical utilities were asked to reduce their emissions of sulphur dioxide, the utilities warned that the cost would be $1,000 a ton. The real cost turned out to be $140 a ton (Gibbs 1995). In another example, the U.S. automobile industry claimed that the cost of a catalytic converter would add $400 to the cost of a car. The actual cost was between $25 and $40 (Lincoln 1997).

The CCC also claims that "40 percent of US jobs and income are in some way dependent on chlorine." Even if this claim is taken at face value—that an astounding 40% of the economy is linked to chlorine—the idea of "dependency" needs to be debated. The economy is not dependent on chlorine. Chlorine-based products are simply options among a range of products that address various application needs. The economy is no more dependent on chlorine than it is on any of the alternatives. In open markets, products rise and fall with changing technologies, new customer requirements, and competitive initiatives. A transition to a chlorine-free economy would lead to increased sales, expanded plants, and higher employment in those industries that supply alternatives. These industries would likely view the CCC's $90 billion dollar figure as an opportunity not a cost.

The CCC does make an interesting point in terms of international competition. However, the competitiveness of a company depends on a number of factors not just raw material costs. This was demonstrated by the early success of the Japanese auto industry in North America. Before establishing plants in North America, Japanese auto manufacturers were forced to import their raw materials and ship their finished goods over long distances. In spite of these disadvantages, they successfully competed against their North American competitors. A long list of other factors contributed to their success including: quality, employee relations, government support, international currency, continuous process improvement, design cycle time, etc.

These factors and others also influence the competitiveness of companies that use chlorine-based products. It would be difficult to hold all of these factors constant in order to determine the exact impact that a ban on chlorine and PVC would have on any company's international competitiveness.

In spite of this difficulty, one can accept the argument that if a company must bear costs that are greater than its international competitors, the company would be at a competitive disadvantage. For example, export products containing PVC would be competitively disadvantaged if the destination country did not have an equivalent tax on PVC. This issue could be addressed by providing a tax exemption on PVC-based products destined for export. This is consistent with established tax policies. For example, the Canadian government exempts GST on all export products. The problem with this approach is that it is administratively cumbersome because of the wide array of PVC-based products, and it perpetuates international pollution.

Another approach is to apply a green tax at the consumption or retail point. In this way, all products—those produced domestically and those imported—would be faced with the same price increase. This would encourage both domestic and foreign producers to consider alternatives. Again, because of the huge range of PVC products, the administrative costs of establishing and collecting green taxes at the consumption point would be excessive.

The use of environmental tariffs applied to imported, PVC-based products could also be considered. This approach is within the rules of GATT and would discourage PVC production from moving offshore (Costanza 1997). However, the same problem remains in terms of the wide range of PVC-based products. Establishing and applying equitable tariffs on imported products would be a difficult administrative task. However, this should not be an excuse for inaction. Perhaps the mere threat of tariffs and the watchful eyes of domestic producers would encourage foreign producers to quickly transition to chlorine-free alternatives.

All of these issues described above underline the importance of international agreements such as the Montreal Protocol to deal with international pollution problems.

Industry has advocated a much different strategy to address the toxic waste problem. Rather than implementing bans or green taxes to eliminate the use of chlorine, industry has proposed better management and control through programs such as Responsible Care®. The Responsible Care® program has the goal to "design, develop, manufacture, transport, use and dispose of products safely and with minimal environmental impact (Rampy 1995)."

The Responsible Care® program originated as a result of a number of high profile international chemical disasters such as Seveso, Love Canal and Bhopal. The chemical industry developed the program in order to forestall tighter, more prescriptive regulatory controls and to help improve its public image. The program has generated a number of positive results including: (1) a decline in workplace injuries, (2) a reduction in transportation incidents, and (3) a 50% reduction in total emissions from 1992 to 1994. The program has also been effective in ensuring that a larger portion of the industry, not just the major producers, work to improve their environmental performance. This has been accomplished by peer pressure and by making membership to organizations such as the Canadian Chemical Producers' Association (CCPA) conditional on Responsible Care® registration. In recognition of the environmental benefits that have resulted from this program, the United Nations Environment Program granted the CCPA a Global 500 award in 1990 (Moffet and Bregha 1997).

Although these achievements are commendable, it should be noted that the Responsible Care® program essentially protects the status quo. The IJC has recommended the elimination of the industrial use of chlorine. There is nothing in Responsible Care® that questions the environmental legitimacy of the products being produced by its member companies (Moffett and Bregha 1997).

Opponents to programs such as Responsible Care® point out that the best way to control toxic compounds is to eliminate them at the source. The reason is that in spite of the best technology and management practices, toxins inadvertently enter the environment. For example, Environment Canada charged Imperial Oil, a Responsible Care® participant, for releasing vinyl chloride into the atmosphere in excess of permitted levels in 1995. This was in spite of the fact that Imperial Oil had invested $3.4-million in 1989 in order to make their environmental emissions control systems "among the best in the world" (Globe and Mail [Toronto], 4 April 1995). Another example is Tioxide, a company that in 1995 received the largest penalty ever imposed under federal environmental legislation. At the time, Tioxide was a CCPA member and a Responsible Care® participant.

Although this program has the goal to control chemicals from cradle to grave, the sheer number of applications and the wide range of users make this an almost impossible task. For example, a 1997 fire at Plastimet Inc., a plastics recycling plant in Hamilton, Ontario, demonstrated one of the difficulties. The result of burning 200 tonnes of PVC during this fire would have produced the same amount of dioxin given off by Canadian industry in a year (*The Globe and Mail* [Toronto], 23 July 1997). It is likely that most of the PVC products in the Plastimet facility were linked to Responsible Care® participants.

Furthermore, many small specialty chemical manufacturers do not belong to the CCPA. There are also hundreds (in Canada) of small and medium companies that blend chemicals for their manufacturing processes who are neither members of the CCPA nor participants in the program.

Industry's approach also advocates better management and control at the disposal stage of PVC products. Industry sources claim that pollutants such as dioxins and furans can be prevented from forming in incinerators with better operating and control systems. Although the idea of applying better controls on incinerators sounds reasonable, it side steps issues such as pollution prevention, externalization of costs, and recycling.

Pollution prevention evolved because people realized that traditional approaches to control pollution were ineffective. For example, toxic chemicals have increased in the Great Lakes Basin in spite of many years of regulatory, end-of-pipe solutions.

A recent case study reported by the Canadian Chlorine Coordinating Committee (C4) demonstrates the failure of traditional approaches. In this case study, one of C4's participants, Du Pont Canada, had detected trace amounts of dioxins and furans in the effluent from their Kingston, Ontario plant. Because the manufacturing processes at this plant (Nylon 6.6 resin and fiber) could not generate these chemicals, an extensive and expensive investigation was undertaken. It was determined that the source of the dioxins and furans was a biocide used to coat the Nylon yarn as it was processed. Within 48 hours the biocide was replaced with an alternative. The Ontario Ministry of Environment and Energy (MOEE) later recognized Du Pont for this initiative under their P4 program (Canadian Chlorine Coordinating Committee 1997).

Du Pont's initiative is indeed commendable. However, many questions are raised because of this incident. How long has Du Pont been using this biocide? How many other companies are emitting dioxins and furans unwittingly? Are other companies willing and able to commit the amount of resources that Du Pont can marshal in order to prevent the emission of small amounts of toxic substances?

To eliminate persistent and bioaccumulative toxins on a global scale, pollution prevention action needs to move upstream to the ultimate source of the problem—the industrial use of chlorine. This idea is consistent with pollution prevention practices found in all industries. It is exactly the approach Du Pont used to solve its problem in the Kingston facility. Du Pont solved the problem by eliminating the source of the pollution rather than capturing it at the emission point.

The second issue that needs to be raised with industry's approach to controlling chlorinated toxins is the incineration issue. Although industry argues that there is no link between chlorine waste inputs and the amount of dioxin produced, other studies have reached opposite conclusions (Costner 1997). It is also important to note that there are no ideal incinerator operating conditions that will eliminate toxic byproducts. Basic chemistry dictates that the combination of chlorine and organic molecules in the presence of heat leads to the formation of chlorinated byproducts—some of which are highly toxic. Technology and management may help to control these byproducts, but they will not eliminate them.

If the cost to control toxic byproducts is borne by municipal and hospital incinerator operators, this cost will be passed on to the public rather than to the chlorine industry. When this occurs, there are no market price signals to indicate the higher cost of chlorine-based products. Thus, there are no incentives to reduce their use or to seek alternatives.

Some researchers have even pointed out that the only way the chemical industry is able to survive is because of its ability to externalize disposal costs:

> "In 1986 the annual output of the chemical industry, as represented by the top fifty products, amounted to 539 billion pounds. Based on the EPA's Toxic Release Inventory, the U.S. Congress's Office of Technology Assessment has estimated that about 400 billion pounds of toxic chemicals are discharged into the environment annually. Some of these are chemical industry wastes and others are the industry's actual products, such as dry-cleaning solvents, that are discarded after being used. In either case, they contribute to the enormous toxic burden imposed on the environment by the chemical industry.
>
> The toxic chemicals enter the environment in various ways: emissions into the air; effluents discharged into sewer systems or directly into surface waters; deep-well injections; surface lagoons; or storage dumps. Only about 1 percent of the industry's toxic waste is destroyed, which is the only way to ensure that these substances, many of them highly dangerous and long-lasting, do not threaten living things. If the present (and still environmentally unsatisfactory) method of destruction—incineration—were applied to the toxic chemicals now discharged into the environment, at average cost of perhaps $100 per ton, the total annual cost would amount to $20 billion. In 1986 the chemical industry's total after-

> tax profit was $2.6 billion. The arithmetic is deadly: if the chemical industry were required to eliminate toxic discharges into the environment, the cost would render the industry grossly unprofitable. In effect, the chemical industry is profitable only because it has thus far managed to avoid paying its environmental bill. Proper treatment of its waste, which given rising public concern over this issue, is likely to be forced on the industry in the near future, will mean higher prices and serious competition from the natural products that it has replaced." (Commoner 1990, 89-90)

Although the chemical industry has made substantial progress in reducing emissions—especially from their own production facilities—there are still enormous amounts of toxic waste produced at their manufacturing plant sites, user facilities and disposal sites. And although the volumes of substances such as dioxins and furans are tiny compared to other toxic waste emissions, the characteristics of these substances make them extremely dangerous even in minute amounts. The adverse impacts of all of these emissions are costs that are borne by society and externalized by the chemical industry.

Another issue regarding incinerators relates to recycling. Some of the problems in establishing recycling programs for plastic products have been mentioned earlier. However, incineration makes recycling even more difficult because incineration consumes the very raw material needed to make recycling programs successful. Some observers have noted that:

> ". . . the only insurmountable hindrance to recycling is building an incinerator. For a simple physical reason, incineration actually *interferes* with recycling: about 80 percent of the trash stream consists of components, such as paper and food garbage, that can either be burned or recycled, but obviously not both. Modern incinerators are expected to last for twenty to thirty years and must be fueled with trash to 85 percent of capacity so that sufficient steam or electricity can be sold to allow them to operate in the black. In fact, most incinerator contracts require the town to supply the incinerator with enough trash to permit economic operation-or failing that, to pay for the lost revenue from energy sales." (Commoner 1990, 138)

Initiatives to Accelerate the Transition Process

Before evaluating a number of initiatives that might help move the transition process forward, it may be useful to provide some further context to industry's arguments that defend the status quo. Industry often warns of serious economic dislocations that will result from environmental initiatives. Plant closings, unemployment and loss of international competitiveness are all cited as reasons to avoid change.

Industry's reluctance to change is understandable. However, change is also unavoidable in competitive industries. Most companies face a continuous barrage of challenges in the form of new technologies, new competitors, new products, and changing customer needs. Successful companies respond by changing their strategies, product offerings and organization structures. Those companies that refuse to change lose market share or cease to exist. This state of affairs is appropriately described by the business cliché that "the only thing that remains the same is change."

The constant evolution and adaptation of industry is clearly seen in the ever-changing list of Fortune 500 firms. A survey completed by Royal Dutch/Shell found that one third of the firms listed on the 1970 Fortune 500 were no longer in business in the 1980s. Shell estimated that the average lifetime of the largest industrial enterprises is less than forty years—roughly half the lifetime of a human being (Senge 1990). Fortune 500 statistics have become folklore in the business world. These statistics are repeated by consultants and executives to underline the fact that change is inevitable. A sampling of Fortune 500 statistics demonstrate that there really is no status quo in the business world:

- Of the 100 largest U.S. companies in the 1900s, only 16 are still in existence.
- Of the top 100 firms appearing on the first Fortune 500 list in 1956, only 29 were still in the top 100 by 1992.
- During the 1980's 46% of the Fortune 500 companies disappeared—almost half of the list.

The chemical industry is not immune to change created by technology and competition. One example was the changing market positions that occurred when chemical companies competed for the tire cord business in the automotive tire industry during the 1970s and 1980s. Changing technologies and changing customer needs created a series of transitions in tire cord products—from cotton to rayon to nylon to polyester. As each new innovative material was introduced, market shares of the existing products changed—slowly at first, but with increasing speed as new products gained market acceptance. For example, in 1970, polyester had 30 percent of the market. By 1977, polyester's share had grown to 70 percent. This was an increase of approximately six points per year. During the middle of the transition, the market leaders were losing market share at the rate of half a percent per month (Foster 1986).

During the transition to polyester, Du Pont lost its leadership position to Celanese. This occurred because Du Pont continued to promote nylon in order to protect its investment in nylon cord manufacturing capacity. Du Pont chose this strategy in spite of the fact that its leading customer, Goodyear, had publicly asserted that polyester made better tire cords. Celanese, which did not have a position in nylon to protect, quickly developed a polyester tire cord and gained a commanding position over Du Pont (Foster 1986).

The point of these examples is to illustrate that change is normal in competitive industries. And furthermore, it is often abrupt and painful because competitors do not attempt to cushion the impact of change on their rivals. Industry stakeholders have the ability to adapt to the elimination of chlorine in the same manner that it has adapted to countless other changes in the past.

There is one key difference when change is initiated by the government (i.e. to eliminate chlorine) rather than by the market. The difference is that industry can provide input regarding the transition guidelines. Industry would influence the transition time frames and the economic instruments used to generate the appropriate market signals. This is very different from open markets where it is difficult to predict the actions and reactions of competitors. Clearly defined transition time frames and an understanding of how economic instruments will be applied will eliminate a great deal of uncertainty and establish a level playing field for all competitors.

Market-Based Incentives

The use of market-based incentives or economic instruments increased substantially during the 1980s and 1990s because they are a powerful complement to direct regulations. It is generally recognized that these kinds of tools provide more flexibility, efficiency and cost-effectiveness when implementing environmental policy (OECD 1991).

Market-based incentives include emission charges, product charges, marketable permits and deposit-refund systems. Product charges or green taxes appear to be an efficient tool to help accelerate the transition process for PVC-based products and are discussed in detail here. Green taxes are applied on products that are harmful to the environment during production, consumption or disposal (OECD 1991).

There are a number of advantages to applying green taxes to PVC rather than bans or emission charges. These advantages include:

- Applying a green tax at the point of PVC production would be easier to administer than applying emission charges to toxic wastes. This is because there are relatively few PVC production sites compared to a multitude of emission sites such as hospital and municipal incinerators. Emission charges would also be ineffective at landfills because of the problems in identifying the source of toxins found in leachate. Emission charges at fires where PVC products were accidentally burned would also be problematic.

- A rising green tax would increase the cost of PVC-based products providing an incentive to reduce the use of PVC-based products and increase the use of chlorine-free alternatives. The transition would be implemented by industry which has the resources and know-how to complete the task most cost-effectively. Steadily rising prices would provide the signals needed for companies to expand production for chlorine-free alternatives or to develop new cost-effective solutions. There is no need for comprehensive planning—the market will respond to the price signals and adapt to the changing conditions.

- Green taxes on PVC offer a great deal of flexibility. The rate of increase of the green tax could be easily adjusted to increase or decrease the rate of transition.

- Green taxes provide government with a revenue raising opportunity. This revenue could be used in special circumstances to assist people and companies who are unduly burdened by the transition. The revenue could also be used to reduce overall taxes. This supports the idea that governments should tax "bads" rather than "goods."

- Green taxes provide the opportunity to use existing administrative and fiscal channels.

- Green taxes on PVC do not restrict the government from establishing different programs for other chlorine-based applications. For example, while green taxes are being applied to PVC, other applications such as water treatment could be transitioned using different approaches. Water treatment might be an area where a comprehensive planning process is more appropriate because this application is primarily controlled by governments.

- Because there are readily available alternatives to most PVC-based products, green taxes are an ideal tool to initiate a transition. Price increases will motivate purchasers to implement the transition process without any encouragement or planning from government.

- Green taxes lessen the opportunity for companies to make short-term windfall profits. For example, if the PVC industry were to simply reduce supply, prices would rise creating the potential for windfall profits if alternatives were unable to meet the demand. With green taxes, the rising cost is in the form of green taxes that are channeled back to the government.

The key implementation issues in applying a green tax to PVC are: (1) What is an appropriate transition time period? (2) What amount of green tax and what rate of increase is required? and, (3) What impact will there be on international trade and competitiveness?

Beginning with the issue of transition time, the time period must be long enough to avoid severe and abrupt economic dislocation. History provides examples of the economic hardships that can occur when prices of important commodities rise too quickly. The economic dislocations and chaos caused by the 1973 oil embargo is a good example. Another example was the sudden drop in Monsanto stock when news of a possible ban on alachlor leaked to the U.S. press in 1984. Monsanto's stock fell so quickly that the New York Stock Exchange was forced to temporarily suspend trading (Fagin and Lavelle 1997).

The IJC initially felt that fifty years might be an appropriate transition time period to eliminate chlorine as an industrial feedstock. Some industry representatives later informed IJC that twenty years might be possible (Durnil 1995). Researchers such as those involved in The Great Lakes Program at the State University of New York (SUNY) at Buffalo have recommended a 30 year phase out for products and applications that generate harmful toxins (Kent 1995). Other authorities have suggested that a twenty five year transition period would give producers and consumers ample time to adapt, plan, and reinvent (Hawken 1993).

The counter argument for a long transition period is that if the current level of toxic pollution is already causing harm, should society accept another twenty to fifty years of toxic loading? A possible solution to this dilemma might be to apply traditional end-of-pipe solutions as an interim measure to eliminate the most serious sources. For example, it has been postulated that hospital and municipal incinerators are major sources of chlorinated toxins. If toxins from these sources could be controlled, a major reduction in toxic loading could be achieved. The long-term solution—the elimination of chlorine as an industrial feedstock—would be implemented over a longer period of time.

In the case of a product application such as PVC pipe, the transition to chlorine-free alternatives could take place rapidly because many of the alternatives are already available. Although there are price and performance differences, these differences do not appear to be unmanageable. The fact that suppliers of PVC and chlorine-free pipe products compete aggressively indicates that a rapid transition would have minimal impact on end-users.

During the transition period, suppliers of alternative products would have to expand their manufacturing capacity to handle increased demand. However, considering the fact that these industries are mature and that there is no need to invent new processes or products, a rapid increase in capacity should not be a serious obstacle.

The downside of a fast transition process is that it would cause serious disruption to manufacturers of chlorinated raw materials as well as producers of PVC. An adequate transition time period is needed to give these companies enough time to: (1) adjust their long-term strategies, (2) achieve payback on existing assets, and (3) assist affected employees. From a strategic business perspective, these companies will have to choose from a number of options: (1) develop alternative, chlorine-free products, (2) merge with existing non-chlorine suppliers, or (3) exit the market. Although the transition time period cannot be established without input from industry, twenty years would likely be a maximum.

The second issue that needs to be addressed is: What amount of green tax should be applied? The theoretical approach to this question is to first determine the cost of the environmental damage caused by PVC, then add a green tax to cover this damage. However, the cost of some of the environmental impacts are difficult to establish. For example, what is the value of a human life that has been lost due to dioxin poisoning?

Although these kinds of questions create difficult ethical dilemmas, economists have nonetheless developed ingenious approaches to establish monetary costs for these sensitive areas. One approach is based on the wage premiums paid in high-risk jobs. By analyzing wage premium data and the probability of death in high-risk jobs, researchers have estimated that a human life is worth between $500,000 and $2 million (Commoner 1990).

However, rather than struggling with the ethical issues raised by these approaches, a more practical course is to simply determine the green fees that would make chlorine-free alternatives more cost-effective. For example, the IJC task force determined that the application of a $10 per kg tax on PVC would eliminate its use in most electrical conduit applications. A $100 per kg tax would eliminate its use in almost all building and construction uses. And finally, a tax of $300 per kg would virtually eliminate all uses of PVC (IJC 1993).

It is important that the green taxes take into account not only the cost of the product but its value-in-use. For example, even if PVC and metallic pipe were the same price, the construction industry would continue to use PVC because of lower installation costs. Thus, the green taxes on PVC would have to be high enough to cover the cost advantages of installation and product.

To examine the impact of the proposed green taxes on PVC pipe, the taxes recommended by the IJC task force were applied to the two and four inch pipe applications described earlier. The resulting impact on total cost is shown in the following charts.

Table 4: Impact of IJC Green Taxes on Two-Inch Pipe Application

IJC Green Tax	Total Cost Impact (Two Inch Pipe Application)
$ 35/kg	cost of PVC pipe equals cost of steel pipe
$ 95/kg	total installation cost (labor and material) is equal for PVC and steel
$140/kg	cost of PVC pipe equals cost of copper pipe
$200/kg	total installation cost (labor and material) is equal for PVC and copper

Note: above calculations assume one foot of 2" PVC is 100 grams

Table 5: Impact of IJC Green Taxes on Four-Inch Pipe Application

IJC Green Tax	Total Cost Impact (Four Inch Pipe Application)
$100/kg	cost of CPVC pipe equals cost of copper pipe
$200/kg	total installation cost (labor and material) is equal for CPVC and copper

Note: above calculations assume one foot of 4" CPVC is 500 grams

The results indicate that, for the above applications, IJC's green taxes are in the right range. However, because of varying labor and installation requirements, purchasers will not switch to chlorine-free alternatives in unison. This means that as green taxes rise incrementally, there will be a smooth transition rather than a sudden, trigger point.

It should also be pointed out that a green tax on PVC will likely have very different impacts on other PVC products such as siding, wire and cable insulation, plastic goods and parts, and packaging. For example, wire and cable manufacturers would have to purchase new equipment in order to manufacture wire and cable using chlorine-free insulation. The wire and cable manufacturers would factor the equipment capital costs into their decision before deciding to switch to a chlorine-free alternative.

However, because pipe and fittings account for the largest volume of PVC, eliminating this product group will have a significant impact on chlorine production. It makes sense to start with this product group because it is a large user of chlorine and alternatives are readily available. The approach would be to first establish a reasonable transition time-frame with industry input and then to determine the rate at which rising green taxes should be applied on PVC. All industry stakeholders would build their business plans based on their forecasts of the expected impact at each green tax price point.

The impact of the green taxes would then be analyzed with respect to other applications such as wire and cable, siding, packaging, etc. The objective is to determine if the transition time frame and the amount of taxes are appropriate for these industries. If the tax model is not appropriate, a different structure would have to be developed for these other application areas.

In every application, the green tax would continue to rise until all applications for PVC were transitioned to chlorine-free alternatives. If there were certain specialized PVC products where chlorine-free alternatives were not readily available, end-user companies could petition the government for financial assistance in order to develop alternatives. Temporary, short-term financial assistance is more defensible than granting exemptions (OECD 1991).

However, this type of financial assistance should be reserved for very special circumstances such as critical health or safety related applications. In general, government should resist using green taxes to assist any company that is providing or developing chlorine-free products. The reason is that government assistance could be viewed as an unfair advantage. If green taxes produce the appropriate price signals, industry will respond to the market opportunities. Government subsidies should not be required to motivate companies to pursue these opportunities.

The final issue with regard to the implementation of green taxes is international trade and competitiveness. This issue was discussed earlier and it was pointed out that it is very difficult to isolate the impact of a single factor such a PVC green tax when determining international competitiveness. The international success of a company or a product depends on many factors such as quality, currency fluctuations, distribution, product attributes, government export programs, and a host of others.

However, in spite of the fact that it would be difficult to determine the amount of impact, it was acknowledged that a unilateral PVC tax would cause trade distortions. Although this underlines the importance of establishing international agreements, it should not be used as an excuse for inaction. Green taxes on domestic production and environmental tariffs on imports would level the playing field and encourage foreign manufacturers to use alternative products.

The main problem with environmental tariffs on PVC-based imports is the wide array of PVC-based products. The administrative costs to collect the tariffs would likely be excessive. However, the threat of tariffs and penalties, and the watchful eye of domestic producers might encourage foreign producers to quickly transition to chlorine-free alternatives.

Public Information and Education

The public's ability to influence industry and policy-makers can be very substantial. The example of Alar, a chemical used to enhance the appearance of fruit, is illustrative. When the public became aware of the potential cancer risks from Alar, reaction was swift. Parents were not interested in what levels of Alar were tolerable. They simply did not want it. Uniroyal responded by quickly removing the product from the market (Commoner 1990).

In another example the "ozone hole" created a triggering event which quickly raised the public's awareness of CFCs. The image of the protective shield around the planet thinning as a result of CFC usage was compelling and disturbing. Politicians were aware of the public's perceptions and were pressured into action.

PVC is a very different situation. It is difficult to imagine the public perceiving that a product found in thousands of everyday applications such as credit cards, lawn furniture, household plumbing and children's toys could be dangerous.

At a chemical industry conference in 1995, a Greenpeace observer noted that the chemical industry believes that the public does not distinguish PVC from other plastics, nor does the public have an appreciation for the links between PVC, chlorine and dioxin (Greenpeace 1995).

Public information and education will certainly assist in the transition process but in the case of chlorine and PVC, it will not likely be a primary factor. It will take government leadership to establish firm goals and guidelines in order to start the process. Once industry accepts that industrial chlorine is going to be eliminated, market-based tools will provide the most efficient means to accomplish the transition.

Multi-stakeholder Roundtables

The multi-stakeholder roundtable approach is a forum which brings government, industry, environmentalists, and the public together in order to form a consensus. The theory is that the opposing groups will eventually work out their differences, then develop and implement solutions to problems. The goal of this approach is to avoid costly and often ineffective government regulation.

The multi-stakeholder approach seems to work best when the issues are local and when industry considers the process an effective alternative to regulation. Regulatory agencies such as the U.S. EPA have pointed out that the approach is very effective in solving site-specific pollution problems. This is because customized, site-specific solutions are often less costly than broadly applied command-and-control strategies (Fillingame 1997).

Unfortunately, when the issues become complex and far-reaching, and when key industry stakeholders have no desire or incentive to change, the process becomes less effective. Experience has shown that when industry is presented with an unfavorable situation, industry generally takes on a siege mentality. The predominant response is denial followed by tactics designed to maintain the status quo (Durnil 1995).

In these situations, opposing stakeholders promote their views using every available tactic and tool. Scientific studies are used by both sides to justify their positions—

industry-sponsored studies show that chemicals are safe while non-industry-sponsored studies show them to be harmful (Fagin and Lavelle 1996). The scientific uncertainty in these studies provide many opportunities for opposing forces to challenge each other.

The uncertainty stems from the facts that: (1) the health effects of minute amounts of toxic chemicals are difficult to quantify, (2) the chemicals are difficult and expensive to measure, (3) the chemicals are widely distributed meaning that there are no populations to act as unexposed controls and, (4) because there are so many other carcinogenic chemicals in the environment, it is difficult to isolate the impact of any single chemical (Steingraber 1997). All of these issues provide many opportunities for debate as well as reasons to avoid action.

Although multi-stakeholder approaches have a poor record in solving complex problems, they have achieved some success in Europe in spite of the obstacles discussed above. The Europeans have found, however, that there are a number of critical elements that need to be in place to ensure success:

- The government must demonstrate clear and well defined objectives up front. General commitments to vague goals do not generate action.

- The public must be aware of the issues in order to motivate all participants to achieve agreement.

- The government must show a determination to introduce regulatory measures if agreements fail to reach targets.

- The agreements must sufficiently cover the industry in question. If the industry is made up of many small companies rather than a few major players, then a business association should negotiate on behalf of the small companies. The key point is that a small group is more likely to achieve consensus because the transaction costs of reaching an agreement is less.

- Intermediate objectives need to be set so that plans can be adjusted at an early stage.
- Results need to be monitored and verified by independent sources with enforcement mechanisms for non-compliance.

- In parallel to the development of an agreement, government needs to encourage consumers, in a non-discriminatory manner, to base their purchase decisions on environmental considerations (Commission of the European Communities 1996).

The IJC's comprehensive transition planning process is essentially a multi-stakeholder approach. Unfortunately, many of the obstacles that prevent the successful application of this approach are present.

First of all, chlorine is a multi-billion dollar business with thousands of suppliers and manufacturers who have links to chlorine. It would be almost impossible to develop a single, comprehensive policy to eliminate chlorine with this number of stakeholders. Second, some of the largest stakeholders such as the PVC industry are global and have massive sunk costs in chlorine technology. These companies have a great deal of incentive to maintain the status quo. Third, there is scientific and economic uncertainty as well as different value frameworks among the stakeholders. And, as we have seen, consensus is very difficult to achieve under these conditions. And finally, there is no strong commitment from government to eliminate the industrial use of chlorine. Because of these factors, it is highly unlikely that a comprehensive transition planning process could be achieved using the multi-stakeholder approach.

A more pragmatic approach is to address broad application areas such as PVC by implementing green taxes then allowing market forces to sort out the transition problems. It must be pointed out that this "hands-off" approach does require industry input to determine transition time-frames and to develop economic instruments. It is also important to underline the importance of government commitment in order to initiate dialogue on these issues.

Industry stakeholders need to understand that the government is committed to eliminating the industrial use of chlorine. The objective of multi-stakeholder forums must be to develop the appropriate time-lines and market based tools—not to debate the science and economics of the policy decision. Only when the policy direction is clear, and industry realizes there is no point in trying to maintain the status quo, can the transition process move forward. When agreement on the fundamentals—time-lines and economic tools—are achieved, government can step back and monitor progress.

Alternative Technology Development

In the case of PVC pipe, many alternatives were in use before PVC was introduced into the market. These alternatives are all readily available to replace PVC. New products will likely be developed as the market for chlorine-free pipe grows.

In terms of accelerating the transition process, government assistance to stimulate the development of alternative technologies should be a low priority because of existing alternatives. Any assistance to companies who are developing new technologies could be construed as providing an unfair advantage to existing suppliers.

The best strategy to stimulate the development of alternative technologies is to ensure that there is a stable market for chlorine-free products. Clear statements from the government regarding the transition time frame and green tax policies will provide the necessary market stability. With a clear picture of the market potential for chlorine-free alternatives, companies can make their own decisions regarding investments for new technologies.

Regulations

The traditional approach to curbing industrial pollution has been regulatory, end-of-pipe, standards. However, this approach has not been successful and may be particularly ineffective in dealing with persistent and bioaccumulative toxins. The problems with this approach are summarized by Durnil below:

> "Environmental regulations tend to be inconsistent, owing to the differing national, provincial, and state jurisdictional standards. Regulatory standards tend to find room for exceptions. And, of course, regulation is an expensive endeavor for the regulators and the regulated. It [regulation] is also a perceived infringement on the personal and business lives of our citizens. A regulatory standard implies that such standard sets a safe level of human exposure for the discharge of whatever substance is being regulated. Regulatory standards imply that a safe standard exists, when more recent information would suggest that even one exposure to dioxin by a pregnant female may be enough to cause an adverse effect on the adult or the progeny. It is also important to realize that many of the chemicals to which we are exposed have never been tested for safety as

they relate to living things. Regulatory standards tend to be excuses which enable governments to set exceptions for the discharge of various poisons into the waters of North America through the collection of fees and the issuance of permits." (Durnil 1995, 26)

The end-of-pipe regulatory approach has been used by the U.S. and Canadian governments for many years in an attempt to reduce the levels of persistent toxins in the Great Lakes. These efforts have reduced the inputs but have not reduced toxins to levels that are considered to be safe. The attempts to regulate the most dangerous substances out of existence simply have not worked (Durnil 1995).

Specific to PVC pipe, one area where regulatory change will be required is building codes. Building codes often name specific products such as PVC for a particular application. Developers and builders must comply with the codes or face serious legal consequences. Changes to the codes will be required in order to allow developers and builders to use alternative materials.

A number of local governments in Europe have initiated changes in their building codes to eliminate the use of PVC. In Vienna, Austria, new hospitals are being built without PVC (Casten 1994). Dozens of local municipalities in Germany have phased out the use of PVC in public construction and government offices (Gibbs 1995).

PERCHLOROETHYLENE (PERC) DRY CLEANING SOLVENT

Perchloroethylene (perc) or tetrachloroethylene is a chlorinated solvent commonly used in the dry cleaning industry. Perc is one of thousands of chlorine-based chemicals produced by the chlorine industry. Relative to the total industry, perc consumes a minor portion of chlorine production.

Like many other chlorinated solvents, the use of perc is decreasing because of environmental and health considerations. In the U.S., the International Agency for EPA's Carcinogen Assessment Group has classified perc as a probable human carcinogen (Rice and Weinberg 1994). In Canada, perc was declared toxic in 1993 under the Canadian Environmental Protection Act (CEPA).

The pressure to reduce the use of perc is based on epidemiological studies which found an association between occupational exposure to perc and increased risk of several types of cancer, including cancer of the esophagus, kidney, liver, bladder, lung, cervix and pancreas, as well as leukemia.

In spite of these studies, many stakeholders in the dry cleaning industry contend that perc does not cause cancer in humans. They claim that the epidemiological studies are procedurally flawed, and/or that the workers involved may have been exposed to petroleum solvents which were widely used in the industry before the advent of perc (Rice and Weinberg 1994).

Other studies suggest that the health problems related to perc are localized to people working directly with the chemical. These studies point out that organic solvents readily vaporize in the air and that their potential for adverse effects in the general environment are negligible. Furthermore, these studies conclude that photo-oxidative chemical reactions destroy these solvents in the atmosphere. They point out that half-lives range from a few to several hundred days (Delzel et al. 1994).

Countering these positions, Greenpeace cites a number of opposing studies which conclude that perc is a serious threat. According to one study:

> ". . . approximately 5% of the perc released into the Great Lakes airshed will enter the Great Lakes water system in a persistent form - either as perc directly entering biota or, alternatively, in the form of persistent breakdown products, reaction or metabolites (Ginsburg 1991). Based on

> these calculations, dry cleaners in the Great Lake Basin contribute more than one million pounds (450,000 kg) of persistent toxic contamination to the Great Lakes system each year." (Rice and Wienberg 1994, 12)

Greenpeace also points out that perc has been found in the atmosphere worldwide, and in locations far removed from anthropogenic sources. Once inhaled or ingested, perc accumulates in the body, and has been found in the blood, fatty tissue, breath, and breast milk of the general U.S. and Canadian populations. Perc has also found its way into groundwater supplies. When discharged into sewer systems, perc can settle to the bottom of the sewer line and migrate through pipes into soil/aquifers.

In spite of some industry opinions that perc is not harmful, growing environmental concerns have resulted in falling perc usage—7.1 kilotonnes in 1990 to 5.5 kilotonnes in 1994 (Environment Canada, 1996). This has been accomplished with: (1) more efficient use of perc through modern equipment and better operating practices and, (2) the displacement of perc by both wet cleaning and hydrocarbon solvents (ChemINFO Services 1996).

Dry Cleaning Industry

The expression "dry cleaning" is an inaccurate term. In the dry cleaning process, clothes are washed in perc rather than in water. Thirty five to fifty pound loads of clothes are placed into a machine that looks very similar to a large domestic front-load washer. With older perc washing systems, operators transfer the clothes from a washer to an extractor that recaptures some of the perc. After the extraction step, the clothes are dried in a special drier that is vented to the outside atmosphere. Newer, unvented machines use a closed loop system that eliminates the transfer step and also recaptures perc that would normally be lost in the drying process. However, even these newer machines do not totally eliminate perc emissions.

The number of dry cleaning establishments number 35,000 in the U.S. of which 95% are individually owned and operated and 98% consist of less than four (4) stores (Patterson Travis 1996). The Canadian industry has the same "mom and pop" attributes. Sixty to 70% of the 3,000 dry cleaning businesses in Canada have less than seven to eight employees (Vandermolen 1997).

The traditional business model for the dry cleaning industry is to have a "perc machine on every corner." The environmental disadvantages of this model are: (1) there are a multitude of pollution sources, and (2) the pollution sources are managed by operators who are often ill-informed and cash-strapped. Industry spokespeople point out that decisions on how to handle toxic wastes are often based on "how much money is in the till at 4:30 on Friday afternoon" (Vandermolen 1997).

Because most dry cleaners are classified as a small business, they are not required to report their emissions—in spite of the fact that their collective VOC emissions in 1991 were more than 12 times as high as all reporting industries combined (Rice and Wienberg 1994). However, the small business classification is becoming less of a protective shield as pressure increases to reduce perc emissions. In October of 1995, the Consumers Union of United States, Inc. released a study that determined that there was danger to the health of apartment dwellers who lived above dry cleaning operations. In July 1996, the Department of Environmental Conservation of the State of New York released (for comment to the public) revisions to the perc dry cleaning regulations which will require dry cleaners who are using older machines to: upgrade their equipment, post warnings of the dangers of perc, construct vapor barriers, adhere to record keeping requirements, pay for semi-annual inspections and attend training sessions. Also, a recently introduced bill in the New York State would phase out perc dry cleaning from all residential buildings in New York City (Patterson Travis 1996).

The dry cleaning industry is under similar pressure in Canada. Under the Canadian Council of Ministers of the Environment (CCME) NOX/VOC Management Plan, Environment Canada, provincial governments and other stakeholders, developed Codes of Practice to prevent/reduce solvent emissions. The province of Ontario established regulations that now require dry cleaning operators to take a training course based on the CCME dry cleaning Code of Practice. Other provinces are considering adopting regulatory initiatives similar to those in Ontario (Environment Canada 1996).

Ontario is also implementing regulations which will require operators of older unvented systems to upgrade to closed loop systems (*The Globe and Mail* [Toronto], 11 February 1997). The problem with this approach is that although emissions will be reduced, the industry will remain locked into perc-based processes.

Alternatives to Perc

There are two alternatives to the perc dry cleaning process. The first is water-based or aqueous cleaning and the second is hydrocarbon (chlorine-free) solvent cleaning.

Aqueous cleaning uses natural soaps, steam and heat to clean clothing. Careful inspection and cleaning of garments is done by a skilled technician who decides which technique (steaming, scrubbing, etc.) will best clean a garment. With perc dry cleaning, all garments receive a standard treatment. Tests done by the EPA have shown that wet cleaning and perc dry cleaning are comparable in terms of shrinkage, color change, feel and damage. Wet cleaned garments receive higher marks for appearance and odor and the process may even be more profitable than traditional perc-based dry cleaning (Rice and Wienberg 1994).

The second alternative, the use of hydrocarbon solvents, produces equal performance but with the increased danger as a fire hazard. Older hydrocarbon solvents such as stoddard solvent have a low flash point of 40°C. New paraffinic hydrocarbon solvents have flash points of 60°C and, therefore, have less risk of fire. The use of hydrocarbon solvents is not widespread because of the fire hazard issue.

Companies such as Dow have developed solvent alternatives which have lower VOC content but improved performance still does not eliminate the problem (Dow Chemical 1997).

Impediments to Change

Industry Resistance

Before examining one of the main impediments to change, industry resistance, it is important to define the industry stakeholders. When broadly defined, there are many stakeholders in the industry with a wide variety of opinions regarding the use of perc. The industry stakeholders include:

- manufacturers/distributors of perc
- manufacturers/distributors of perc washing/drying equipment
- manufacturers/distributors of aqueous washing/drying equipment
- garment cleaning businesses (perc/hydrocarbon/aqueous)
- end-users (customers)

Like the PVC industry, there are potential winners and losers in a transition away from perc based garment cleaning. For example, companies that market aqueous cleaning systems would clearly benefit from a transition to chlorine-free alternatives. Other potential winners include companies who provide the specialized soaps and other wet cleaning equipment required for aqueous cleaning.

Potential winners also include companies who produce hydrocarbon solvents. In Canada, Imperial Oil Ltd. (Sarnia, Ont.) and Shell Canada (Scotford, Alta.) are both major producers of hydrocarbon solvents. Since there are no perc manufacturers in Canada, a transition to hydrocarbon based solvents could create a net economic gain for Canada. It should be pointed out, however, that hydrocarbon products have their own problems because they are more flammable than perc and they include chemicals such as toluene and xylene (ChemINFO Services 1996).

Potential losers in a transition process include dry cleaning operators who have made investments in perc-based systems and equipment. In order to realize a return on their investment in perc-based systems, they must use these systems until they are depreciated and in need of upgrading. Their support for the continued use of perc-based systems is clearly seen in comments from industry spokespeople, such as William Seitz, executive director of the Neighborhood Cleaners Association (New York), who points out that: "The industry is looking at all alternatives, but perc is very much part of the future (*New York Times* [New York], 29 October 1995)."

In Canada, the Ontario Fabricare Association also supports the continued use of perc but agrees that there needs to be a better balance between aqueous and non-aqueous cleaning. Spokespeople from Ontario Fabricare believe that 15% of all clothing entering a dry cleaning establishment must be cleaned with non-aqueous solvents. Another 15% must be cleaned with water. The 70% in the middle is the gray area. Although these spokespeople point out that the industry is "married" to perc, they also believe that perc will eventually be phased out (Vandermolen 1997).

Other potential losers in the transition process include companies that produce perc and the companies that manufacture perc cleaning equipment. There is less of an impact on the distributors of these products because distributors can shift their product mix to aqueous or hydrocarbon based alternatives.

Major perc producers such as Dow Chemical have already begun to develop new products in anticipation of a perc phase-out. Dow's initiatives include the formation of an advanced cleaning systems business. This business has developed new technologies to capture vapors from chlorinated solvents. It is also assisting customers, like dry cleaners, in the proper use of existing control technologies. Although these products and services support the continued use of perc, they provide interim solutions to reduce the environmental impact. The longer-term solution is a transition to chlorine-free alternatives. Dow's advanced cleaning systems business seems to have this in mind with the development of a number of aqueous and semi-aqueous cleaning products to use as substitutes for chlorinated solvents (Hileman 1993).

If we look beyond individual dry cleaning operators and view the total dry cleaning industry, we see that the impact of transition on the total economy is small. A loss in market share by one company is a gain in market share for another. As long as the application for garment cleaning remains, companies will offer services to capitalize on the need. It does not matter whether these services are based on chlorine or chlorine-free alternatives. If perc dry cleaning processes are unavailable, alternative products or processes will soon appear to fill the application need.

The relevant question becomes: "What companies will be adversely affected by the transition?" The goal of the transition process must be to ensure that these companies have an opportunity to: (1) recoup their capital investments, (2) develop alternative business plans, and (3) ensure that their employees are re-trained or, given ample time to find new career opportunities. Government's role in this process should be to demonstrate a commitment to eliminating perc then setting firm transition guidelines which will establish a level playing field and a stable market. Industry will then handle the transition details in a cost-effective manner.

The time period to accomplish a perc-free transition is difficult to ascertain without industry input. However, based on the type of equipment and systems in the industry, ten years should be a maximum target. As the transition process to eliminate perc moves forward, initiatives to reduce perc emissions through better training and the use of state-of-the art technology should be viewed as interim solutions. Those companies that choose to invest in state-of-the-art perc technology will do so based on achieving an adequate return on investment within this transition time-frame. Their decision will be based on a number of criteria including financial strength, depreciation of current perc-based assets, and their assessment of the market and competitors.

Labeling Liability

Labeling liability can be an obstacle to the transition process because if wet cleaning is applied to a garment with a "dry clean only" label, the cleaner is liable for any damage. In the U.S., government regulators are becoming aware that wet-cleaning can be as safe to garments as dry-cleaning. As a result, wet-cleaning industry proponents and Federal environmental officials have petitioned the Federal Trade Commission to change the wording on labels in non-washable garments from "dry clean only" to "professionally clean only" (*New York Times* (New York) 29 October 1995). Although the commission has not yet ruled on the issue, this change will likely take effect as experience with wet cleaning continues to grow. The same issues have been raised and are being examined in Canada.

Another liability issue that may accelerate the transition process is the potential for liability suits from tenants who occupy builders where dry-cleaning operations are located. To avoid liability, dry cleaners would have to move their dry cleaning production to industrial sites or, if they wanted production to remain close to their customers, they could switch to aqueous cleaning. Because of the similar location problems, hydrocarbon based systems will be difficult to establish in residential areas because of fire hazard issues.

Established systems and processes

Another factor which impedes the transition process is simply a natural resistance to change. Changing established systems and processes increases uncertainty and risk. Business people avoid uncertainty and risk unless the rewards are substantial.

Industry spokespeople who have transitioned to wet cleaning point out that lack of knowledge of wet cleaning processes leads to a fear of change and a desire to remain with traditional systems (Hough 1996).

The reluctance to change will only be overcome when the business case for alternative approaches becomes compelling. The factors that will create a compelling business case include: (1) high-cost regulation, (2) shifting consumer demand, and (3) higher costs of perc-based systems.

Initiatives to Accelerate the Transition Process

In this section we will review some potential initiatives which might accelerate the transition process to perc-free cleaning. Before reviewing these initiatives, it is interesting to note how quickly other industries have responded to bans on chlorine-based solvents. For example, when CFCs were banned, the electronics industry was forced to find alternatives to their solvent cleaning processes. The electronics industry was remarkably successful in their transition to alternative products which proved to be both cost and performance effective.

By comparison, the dry cleaning industry's transition to chlorine-free alternatives is moving at a snail's pace despite growing regulatory pressure and the availability of alternatives. This relatively slow pace may be due to the fact that, unlike larger well-financed companies in the electronics industry, dry cleaners do not have the resources to make a fast transition. It may also be due to the fact that the dry cleaning industry simply does not experience the constant change and innovation that is normal in the electronics industry.

Market-Based Incentives

As discussed in the PVC case, value-in-use must be considered in order to determine the appropriate level of market based incentives such as green taxes. Value-in-use considers the price of the product to be only one component of the total value. The price of the product needs to be considered in relation to the total value of the application.

The value-in-use concept was considered by Environment Canada in the phase-out of methyl chloroform (MCF), a metal cleaning solvent, and an ozone depleting chemical. Rather than applying a green tax, Environment Canada decided that a gradual phase-out of MCF was more appropriate.

Environment Canada felt that increasing the price of MCF would generate some conservation measures. However, the relatively low contribution of cleaning costs to total cost would allow the absorption of significant cost increases. Even a doubling of the price would likely result in only a 10 to 20% decline in MCF consumption. Environment Canada concluded that the lack of availability of MCF would be the driving force for finding substitute solvents or processes. As a result, regulations were written which slowly reduced supply by forcing manufacturers and importers to reduce their production or import volumes (Environment Canada 1994).

The value-in-use concept also applies to perc. Table 6 compares the annual costs of a dry cleaning business compared to a multiprocess wet cleaning.

Table 6: Line Item Operating Cost Comparison of Dry and Wet Cleaning

Cost Category	Dry Cleaning	%	Wet Cleaning	%
Capital recovery cost	$6140	14.0%	$90	0.2%
Pressing labor	$22,500	51.2%	$22,500	51.3%
Cleaning labor	$5,000	11.4%	$15,500	35.3%
Steam	$4,400	10.0%	$4,340	9.9%
Hazardous waste disposal	$1,390	3.2%	$0	0.0%
Electricity	$1,170	2.7%	$110	0.3%
Maintenance/Repair	$1,000	2.3%	$30	0.1%
Filters	$630	1.4%	$0	0.0%
Spotting chemicals and detergents	$1,230	2.8%	$1,070	2.4%
Perchloroethylene (perc)	$370	0.8%	$0	0.0%
Water and sewer	$10	0.0%	$240	0.5%
Permit fee	$80	0.2%	$0	0.0%
Total	*$43,920*	*100.0%*	*$43,880*	*100.0%*

Source: U.S. EPA. Multiprocess Wet Cleaning, Cost and Performance Comparison of Conventional Dry Cleaning and An Alternative Process, EPA 744-R-93-004, September 1993.

The two key points shown in Table 6 are: (1) perc represents less than 1% of a dry cleaning operator's total cost, and (2) the operating cost of wet cleaning and dry cleaning are virtually identical. The question is: What would compel a dry cleaning operator to transition to wet cleaning?

Let us assume that at least some dry cleaning operators would switch to wet cleaning if their costs rose to a level that was 20% higher than a wet cleaning operation. Let us also assume that this cost increase was the result of rising perc prices.

First, to obtain a 20% cost differential, the annual operating cost for the dry cleaning business must rise to roughly $53,000 as compared to approximately $44,000 for the wet cleaning business—a difference of $9,000. If this additional cost was allocated to the perc line item, then the cost of perc would have to increase by almost 25 times to achieve the $9,000 differential.

Also it is important to note that the choice between perc or water affects a long list of operating line items in the business. The decision is not as simple as removing a chlorine-based product and inserting a chlorine-free alternative.

This situation is very different from that observed in the PVC pipe case study. In that case study, the decision to use PVC pipe or metal pipe affects relatively few line items—mainly pipe cost, installation labor, and use of installation equipment. As a result, the pipe material decision is more akin to a simple replacement of one product for another.

The perc situation is more comparable to the MCF example described earlier. Perc is similar to MCF because the use of solvents such as MCF to degrease metals requires specific equipment and processes. To eliminate MCF, one cannot simply replace MCF with water or some other chemical. Entirely new processes and new equipment are required. Because of these characteristics, Environment Canada decided that a phase-out of MCF was more appropriate than applying a green tax. Environment Canada realized that very substantial green taxes would be required in order to overcome the low value-in-use of MCF in degreasing applications.

Implementing a phased-in ban on MCF and perc will generate market signals similar to green taxes. The declining supplies result in: (1) price increases, and more importantly (2) strong incentives to develop alternative cleaning systems in order to avoid production stoppages. A phased-in ban to eliminate perc is better than the current approach of tighter controls to reduce volatile organic compound (VOC) emissions for the following reasons:

- A ban eliminates the problem at the source. This removes the problem of accidental releases and non-compliance as well as the long-term dependence on perc.

- Monitoring costs are greatly reduced. Rather than monitoring over 30,000 dry cleaning establishments, government would need to monitor only a handful of importers who ship perc into Canada.

Companies such as Dow have responded to the call for tighter VOC controls with new solvent products which can be applied in applications such as metal and textile cleaning (Dow Chemical 1997). These reduced VOC content products have the advantage that they can be applied with minor changes to existing processes. However, in spite of the reduced VOC content, the issues of accidental releases and the continued use of these chlorine-based chemicals remains. There are many chlorine-free alternatives that should be considered such as: aliphatic and aromatic hydrocarbons, terpenes, oxygenated solvents (alcohols, ketones, esters, glycol ethers), or high-performance water based systems. At best, reduced VOC products should be considered as interim products which will also eventually be banned.

Public Information and Education

In Ontario, the MOEE has sponsored several "green clean" depots where the public can obtain aqueous cleaning services. The depots provide brochures which describe the environmental advantages of aqueous cleaning. As well, from time to time, the press carries articles on perc-based dry cleaning which remind the public of the dangers of perc.

However, the dangers of perc do not have much of an impact on the public because most of the health issues are with dry cleaning workers or people who live very close to a dry cleaning operation. As a result, the emission of VOCs from dry cleaning operations does not generate a sense of urgency in the public.

Without a sense of health-related danger, it is difficult to imagine a large portion of customers demanding alternative cleaning technologies. The availability of "green clean" depots will likely create awareness and some local customer demand but not a major consumer trend. If one assumes that dry cleaning customers are primarily people who are too busy to clean their own clothes, the added inconvenience of driving to a depot may discourage their desire to be environmentally correct.

Public education will only have a major impact if there is a major campaign to warn the public of the dangers of perc. Compared to the information that the public received concerning CFCs and ozone, public education on perc is almost insignificant. As a result, there has been no major shift in consumer demands or trends.

It is difficult to predict consumer demands and trends that may occur as a result of a phase-out of perc. Many scenarios are plausible. Consumers may continue to demand clothes that can only be effectively cleaned with solvents. These include rayon, colored silks, and structured garments that have interfacing and lining (Consumer Reports 1997). The dry cleaning industry may respond by building hydrocarbon based cleaning plants in industrial areas in order to meet this demand. Or, because of inconvenience, higher prices, environmental concerns, changing dress codes, or other factors, consumers may begin demanding clothing that can be cleaned with water.

These issues will be settled through thousands of decisions made by clothing manufacturers, dry cleaning operators, and consumers. There is no need for a government planning process to determine the optimal outcome.

Multi-stakeholder Roundtables

Government regulators have applied the stakeholder approach with the dry cleaning industry in an attempt to develop new approaches to eliminate the use of perc. In the U.S., the E.P.A. formed a partnership with the dry cleaning industry and environmental groups to identify and evaluate alternative cleaning technologies. The first technology evaluated was multiprocess wet cleaning (aqueous cleaning) which was recommended for a performance and economic feasibility study. The study found that wet cleaning was both cost competitive with solvent based dry cleaning and was able to clean clothes as well as or better than existing methods (U.S. EPA 1994). Other roundtable participants have pointed out that wet cleaning would create jobs because it is more labor intensive. It has been estimated that up to 33,000 jobs would be created if the entire U.S. dry cleaning industry were to move to wet cleaning.

Environment Canada launched a similar roundtable discussion resulting in the opening of test facilities to study aqueous cleaning. The results prompted the Canadian Government to provide seed money to entrepreneurs willing to open dedicated wet cleaning establishments (U.S. EPA 1994).

It also prompted the Ontario Fabricare Association (OFA) to help develop the Canadian Council of Ministers of the Environment's Code of Practice for the Reduction of Solvent Emissions from Dry Cleaning Facilities. The OFA created training material called The Green Team: The Environmental Code of Practice for Dry Cleaners (Great Lakes Pollution Prevention Centre 1995). Although these initiatives are commendable it is important to note that the focus is on solvent reduction not elimination.

OFA's position in support of environmental initiatives is positioned as a "three-pronged" approach:
1) support of educational competence standards
2) support of equipment and performance standards

3) support of research to determine viable alternative fabricare processes

Although the initiatives described above will no doubt reduce solvent emissions, the dry cleaning industry and its core processes remain intact. And while OFA's initiative to determine viable alternatives appears to support fundamental change, more research could also be construed as a delay tactic. Companies such as Ecomat, Inc. would argue that alternatives are already available. Ecomat, Inc. believes that its wet-cleaning process can replace perc based dry-cleaning using technology that is already available (Patterson Travis 1996).

Alternative Technology Development

Alternative technologies to replace perc are readily available. Additional development might be required to refine existing processes and techniques but there is no need for fundamental technology development.

In the U.S. and Canada, the EPA and the MOEE implemented initiatives to demonstrate the feasibility of existing chlorine-free technologies. Although some people in the industry continue to argue that perc-based cleaning is necessary, there seems to be an acceptance that perc will eventually be phased-out.

Policy-makers need only to set up the conditions that will encourage the industry to move to chlorine-free alternatives.

Regulations

Until recently, the dry cleaning industry was able to avoid regulations because individual operators were considered small businesses and were not subject to the stringent environmental controls and monitoring that are typically imposed on large companies.

This situation is changing with the realization that the dry cleaning industry is a significant source of pollution resulting from the use of perc. In Canada, new regulations in 1998 will require dry cleaners to modernize equipment to reduce the use of perc by 70 percent by 2001. More than half of Canada's 3,300 dry cleaners will need to invest $35,000 to $100,000 in order to achieve the new standards (*The Globe and Mail* (Toronto) 11 February 1997). Similar regulations are appearing in the U.S. In New

York state, for example, new regulations require dry cleaning businesses to use state-of-the-art equipment and to create vapor barriers around their machinery. The cost of conforming to the new state regulations run between $47,000 to $70,000 (*New York Business* (New York) 2-8 September 1996).

If we look at these costs from a dry cleaner operator's point of view (in New York), we see that there are a number of options to choose from:

- Pay the compliance cost and continue to use perc-based systems. The cost for this option can range from $47,000 to $70,000.

- Convert the current business to water-based garment cleaning business by purchasing a business upgrade package from a company such as Ecomat. The cost for this option can range from $15,000 to $105,000 (Patterson Travis, 1996).

- Convert the current business to a multiprocess wet cleaning operation. Based on U.S. EPA studies, the operating cost of multiprocess wet cleaning is equivalent to dry cleaning. There would be some transition costs in terms of training and new equipment. These costs would likely be in the same range as Ecomat's conversion package. This option would entail greater risk than the Ecomat option because operators would have to develop their own conversion and implementation plans.

- Exit the industry.

Another possible option is to convert to hydrocarbon based solvents. However, this option is very much dependent on fire codes. There have been no strong moves to hydrocarbon based solvents because of the fire code issue.

If the experience in Germany is repeated, many of the small operators will choose the last option—exit the business (Hough 1996). For those who decide to remain, the choice is between complying with new regulations or moving to aqueous cleaning. If the cost of both of these options are approximately the same, a weighing of short-term risk and return would likely result in a decision to pay the compliance cost and continue to use perc. This is because converting to an aqueous based system requires processes and procedures that are different, and thus more risky, than the familiar perc based systems. If operators believed that perc would eventually be phased out, they might take the longer-term view and move to aqueous based systems.

One measure of the slow acceptance of water-based cleaning is the fact that by 1995, Aqua Clean, the leading producer of water-based washing and drying machines had sold only 50 systems in all of North America (*New York Times* (New York) 29 October 1995). Considering that there are over 30,000 dry cleaning establishments in North America, this represents an insignificant market penetration.

It is also important to point out that the regulatory approach in the dry cleaning industry will likely prove to be less than effective. Although regulations will certainly lead to some reductions in VOC emissions, it is important to note that monitoring will be a major challenge for the government. Dry cleaning association spokespeople have pointed out that most dry cleaning operators are small family run businesses who (1) do not belong to any professional associations, (2) do not receive industry newsletters or trade magazines, and (3) do not attend industry conferences. Most of them don't even know there's a debate over perc (Hough 1996).

In order to lessen the financial burden of compliance, various assistance programs have been proposed. For example, the Province of Quebec has proposed a $2.50 per gallon tax on perc. The revenue from this tax is to be used to help dry cleaner operators who are using first generation equipment to upgrade to modern closed loop systems. Some industry spokespeople, however, have argued that the effect of this tax is to penalize operators who have already upgraded. In effect, these environmentally proactive operators are subsidizing the upgrades of the less efficient and less environmentally conscious operators. Industry pressure forced Environment Canada to drop this idea at the federal level (Vandermolen 1997).

CONCLUSIONS AND RECOMMENDATIONS

Policy-makers have very few unequivocal facts in which to guide their decisions in the chlorine debate. Scientific uncertainty, economic uncertainty, and a complex industry make it almost impossible to make decisive recommendations. Under these conditions, the only alternative for policy-makers is to apply the weight-of-evidence approach in order to reach their conclusions and develop their recommendations.

The IJC contends, and this thesis supports the contention, that the weight-of-evidence points to a serious environmental threat from increasing amounts of bioaccumulative and persistent toxins found in humans and animals throughout the globe. To address this threat, the IJC has recommended that the industrial use of chlorine be eliminated—a recommendation that is unprecedented in its scope.

The producers of chlorine and chlorine-based feedstocks strongly dispute both the IJC's characterization of the threat and the IJC's approach to solving the problem. Because of different value-frameworks, as well as economic and scientific uncertainties, it is highly unlikely that consensus can ever be achieved among those opposing or supporting the IJC's position. Breaking the impasse will require: (1) new, and compelling evidence which clearly demonstrates the threat of toxic chemicals, or (2) a clear and firm government commitment to eliminate chlorine as an industrial feedstock.

Because it may take many years to achieve compelling evidence and scientific certainty, a new approach is needed in order to move the transition process forward and to avoid potentially disastrous impacts on human health. The consequences of inaction are huge in comparison to the cost of moving to a chlorine-free economy.

The approach recommended by this thesis advocates less emphasis on comprehensive, multi-stakeholder planning and more emphasis on the market based instruments to transition to a chlorine-free economy. Multi-stakeholder planning would be limited to: (1) establishing broad transition guidelines by major chlorine-based product groups, (2) determining realistic transition time-frames, and (3) developing appropriate market incentives to drive the transition process. To the greatest degree possible, the market would handle the transition process with minimal government interference. A fundamental requirement of this new approach is that government must demonstrate its resolve and commitment to eliminating chlorine as an industrial feedstock.

It is important to summarize and put into context the arguments put forward by industry to oppose the elimination of chlorine as an industrial feedstock.

Industry often points to the lack of compelling scientific evidence as a reason to avoid action. However, as pointed out earlier, the weight-of-evidence approach is the only pragmatic way of dealing with the scientific uncertainty that exists in this debate. The threats are simply too great to wait for conclusive proof. And after many years of evaluation and a great deal of input from scientists, the weight-of-evidence suggests that there is a significant threat to human health and the environment.

Industry also claims that huge costs and a lack of alternatives make a transition to a chlorine-fee economy impossible. However, based on the examination of PVC and perc in this thesis, these claims are highly exaggerated.

Industry's real objection to change is based on a desire to protect existing investments in chlorine-based technology. Because chlorine-free alternatives can be supplied by other industries, companies with significant investments in chlorine-based technology may find it difficult to transition to chlorine-free alternatives and maintain their existing levels of business.

However, industry's resistance to change and its desire to protect existing investments needs to be put into context. The fact is that competitive industries are characterized by constant restructuring and evolution due to change-drivers such as emerging technology, competition, and new customer requirements. The most successful companies in any competitive industry are those that can anticipate change and adapt early.

Examples of industry leaders who are repositioning their companies due to environmental change-drivers include Monsanto and British Petroleum PLC (BP). Robert Shapiro, CEO of Monsanto, has recognized that modern agriculture is unsustainable and is shifting Monsanto's product base to biotechnology, which he considers to be a sustainable alternative to agricultural chemicals (Magretta 1997). Although the view that biotechnology is a sustainable alternative to chemicals is far from being a universally accepted, the point is that large companies like Monsanto can, and do, implement major changes in their business strategies.

In his strategic move to biotechnology, Monsanto's Shapiro is applying Theodore Levitt's classic business strategy. Levitt pointed out that the reason most companies eventually decline is because they focus on product rather than on application. Eventually, almost all products become obsolete but the underlying customer need or application tends to persist. In other words, the need for productive agriculture—an application—will persist long after products such as agricultural chemicals are replaced by products such as biotechnology.

Monsanto's moves into biotechnology have not gone unnoticed by other major industry players. E. I. Du Pont de Nemours & Co. (Du Pont) recently agreed to buy a 20 percent stake in Pioneer Hi-Bred International Inc. for $1.7 billion (*The Globe and Mail* [Toronto], 8 August 1997). These strategic initiatives by Monsanto and Du Pont may signal a major shift away from chemical based agriculture.

Another example of an industry change leader is John Browne, group chief executive of BP. In May 1997, during a speech at Stanford University, Browne pointed out that the time to act on global warming is not when the effects are creating havoc but when the weight-of-evidence demonstrates that that we are heading in the wrong direction. Unlike the rest of the energy industry, Browne has openly joined the public debate. He has also demonstrated a commitment to alternative approaches by directing BP investments toward the development of renewable energy sources (Kendall 1997). BP recently invested $20 million to develop a solar cell manufacturing plant in the U.S. (*Herald Tribune* [Chicago], 27 August 1997). Browne is taking a long-term view by anticipating change and responding to major trends in his industry. Responding early will increase BP's chances of achieving a leadership position in future energy markets.

It has been shown time and again that successful companies respond to change drivers early (Porter 1985). Some of the most successful companies in the world such as IBM, Hewlett-Packard, Procter & Gamble, Johnson & Johnson, United Technologies, Harris, and Corning continually challenge the status quo in their organizations in order to maintain their leadership positions in their respective industries (Foster 1986).

To summarize, change is business-as-usual in all competitive industries. Industry players who claim that nothing can be done because of high costs, industry complexity, economic necessity, etc. are disregarding the continual evolution of markets and industries that occurs in all open economies.

The main issue in a transition is the time-frame. Government and society have a responsibility to establish a time-frame that is long enough for negatively impacted companies to achieve a return on their investment and to build new business strategies. In competitive industries, where change is a constant, this degree of certainty is a rarity.

As for the supply of chlorine-free products, the market will determine the most cost-effective alternatives. To the greatest degree possible, market-based incentives such as green taxes should be applied in order to drive change and encourage investment decisions. This will reduce the transition costs because the innumerable details of the transition will be in the hands of individuals and organizations who are most capable of making cost-effective decisions.

The major steps in this new approach are summarized as follows:

- The Canadian and U.S. governments need to demonstrate their support of the IJC's recommendation to eliminate the industrial use of chlorine. This commitment is required in order to:
  - Shift the debate from discussion to action.
  - Create a stable, long-term business environment that will motivate companies to pursue initiatives which will build a chlorine-free economy.

- In consultation with industry, the IJC needs to establish broad product groups in which to set guidelines and transition timetables. Examples of these product groups include PVC Pipe and Fittings, Dry Cleaning Solvents, Industrial Solvents, Water Purification, etc.

- In consultation with industry, the IJC needs to determine the appropriate time-frames to eliminate these products and transition to chlorine-free alternatives. The time frames need:
  - To provide enough time for companies to achieve a reasonable return on their chlorine-based assets. A reasonable return could be determined by examining the industry's current return on assets. The time period would have to be determined with industry input. For example, a large manufacturing plant producing PVC might require twenty years of operation to achieve an adequate return. The operating life of a perc-based laundry system might be five to ten years. If required, government could shorten these time frames substantially by implementing special capital cost allowances for chlorine-based assets. In this way, companies could achieve a faster return on these assets through tax savings.
  - To provide enough time for chlorine-based companies to restructure their business plans for a chlorine-free economy.
  - To provide enough time for companies with alternative products to build capacity and ensure a smooth transition.

Interim regulatory measures should be implemented to address the most serious sources of toxins such as hospital and municipal incinerators.

- In consultation with industry, the IJC needs to establish market-based approaches which will accelerate the transition process. The objective is to set up the conditions that will allow industry to manage the transition process with minimal interference from government. It should be noted that market-based incentives such as green taxes may not apply in every product area. For example, a phased-in ban may be a more effective for perc. A comprehensive planning process may be more effective for water treatment applications governments control most of the existing treatment plants. However, the goal is to minimize government involvement by using market-based approaches wherever possible.

- The IJC and government would monitor the transition and take any necessary action to redirect the process if the goals are not being achieved.

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