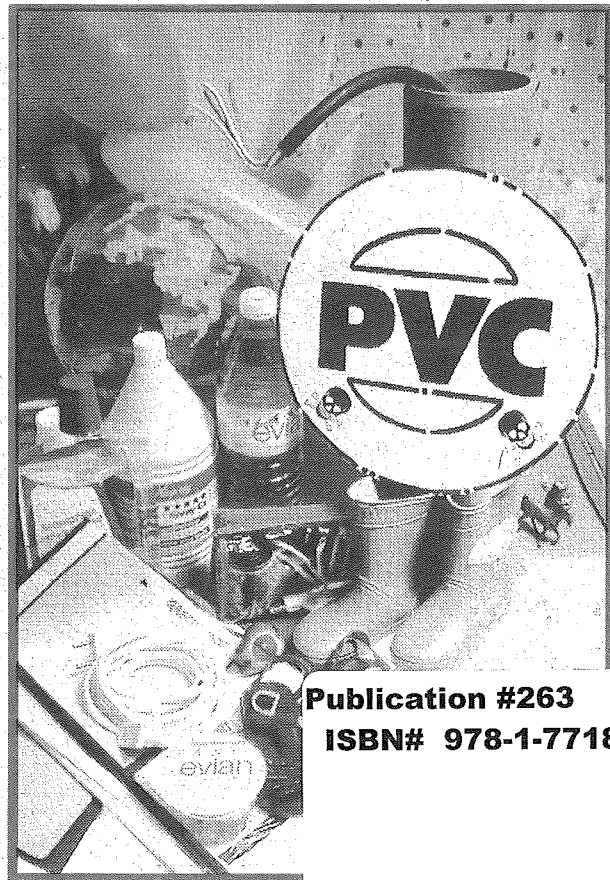


# Planning for the Sunset

## A Case Study for Eliminating Dioxins By Phasing Out PVC Plastics



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prepared by the  
**Clean Production Task Force**  
 of  
**Great Lakes United**



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## **Introduction**

First, the International Joint Commission (IJC) warned of injury to human health and to the environment caused by persistent toxic pollution. In so doing, the IJC identified a serious problem that demanded action.

Next, the IJC proposed a remedy: Sunsetting, a public policy to phase-out the sources of persistent toxic pollutants (substances, processes or feedstocks) by a date certain. In so doing, the IJC identified the appropriate goal or end point for societal action.

Now the IJC has begun an exploration of strategies and mechanisms society can use to rationally implement a sunset policy. After identifying a problem and *what* society must do, the IJC has now begun a discussion of *how* to do it.

A Working Group of the IJC has proposed to begin the discussion of *how* around the concept of "Transition Planning." This term has been introduced as the name for toxic chemical sunsets in ways that minimize costs and social disruptions, and that maximize the environmental and social benefits and opportunities.

## **About this Report**

This report was prepared by a consortium of environmental groups in reply to a call for papers by the Science Advisory Board's Parties Implementation Working Group of the International Joint Commission. The assigned topic was an exploration of the concept of Transition Planning as it might be applied to sunsetting environmental sources of dioxins and furans.

Writing of this report was coordinated by Great Lakes United with contributors from Greenpeace, the Canadian Environmental Law Association, the Ecology Center of Ann Arbor, the Midwest Center for Labor Research, and Indiana University, Northwest. Participants worked to integrate their views and perspectives. The thoughts expressed in this report, however, are the result of discussions by a broad array of groups and individuals

from a multitude of disciplines interested in the Transition Planning concept.

### Executive Summary

The overall thrust of this report is fairly simple and can be summarized as follows:

- (a) Transition Planning can be defined as a planning process to shape and guide implementation of sunset policy whose target, completion date and interim performance goals have already been mandated. While Transition Planning need not be used in all instances where the phase-out of a substance, process or feedstock is mandated, it is an important tool to facilitate an equitable and orderly transition to cleaner production processes.
- (b) In examining dioxin elimination as a case study for Transition Planning, it makes sense to narrow the field of inquiry since dioxin pollution results from numerous different products and processes. PVC plastic was chosen as the focus of this case study to provide an opportunity to focus on a feedstock and also to focus on what is probably the single largest and fastest-growing dioxin source. Studying a phase-out of PVC also highlights many of the transition issues that must be addressed in the phase-out of any substance, process or feedstock.
- (c) Various mechanisms can facilitate transition to cleaner processes. Each must be assessed in light of the circumstances of particular applications of the sunset policy. For PVC, the most appropriate mechanism, possibly in addition to other mechanisms, is the imposition of a generators tax on PVC feedstock.
- (d) While this report focuses on PVC, the approach outlined here can inform the Transition Planning concept for many other substances, processes and feedstocks.
- (e) Previous IJC recommendations to sunset sources of dioxins and furans and to sunset chlorine-containing industrial feedstocks should be made more explicit by naming specific products, processes and/or feedstocks. In particular, we urge the IJC to recommend that the Parties mandate a sunset date for production of the basic feedstocks for PVC plastics: ethylene dichloride and vinyl chloride monomer.
- (f) During the next biennial cycle, the IJC should establish a roundtable to further explore and elaborate on Transition Planning, using the contents of this report as a starting point. For the purpose of the roundtable discussion, the PVC phase-out mandate should be accepted as a given and participants should be asked how to structure and direct a Transition Planning process that could most effectively and rationally achieve that mandate.

This paper is divided into three parts. Part I provides an overview of the concept of Transition Planning, especially its relation to the Great Lakes Water Quality Agreement and recommendations made by the International Joint Commission. Part I provides a definition, a brief rationale, and some examples of the application in other contexts of the transition planning concept.

Part II outlines the nature of dioxin and why the sunsetting of PVC is an excellent case study for the elimination of dioxin sources.

Part III provides a profile of the PVC production industry, its current uses, alternatives and identifies worker constituencies and communities that would be affected by a phase-out. This Part also outlines mechanisms for sunsetting PVC and facilitating a transition out of PVC production. The report's recommended transition mechanism is a generator's tax used to create a fund for assisting workers and communities manage the economic and social disruption of the phase-out.

## PART I - TRANSITION PLANNING: THE CONCEPT

### 1. The Policy Context for Transition Planning

The starting point for this discussion of "Transition Planning" is the Great Lakes Water Quality Agreement and the subsequent recommendations and activities of the International Joint Commission and its advisory bodies.

#### 1.1. The Great Lakes Water Quality Agreement and the Goal of Zero Discharge

Persistent toxic substances have been a source of concern in the Great Lakes basin for over three decades. This problem was formally recognized in the 1978 Great Lakes Water Quality Agreement. The goals and objectives of the Agreement are instructive. The overall purpose of the Agreement, as articulated in Article II, is to "restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem."

To further this purpose, Article II then states that, "the discharge of any or all persistent toxic substances be virtually eliminated."

The GLWQA's goal of virtual elimination has been the source of considerable debate. The Agreement, however, does give some guidance on its interpretation and implementation. Annex 12, entitled "Persistent Toxic Substances," states that the "philosophy adopted for control of inputs of persistent toxic substances shall be zero discharge."

The Agreement makes it clear that the drafters intended to take the most dramatic route possible to address persistent toxic substances. The goal is to "virtually eliminate" their discharge and that regulatory programs would be designed to achieve zero discharge of those substances.

While the Agreement provides the framework for dealing with persistent toxic chemicals, the International Joint Commission, in successive Biennial Reports to the governments of Canada and the U.S., has expanded and added substance to the framework. The rationale for the zero

discharge goal is presented in the Commission's Fifth Biennial Report:

- (a) All persistent toxic substances are ultimately harmful to the integrity of the environment, both in the Great Lakes region and globally, and should not be allowed to enter the environment.
- (b) Persistent toxic substances find their way into environment in many ways, through production, residuals discharge, use and destruction.
- (c) The technology either exists -- or can, with very few exceptions, be developed at some cost -- to replace (or control in the interim) the use of persistent toxic substances.
- (d) Sufficient information is known for society to take a very restrictive approach to allowing persistent toxic substances in the ecosystem and to declare such materials too risky to the biosphere and humans to permit their release in any quantity. They result in implications far beyond conventional measures of long-term net economic costs referred to in premise (c).

The goal of virtual elimination is further elaborated in the Commission's introduction of the concept of sunset chemicals.

#### 1.2. The Concept of Sunset Chemicals

In its Sixth Biennial report, the IJC identified sunseting as necessary to achieve zero discharge. According to the Commission, sunseting is

"...a comprehensive process to restrict, phase-out and eventually ban the manufacture, generation, use, transport, storage, discharge and disposal of a persistent toxic substance. Sunseting may require consideration of the manufacturing processes and products associated with a chemical's production and use, as well as of the chemical itself, and realistic yet finite time frames to achieve the virtual elimination of the persistent toxic substance.

Effective sunseting also requires a cooperative approach whereby the traditional regulatory approach is blended with consultation and dialogue among all stakeholders, using a range of mechanisms and partnerships."

The concept of sunseting chemicals is not new. As a theoretical construct, sunseting has

been through a number of previous formulations. But the core meaning of sunseting is that elimination of the use, generation and discharge of substances, processes or feedstocks within a defined time period. The IJC has recommended the sunseting of specific substances. For example, in its Sixth Biennial report to the governments, the IJC recommended that the "Parties sunset DDT, dieldrin, toxaphene, mirex and hexachlorobenzene" The IJC has also recommended the phase-out of feedstock chemicals, particularly chlorine. Recommendation no. 7 of the Sixth Biennial Report states that:

"the Parties, in consultation with industry and other affected interests, develop timetables to sunset the use of chlorine and chlorine-containing compounds as industrial feedstocks and that the means of reducing or eliminating other uses be examined."

This recommendation was affirmed in the IJC's Seventh Biennial Report to the governments.

The IJC also recognized the rationale, need and appropriateness of Transition Planning mechanisms in the context of sunseting chemicals. The IJC made a number of important recommendations in its Seventh Biennial Report:

"All interests must also work together within a common framework and a clearer understanding of their collective and individual roles in the ecosystem. Their efforts should be based primarily on a preventive and environmentally conservative approach which recognizes economic, environmental and social goals as being compatible rather than inconsistent. A consensus-building approach is essential which addresses the concerns of labour, industry, municipalities and other interests to ensure an orderly transition to an economy without persistent toxic substances.

19. Labour unions include in their negotiations the issue of transition to a sustainable economy without persistent toxic substances.

20. Governments, industry and labour begin devising plans to cope with economic and social dislocation that may occur as a result of sunseting persistent toxic substances."

The IJC, however, has not yet elaborated on the context, definitions of the terms, and implications of the recommendations.

## 2. Transition Planning and Virtual Elimination

Environmentalists first proposed that Transition Planning be incorporated into proposals to sunset sources of persistent toxic pollutants as a reaction to a report by a consultant for the chlorine-chemistry industry. That report, "Assessment of the Economic Benefits of Chlor-Alkali Chemicals to the United States and Canadian Economies" (Charles River Associates Incorporated, April 1993), concluded that implementation of the IJC's chlorine recommendation would cost the U.S. and Canadian economies an annual US\$102 billion, would affect 1.4 million jobs, and would severely disrupt local and regional economies.

A critiques of the Charles River study, "Transition Planning for the Chlorine Phase-Out: Economic Benefits, Costs, and Opportunities" (Greenpeace, October 1993), concluded that the chemical industry consultant's results were "based upon invalid assumptions that drastically overestimate the costs and underestimate the benefits of a well-planned transition." The Greenpeace critique continued:

"The industry's calculations are based upon a methodology that assumes the chlorine phase-out will be implemented instantaneously, without thought, planning, or prioritization. The industry assumes that the alternatives that will replace chlorine will be processes that perform poorly, are unreasonably expensive, or are not the cost-effective substitutes the market would select...

... [T]he industry's scenario looks only at costs and burdens and fails to explore the benefits and savings associated with the transition to a chlorine-free economy....

... Implemented with careful planning, the transition to a chlorine-free economy can be economically beneficial and socially just. It can save money and create new jobs."

Environmentalists do not deny that implementation of the IJC's sunset chemicals strategy will have economic impacts on society as a whole. We also understand that these impacts may affect different groups in society in different ways. There will be winners and there will be losers. It would be arrogant to claim the ability to fully predict or understand all economic consequences that would flow from implementation of a decision to phase-out even a single major industrial chemical or feedstock. Continued inaction, however, poses an even greater threat to the health and well-being of this and future generations.

Projections of the economic consequences that flow from the implementation of a chemicals sunset policy vary wildly for several reasons. One obvious reason is the logic of debate: proponents and opponents each are attracted to analysts who make projections that bolster their argument. Each side counts different things; each ignores different things. Sunset opponents, however, go beyond differences in emphasis - they almost always assume a worst-case scenario. They assume that the implementation of sunset will be bureaucratic and irrational.

Environmentalists agree that the actual economic consequences of IJC's chemical sunset policy will be determined in large measure by the detailed and practical decisions that govern how the policy will actually be implemented. Those decisions will shape the character of the economic consequences and also, their magnitude and distribution in society. The call for this paper was made, we believe, to address this very concern.

Transition Planning begins only when the debate in society over policies to eliminate persistent toxic pollution shifts from "if" to "how." So long as we continue to debate "if," opponents have little motivation to cooperate or to openly and honestly share expertise, insights and real concerns. Once the debate actually becomes "how," that is, once it has become clear that a policy that will achieve virtual elimination is certain to be implemented, then all parties are motivated to constructively participate and cooperate in working out its details.

### **2.1. Definition and Concept of Transition Planning**

Transition Planning should be defined as a planning process to establish, review and refine implementation mechanisms for a given sunset policy. The guiding principle is to establish mechanisms that will achieve the sunset policy by a given completion date in ways that: minimize associated costs and dislocations; maximize associated benefits and opportunities; ensure associated costs and benefits are equitably distributed; and prevent, minimize or ameliorate dislocations.

Transition Planning should be initiated as soon as society makes the decision to implement a

sunsetting policy. Any given Transition Planning exercise should be organized around a very specific mandate. The mandate should be clearly defined as a decision to phase-out: (1) an individual chemical substance or product; (2) a well-defined class of chemical substances or products; (3) an individual or a class of industrial processes; (4) an individual application; or (5) a well-defined class of applications. The mandate should include a final sunset date that establishes when the phase-out must be completed. The mandate should also include interim performance goals, and timeliness and criteria for achieving them.

Transition Planning can then be defined as a planning process to shape and guide implementation of sunset policy whose target, completion date and interim performance goals has already been mandated.

The Transition Planning process will consider a range of mechanisms that, taken together, can achieve full implementation of the mandate on or before the sunset date. These mechanisms can include legally binding prohibitions or bans; economic incentives; market mechanisms; technical assistance; and/or voluntary action. The Transition Planning process will consider possible economic or social hardships that may result from the transition and will be instructed to establish mechanisms whose purpose is to offset or ameliorate them. Such mechanisms include:

- Proposals that encourage businesses and workers who now produce or otherwise depend upon substances targeted for sunset to also produce or use the substances' replacements or alternatives, with a goal of no net job loss.
- Incentives to offer workers facing job loss associated with the transition the opportunity for comparable jobs at the same facility, or in the same community where the job loss occurs.
- Incentives for alternative economic development in communities that would be economically harmed by the transition.
- Various forms of transitional assistance to workers, communities, companies or others affected by the transition who need it.

More generally, the Transition Planning process must include a mission statement instructing

the planners to define programs, policies and mechanisms that will implement the mandate as quickly as is practical in a way that:

- Minimizes all associated costs and dislocations;
- Maximizes all associated benefits and opportunities;
- Ensures all associated costs and benefits are equitably distributed; and
- Prevents, minimizes or ameliorates dislocations or other negative impacts on effected workers, communities, or corporations.

## 2.2. Transition Planning Process

Transition Planning is a process to determine how to achieve the sunset date, not if it should be achieved. As a general rule, phase-out regimes for substances, processes and feedstocks should include a Transition Planning process, although there can be exceptions, such as where the phase-out is such that a transition plan is neither needed nor desired.

Transition plans cannot be made generically. While they may have common elements and even a common framework, each transition plan must be customized to address the substance, process or feedstock targeted for sunset. There is a whole menu of transition mechanisms and decisions that must be made to determine which mechanism is the best suited for the circumstances at hand.

The Transition Planning process should be guided by a board, panel or commission that includes representatives of the various stakeholders, and also representatives of society at large. It should have an independent chair (or co-chairs) who believes in the Transition Planning mandate and mission and whose primary responsibility is making certain that the mandate and mission are accomplished. Consensus should be sought, but where it cannot be achieved, the chair(s) should make final decisions and approve final reports or findings. The planning process should have qualified staff and access to technical support.

Participation in the Transition Planning process should include representatives of various

stakeholders. Even stakeholders who do not support the mandate, or who actively oppose it, should be invited to participate. That participation, however, should be conditioned on the representatives' willingness to: temporarily suspend lack of support or disagreement while participating; constructively engage in the planning process; and contribute their own unique insights and expertise.

It should be understood that a stakeholder's participation does not constitute endorsement of either the Transition Planning process mandate or its reports, findings and conclusions. It should also be understood that the process will be organized in a way that prevents any stakeholder who does not support the mandate from attempting to obstruct or delay implementation or from attempting to transform the Transition Planning process into a platform for opposing or discrediting the mandate itself.

Transition Planning can utilize various mechanisms. One important mechanism is a generator tax. The tax would be imposed at some point in the production process (at the feedstock stage or the end product, whichever is more efficient). The revenues from the tax would be used to create a Transition Fund that could then be used for various purposes including transition assistance to dislocated workers or others. If a Transition Fund is created through a generator's tax, the Transition Planning process will help direct how those funds are to be used.

Many other mechanisms for transition can be used. These could include a Job/ Facility Freeze: an agreement among the stakeholders that, despite the phase-out target, there will be no net loss of job to workers and no facility dislocation. This mechanism may come about for a number of reasons ranging from the fact that there may be some real benefit to the phase-out to a government assistance program that would assist the industry through the transition phase.

Another option is to have the affected industry simply finance the transition. For instance, the industry may pay the dislocated worker monies to be retrained for another job without the need to impose a new tax. In many cases, however, the transition raises serious concerns and problems and will require more extensive planning mechanisms.



Transition planners will often need to survey the availability of cleaner alternatives and the obstacles that may be associated with their rapid introduction. They will need to identify which alternatives are most promising and which should be avoided based on criteria that include performance, ecological impact and economic cost. The Transition Planning process may also sponsor research and technology transfer programs to help develop alternatives and bring them to market.

### **2.3. Guiding Principles**

While a range of different transition mechanisms could be used to achieve the same mandated sunset target, the choice will strongly impact costs and benefits associated with the transition and also the distribution of potential winners and losers. As stated above, the mission is to maximize the benefits and minimize the costs to society as a whole while seeking equity for all impacted interests. The following principles can help guide the transition in ways consistent with this mission.

#### **2.3.1. Enforceable Conclusions**

The Transition Planning process must be constructed so that it is accountable to the parties and so that its decisions and conclusions are enforceable. In short, the transition plans have to be real.

#### **2.3.2. Participation**

Affected constituencies must have a fair and equal opportunity to influence the development and implementation of the transition plan. This means a stakeholder process that includes the industry, workers, and community leaders as well as environmental and public health advocates and representatives of the public at large.

#### **2.3.3. Open process**

The various stakeholder groups participating in a Transition Planning process will not necessarily be homogeneous but may contain within themselves conflicting interests or concerns: corporations compete with one another; often different communities and workers from different facilities have some conflicting interests. The Transition Planning process should not be in the business of picking individual winners or losers; participation by a

representative of a particular corporation, union or community should not convey a competitive advantage.

For this reason Transition Planning must be an open process. Expert reports, deliberations and working papers must be broadly available to the interested public. There must be ample opportunity for any interested party to submit comments.

#### **2.3.4. Predictability and Stability**

It can be difficult for corporations to make intelligent, long-term investment planning decisions if they cannot predict what rules will govern the future. When there is conflict and tension in society over toxic chemicals policy, unpredictability and uncertainty grows. The Transition Planning process should be guided by what might be called the Principle of Predictability and Stability. In considering proposals to sunset sources of persistent toxic pollution, active preference should be given to arrangements and policies that will encourage the creation of a long-term, stable, predictable planning horizon for industry and other impacted stakeholders.

#### **2.3.5. Parsimony**

The Transition Planning process should guide its deliberations by what might be called the Principle of Parsimony. When there is more than one competing proposal to achieve a given outcome, Transition planners should actively prefer the one that:

- is simplest, most transparent, and whose consequences are easiest to understand;
- can achieve the desired result with the least intrusive government involvement and the smallest permanent regulatory or enforcement apparatus;
- best harnesses the creative energy of market forces to achieve the desired end; and
- most importantly, will actually work.

#### **2.3.6. Reward Active Cooperation**

While there have been many "good news" stories that illustrate how pro-environment corporate policies enhance profitability, virtue is not always rewarded. Often, a company can

be punished by the steep learning curve and risks associated with innovation while its competitors can wait, and then, if necessary, make a similar change later at much lower cost and without loss in market share. Active preference should be given to policies that provide incentives and rewards to companies who are willing to invest in innovation. Incentives should also be structured to encourage companies to cooperate and to quickly implement practices that advance the mandate and mission of the Transition Planning process. Negative incentives should be imposed on companies who resist or delay implementation.

### 3. Previous Experiences with Transition Planning

North American societies do not have long and varied experience with Transition Planning. Nevertheless, there have been a number of examples which fit wholly or partially within the concept. Each advance of industrial society has increased the instances of such planning compared to earlier, simpler times.

Most previous examples of planning for, and making provisions for, wrenching transitions have taken the form of ameliorating the negative consequences for an impacted sector or class of the population. In these instances, public policy aims to offset an undesired consequence of change. This "offset" role can be contrasted with a "bystander" role, where public policy ignores the issue, or a "player" role, where public entities directly involve themselves in the activity out of which the issue arose.

While there are literally hundreds of examples of offset interventions available, here we will cite only two of recent vintage. Both examples concern the United States, although Canada has many easily identifiable similar examples. The two examples we choose are, respectively, a "business offset" measure and a "labor offset" measure.

When the Chrysler Corporation faced bankruptcy in 1979, the company turned to the United States government for assistance. With federal guarantees, Chrysler received \$1.5 billion in credits which allowed the company to extricate itself from its financial difficulties and restructure for a more secure future. Although the Chrysler bailout was unusual in terms of size and impact, it is illustrative of a process which is routinely employed in financial sectors such as banking where the sector is felt to be vital to the overall health of the economy.

In contrast to this business offset measure, a labor offset measure is illustrated by passage of two U.S. laws in 1988, the Worker Adjustment and Retraining Notification (WARN) Act and the Economic Dislocation Worker Adjustment Act (EDWAA). WARN requires businesses of a certain size to notify employees 60 days prior to closing or large scale layoff at a worksite. EDWAA provides for state and local government Dislocated Worker Units which engage "rapid response" teams in efforts to avert closure and/or provide training and referral services to dislocated workers.

In these two cases and in numerous others, government responds to pressure from a sectorial, corporate, or class constituency which pressures it to aid in transition activities to adjust to (or alter) trends negatively impacting on the constituency. The normal pattern that emerges, depending on the strength of the organized constituency, is offset measures which are targeted toward that particular constituency in transition. Two limitations on this type of Transition Planning are (1) it concerns only ameliorative measures, not the broader transition as a whole; and (2) it is confined to impacts on a particular sector, class, entity, etc.

Compare this to the role of the United States government in transitional planning for conversion to, and maintenance of, a wartime economy during World War II. The U.S. government set up a wide variety of commissions, boards, and offices (with initials like NDAC, NDMB, NWLB, OES, OPA, OPM, and OWM) which planned and oversaw public policy regarding mobilization, dispute resolution, wage and price levels, capacity utilization, and the like as the economy moved to a wartime footing.

Several differences from previous offset measures are immediately apparent. First, the planning process and the activities undertaken were not initiated at the request of one of the participants in the economy. Second, the planning and implementation measures were not limited to offsetting negative impacts to a particular sectoral or class interest, but rather extended to regulation of all major aspects of the overall transition. Third, the reason for the planning was a major external threat to the society and economy as a whole, not internal pressures growing out of the normal functioning of the economy.

Although we are not concerned with governmental intervention into the economy on anything approaching the scale of World War II intervention, any Transition Planning for elimination of persistent toxic substances share important features with the World War II precedent. In this case, none of the major economic actors involved in production of such substances has an immediate or obvious economic incentive to push forward a transition. To the contrary, all incentives are to oppose a transition and to maintain the status quo. And again, it is an external threat to society as a whole -- irremediable contamination and threats to health and life -- which makes the transition necessary, just as it was in World War II. And similar to World War II, planning must go beyond mere amelioration to one negatively affected

segment of interested parties.

One consequence of these similarities to wartime experiences is the lack of any one particular "interest group" in the production process to mobilize political pressure on governments to act on the problem. Instead, governments must act upon the general interest against the external threat, and must regulate the transition in a manner that is as fair and participatory as possible to directly involved stakeholders. Reliance on the economic self-interest of those most directly involved in persistent toxic substance creation to drive the process would mean failure to address the problem in a timely fashion.

## PART II - A CASE STUDY OF DIOXINS

### 4. Dioxin: A Priority for Virtual Elimination

The IJC Science Advisory Board's Parties' Implementation Workgroup requested discussions of the role of Transition Planning in strategies for the virtual elimination of persistent toxic substances, using dioxin as a case study.

The term "*dioxin*" has long been used as shorthand for a single substance, 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), and for the group of all polychlorinated dibenzo-p-dioxins (PCDDs). More recently, the term has been used to refer to the much larger group of all compounds similar to 2,3,7,8-TCDD in chemical structure and biological effects. As defined by the U.S. Environmental Protection Agency (EPA), this group of dioxin-like chemicals includes all PCDDs and polychlorinated dibenzofurans (PCDFs) with chlorines or bromines substituted in the 2,3,7, and 8 positions, along with a number of polychlorinated biphenyls (PCBs). All these compounds cause a similar spectrum of health effects via a common mechanism, which begins with binding to a common intracellular receptor [EPA 1994a]. A large number of other halogenated, co-planar polynuclear aromatic hydrocarbons also produce dioxin-like toxicity and should also be included in this group, including some polychlorinated biphenylenes, naphthalenes, and dibenzothiophenes. In this report, we use "dioxin" or "dioxins" in this latter, more inclusive sense of all dioxin-like compounds that produce dioxin-like toxicity.

2,3,7,8-TCDD, 2,3,7,8-TCDF, and PCBs are all present on the IJC's list of 11 "Critical Track" pollutants. As early as 1985, substances on this short list were designated priorities for regulatory action, because they were all "known to be persistent and highly toxic, and known to be present in the Great Lakes ecosystem at levels of concern" [GLWQB 1989]. Moreover, these compounds were "recognized threats to human health and the aquatic ecosystem" [GLWQB 1987]. Under the terms of the Great Lakes Water Quality Agreement, the Commission has recognized that discharges of all persistent toxic substances must be brought to zero. The IJC called for particularly speedy action to virtually eliminate these 11 critical pollutants [IJC 1989, IJC 1991, IJC 1993].

Two aspects of the environmental behavior of dioxin make it a particular hazard. First, dioxin-like compounds are highly persistent. According to EPA, there are no effective means of degrading dioxin in the environment or in the bodies of organisms [EPA 1994a]. As a result, dioxin builds up over time, reaching its highest levels in two primary sinks: aquatic sediments and the food chain. Because of this persistence, dioxin has accumulated in the environment and is now distributed on a truly global basis. For instance, dioxin can now be detected in the environment and in living tissues even in the most remote regions of the planet, such as the Arctic Circle, thousands of miles from any dioxin source.

Second, dioxins are extremely bioaccumulative. Highly soluble in fats but insoluble in water, dioxin is powerfully attracted to the fatty tissues of living organisms, multiplying in concentration as it moves up the food chain. In the Great Lakes and elsewhere, dioxin concentrations in upper trophic species are typically millions of times greater than concentrations in the ambient environment.

Since the IJC first recommended that 2,3,7,8-TCDD and TCDF be treated as critical track pollutants, emerging scientific evidence has strengthened the case for immediate action to bring to zero all discharges of dioxin-like compounds. Information developed under the auspices of the U.S. Environmental Protection Agency's (EPA) multi-year *Dioxin Reassessment* [EPA 1994a] indicates that dioxin accumulation poses an even greater threat to health than previously recognized. Among the major findings:

- Dioxin acts as a powerful environmental hormone. Much like a natural steroid hormone, dioxin crosses cell membranes, binds to an intracellular receptor, and is then transported to the nucleus, where the receptor-dioxin complex interacts with DNA, turning on genes whose products control a wide range of biological functions. Unlike a natural hormone, however, dioxin resists degradation within the body and has an extraordinarily high affinity for its receptor. Tiny doses of these "false signals" can thus have powerful effects on physiological functions regulated by endocrine mechanisms, including reproduction, development, and the immune system.
- The "background" exposures and body burdens to which the general human population in the U.S. is now subject are already in the range at which metabolic, reproductive, developmental, and immunological effects are known to occur in laboratory animals. "Background" exposures for the Canadian population is in the same range.

- Human sensitivity to dioxin does not appear to be substantially different from that of other species. A growing body of epidemiological data supports the inference that humans are at risk for a broad spectrum of dioxin-related effects.
- There is no evidence of a safe or "threshold" dose of dioxin below which no health effects occur. The available data indicate a linear or supralinear dose-response relationship for those biochemical effects that have been investigated. In any case, EPA concludes that the threshold issue is "moot," considering our already excessive exposures to these compounds.
- Additional evidence clearly indicate that dioxin-like compounds in the environment are causing large-scale effects on wildlife populations, both in the Great Lakes and elsewhere. The most severe effects appear to be endocrine-mediated impairment of development, reproduction, and neurological and immune function [Reinjders 1992, Fox 1992, SAB 1989, SAB 1991, SAB 1993].

This body of information indicates that dioxin contamination poses a long-term, large-scale hazard to the health of humans and other species. There is good reason to believe that dioxin may already be contributing to society-wide incidence of cancer, infertility, impaired development, and other conditions. There is no question, however, that the health of the human population is at risk, and any increase in exposure will increase that risk and/or the severity and number of persons affected. This picture provides a compelling case for immediate action to virtually eliminate all further generation and discharge of dioxin.

## 5. Applying the Sunsetting Strategy to Dioxin

As the IJC has made clear, only "front-end" solutions are an effective means of achieving virtual elimination of persistent toxic substances. Pollution control technologies can never achieve this goal, for these devices merely move chemicals from one place or environmental medium to another after they are created, and release to the environment will take place eventually. In contrast, pollution prevention strategies avoid the generation of persistent toxic substances in the first place by changing production processes, substituting feedstocks, or reformulating products. These approaches, the cornerstone of a virtual elimination strategy, involve the timed phase-down, or sunsetting, of the production and use of persistent toxic substances.

Historical data clearly support the effectiveness of sunsetting strategies. Vast investments in pollution control equipment have not yielded significant reductions in discharges or environmental levels of any major pollutants [Commoner 1990]. In contrast, all the major success stories of the environmental effort have involved bans and phase-outs of specific toxic substances. For instance, discharges of DDT and other restricted chlorinated pesticides, CFCs, PCBs, and lead have all been drastically reduced -- and environmental concentrations have begun to decline -- following restrictions on the production and/or use of these chemicals.

All these policies, however, have addressed substances that were deliberately produced for sale. Dioxin is never manufactured on purpose but is the accidental by-product of a host of industrial processes involving chlorine and chlorine-derived chemicals. Formulating a strategy for virtual elimination of dioxin must thus begin with an identification of dioxin sources.

### 5.1. Identifying Dioxin Sources

As part of its reassessment, EPA has compiled a preliminary inventory of dioxin sources in the U.S. [EPA 1994b]. EPA admits that its database is incomplete and that the sources have yet to be identified for a significant portion of the total U.S. dioxin burden. Further, there are a number of known dioxin sources for which EPA did not or could not offer quantitative estimates of annual releases, and others for which EPA's figures may underestimate actual

releases. Nevertheless, EPA's dioxin source inventory is the most complete such effort yet undertaken, and the information it contains provides a starting point from which to begin discussion of a virtual elimination strategy for dioxin.

According to EPA, combustion-related industrial processes account for the majority of dioxin entering the environment from known sources (see table 1). Medical waste incinerators are the largest identified dioxin source sector, followed by municipal waste incinerators, hazardous-waste-burning incinerators and cement kilns, industrial and residential wood-burning facilities, and sewage sludge incinerators. Also important in this category are combustion-based metallurgical processes (including copper, lead, and steel smelters/recyclers), accidental combustion in both structural and forest fires, and combustion of automobile and truck fuels. Minor sources within this category include coal-fired utilities, drum and barrel reclamation, tire incineration, and carbon reactivation furnaces.

EPA also identified a number of important dioxin sources not related to combustion. For instance, pulp and paper mills rank third among all dioxin source sectors. Chemical manufacturing is the other important non-combustion-related dioxin source. Among chemical products contaminated with dioxin, EPA identifies over 100 pesticides, along with a wide range of chlorinated solvents, feedstocks for plastics, and chemical intermediates. This list includes representatives of the full range of chlorinated compounds, from simple aliphatics to complex aromatics. EPA does not provide a quantitative estimate of total dioxin releases associated with the use of chlorine in the chemical industry. Given the huge quantity of organochlorine products manufactured in the U.S. and Canada -- containing some 9 million tonnes of chlorine each year [SRI 1993] -- dioxin contamination in the parts per billion or even parts per trillion range would make the production of organochlorines a dominant dioxin source. Finally, the use of chlorine in metallurgical processes, water disinfection, and the manufacture of some inorganic chemicals is also known to produce dioxin, but in lesser quantities than those sectors discussed above.

A similar national inventory has not been prepared for dioxin sources in Canada. All the major dioxin sources identified in the U.S. by EPA are present in large numbers in Canada. Differences in the patterns of industrial development between the two nations, however, will

have some effect on the relative fraction of dioxin contributed by specific sectors. As of 1990, for instance, pulp mills consumed 11 percent of the chlorine in the U.S. and 34 percent in Canada, while organic chemical manufacturing consumed 52 percent in the U.S. and only 39 percent in Canada [SRI 1993]. In Canada, then, pulp mills are likely to account for a larger fraction and chemical manufacturing for a smaller fraction of total dioxin releases than they do in the U.S. Nevertheless, it is likely that incinerators and other combustion sources, pulp bleaching, and chemical industry sources are the major dioxin sources in both Canada and the U.S.

Industrial sectors responsible for the largest dioxin loadings into the Great Lakes are likely to be the same as the major dioxin sources nationwide. For instance, according to EPA, pulp mills are the largest source of dioxin discharges directly to waterways; these facilities are well-represented along both the U.S. and Canadian shores of the Great Lakes. The majority of dioxin loadings into the Great Lakes come from airborne deposition, and the "airshed" for the Great Lakes includes a vast area covering a large portion of North America. Thus, incinerators and other combustion sources -- in the Great Lakes region and elsewhere in North America -- can be assumed to be the largest contributors to dioxin loadings in the Great Lakes themselves. The "fingerprint" of dioxin congeners in Great Lakes sediments supports this inference [Czuczwa 1986].

One comprehensive attempt to catalogue dioxin sources directly into the Great Lakes confirms the central role of these sources. This study by the Center for the Biology of Natural Systems identified hundreds of dioxin sources in the Great Lakes airshed and used air deposition models to estimate the contribution of each into the Great Lakes [Commoner and Cohen 1995]. Six source sectors were found to account for 91.5 percent of all identified dioxin deposition into the Great Lakes: medical waste incinerators, municipal solid waste incinerators, iron ore sintering plants, hazardous waste incinerators and cement kilns, and secondary copper smelters (see table 1).

**TABLE 1**  
**Major Dioxin Sources and Releases**  
**in the U.S. and the Great Lakes**

| Dioxin source   | U.S. dioxin releases (g/yr TEQ) <sup>1</sup> | Contribution to Great Lakes <sup>2</sup> (%) |
|---|--|--|
| Municipal waste incinerators                          | 2,110 - 10,700                               | 20.1   |
| Hospital waste incinerators                           | 1,600 - 16,000                               | 48.7   |
| Pulp mills  | 256 - 504                                    | ND <sup>3</sup>                              |
| Haz. waste incinerators/<br>cement kilns <sup>4</sup> | 120 - 1,200                                  | 8.0  |
| Wood burning  | 113 - 1,063                                  | 1.9  |
| Secondary copper smelters                             | 74 - 740                                     | 4.2  |
| Chemical manufacturing                                | ?  | ?  |
| Home and building fires                               | ?  | ?  |
| Ferrous metal smelting/refining                       | ?  | 10.6   |
| Vehicle fuel combustion                               | 27 - 274                                     | 1.4  |
| Forest fires  | 27 - 270                                     | ND   |
| Sewage sludge incineration                            | 10 - 52                                      | 0.6  |
| Secondary lead<br>smelting/refining                   | 0.7 - 3.5                                    | ND   |

1. Source: U.S. EPA [1994a]. Sum of releases to all media from each source. Ranked by lower-range estimate.
2. Percent of *identified* airborne dioxin emissions to the Great Lakes, Commoner and Cohen 1995.
3. Commoner and Cohen estimate airborne deposition only. They do not estimate releases from pulping sources.
4. Based on EPA's estimate that dioxin emissions from cement kilns burning hazardous waste are one order of magnitude greater than from kilns burning traditional fuels, EPA 1994b.

## 5.2. Focusing on Feedstocks

Dioxin synthesis requires only three things: a source of chlorine, organic matter, and a thermally or chemically reactive environment in which these materials can combine. In virtually all cases, the chlorine donor is a product or waste of industrial chlorine chemistry.

The field of industrial chlorine chemistry provides a chain of opportunities for dioxin synthesis in which these three elements are present. Dioxin generation begins with the production of chlorine gas in a chlor-alkali plant, where large quantities of electricity are used to transform a salt solution (sodium chloride) into elemental chlorine gas, sodium hydroxide, and hydrogen. Opportunities for dioxin synthesis continue with the use of chlorine in industrial or municipal processes, where the chlorine gas itself creates the reactive environment. Further dioxin generation takes place when organochlorines are used in reactive environments, recycled by combustion, or disposed of by incineration. Once released into the natural or human environment, chlorinated organic chemicals are subject to additional transformation processes that can produce dioxins, including photolysis, forest fires, and building fires. Thus, dioxin generation is associated with the entire field of chlorine chemistry, since it appears to be formed at some point in the life-cycle of virtually all chlor-alkali products and processes (see table 2).

Virtual elimination efforts should focus on this chain of dioxin-producing opportunities created by the chemical industry's dispersal of chlorine donors into the natural and technological environments. When a dioxin source is identified, it should be viewed not in isolation but as the final link in a chain of materials processing that can be traced back to chlor-alkali itself. A discussion of each dioxin-producing sector must include an identification of the chlorine donor or donors that turn an industrial or other process into a dioxin-producing environment.

This framework for thinking about dioxin elimination is closely related to the use-tree approach suggested by the IJC's Virtual Elimination Task Force [VETF 1993]. That approach traced chlorine uses from the chlor-alkali process through all its downstream applications and points of discharge to the environment, evaluating the most effective points of possible intervention to achieve virtual elimination of organochlorine discharges. In this

case, we begin with the facilities that discharge dioxin and work backwards, up the use-tree, to identify the common feedstocks and precursors that cause dioxin formation in each facility. By shifting focus from the point of discharge to an upstream emphasis on the production and use of dioxin-generating materials, a virtual elimination strategy seeks to prevent chlorine donors from entering reactive environments *before* they can turn into dioxin.

Dioxin sources are highly diverse, comprising dozens of industrial sectors, hundreds of specific products, and thousands of individual facilities. Formulating a dioxin elimination strategy may thus seem overwhelming at first. In fact, however, the use-tree approach reveals that many dioxin sources can be tied together by the common chlorine-containing feedstocks they share. The appropriate targets for a virtual elimination strategy are this much smaller group of front-end factors that *cause* dioxin formation. Such an approach replaces the fruitless attempt to control releases from each of the innumerable smokestacks, discharge pipes, and tailpipes from which dioxin is released.

TABLE 2

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**Summary of Processes that form Dioxin and Related Chemicals****Production of chlorine gas**

- Chlorine electrolysis with graphite electrodes
- Chlorine electrolysis with titanium electrodes

**Use of chlorine gas -- chemical industry**

- Synthesis of chlorinated aromatic chemicals
- Synthesis of chlorinated solvents (TCE, perc, carbon tetrachloride)
- Synthesis of feedstocks for PVC plastic
- Synthesis of other aliphatic organochlorines
- Manufacture of some inorganic chlorides

**Use of chlorine gas -- other industries**

- Pulp and paper -- chlorine bleaching
- Water and wastewater disinfection
- Production of refined metals -- manufacture with chlorine (Ni, Mg)

**Use of organochlorines**

- Chemical industry -- use of organochlorine intermediates in chemical synthesis
- Solvents -- use in reactive environments
- Oil refining with organochlorine catalysts
- Use of pesticides in presence of heat (wood treatment, etc.)
- Iron/steel sintering with organochlorine cutting oils, solvents, or plastics
- Burning gasoline or diesel fuel with organochlorine additives
- Chlorine-based bleaches and detergents: use in washing machines/dishwashers

**Combustion of organochlorines**

- Medical waste incinerators
- Municipal waste incinerators
- Hazardous waste incinerators
- Cement kilns burning hazardous waste
- Accidental fires in homes, offices, and industrial facilities
- Aluminum recycling/smelting
- Steel and automobile recycling/smelting
- Copper cable recycling/smelting
- Aluminum recycling/smelting
- Wood burning (w/organochlorine residues, pesticides, etc.)

**Environmental transformation**

- Transformation of chlorophenols to dioxins in the environment

This list includes sectors in which formation of dioxin or related compounds (PCBs, chlorinated dibenzofurans, and/or hexachlorobenzene) has been confirmed in chemical analyses, as well as sectors in which dioxin formation is "known or suspected" according to EPA. For full reference information, see EPA 1994b, Thornton 1994, and Thornton 1995.

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A handful of individual chlorine-related products and processes are, in fact, responsible for the vast majority of dioxin emissions from a multiplicity of sources. For instance, chlorine bleaching in the pulp and paper industry results in dioxin emissions from pulp mills, black liquor boilers, sludge incinerators, sludge land disposal sites, and municipal waste incinerators. Similarly, the life-cycle of chlorinated solvents may result in dioxin emissions from the chemical plants where the solvents are produced, the on-site incinerators where wastes from their synthesis are burned, the manufacturers and other facilities where they are used, and the commercial waste incinerators where they are ultimately disposed. Most significantly, the life-cycle of PVC results in dioxin formation during feedstock synthesis, incineration of wastes from synthesis, accidental combustion of products, recycling of products in steel, copper, or metal smelters, burning of residues in wood combustion and steel sintering, and incineration of spent products in hospital and municipal incinerators.

A virtual elimination strategy must focus on the processes and products that are the primary contributors to the dioxin burden in the Great Lakes. Emissions from individual source sectors must be traced back to the chlorine donors they share. In this way, a virtual elimination strategy can address the preventable causes of dioxin pollution in a focused and effective way.

### **5.3. Priorities for Dioxin Elimination**

A virtual elimination strategy must ultimately address all anthropogenic sources of dioxin (see tables 3 and 4). Because dioxin formation is associated with the many uses of chlorine in U.S. and Canadian industry, this program will require substantial technical and economic conversion. Thus, a virtual elimination strategy should begin by setting priorities, so that the largest dioxin-producing sectors for which alternatives are available and feasible can be subject to immediate action, while those requiring longer implementation phases are placed on longer timelines for dioxin elimination. Based on EPA's source inventory, two sectors emerge as immediate priorities: (1) pulp and paper mills, and (2) Incinerators and other combustion sources.

For pulp mills, the nature of a strategy to eliminate dioxin-producing feedstocks is obvious. Pulp mills generate and release dioxin because of the introduction of chlorine and

chlorine-based bleaches. Mills that substitute chlorine dioxide for elemental chlorine reduce but do not eliminate the generation of dioxin-like compounds and other persistent toxic substances [Solomon 1993, EPA 1993]. In contrast, mills that produce chlorine-free paper, using ozone, oxygen, hydrogen peroxide, and other methods of bleaching and delignification, do not produce dioxin. Elimination of chlorine-based bleaching in the paper industry with existing technologies for chlorine-free pulp manufacture would thus eliminate the largest source of dioxin discharges directly to waterways, along with elimination or reduction of dioxin emissions from associated sources, such as mill sludge incinerators, black liquor boilers, and municipal solid waste (MSW) incinerators.

**TABLE 3**  
**Major Dioxin Sources and  
Their Chlorine Donors**

| Dioxin-generating process   | Primary chlorine donor                             |
|---|--|
| Municipal waste incineration  | PVC, bleached paper                                |
| Hospital waste incineration   | PVC  |
| Pulp mills  | Chlorine-based bleaches                            |
| Hazardous waste incineration  | Spent solvents, chemical industry wastes           |
| Wood burning<br>(industrial and residential)                          | PVC, pentachlorophenol, chemical hardeners         |
| Secondary copper smelting   | PVC  |
| Chemical manufacturing<br>(plastics, solvents,<br>pesticides, others) | Chlorine as a reactant                             |
| Home and building fires   | PVC, pentachlorophenol                             |
| Ferrous metal smelting  | PVC, chlorinated solvents and cutting oils         |
| Vehicle fuel combustion   | Halogenated scavengers                             |
| Forest fires  | Pesticides, deposition of airborne organochlorines |
| Sewage sludge incineration  | Chlorination by-products                           |
| Secondary lead smelting   | PVC  |

Source: U.S. EPA, "Estimating Exposure to Dioxin-Like Compounds, Volume II: Properties, Sources, Occurrence and Background Exposure." External Review Draft, June 1994. Sum of releases to all media from each source. Ranked by lower-range estimate.

For combustion sources, the feedstocks that lead to dioxin formation are more diverse and may vary from process to process. According to EPA, "Dioxin-like compounds can be generated and released to the environment from various combustion processes when chlorine donor compounds are present" [EPA 1994b]. Although many materials can serve as chlorine-donors in combustion-based processes, one -- PVC plastic -- appears to be dominant in virtually all of the major dioxin sources:

- Medical waste incinerators. Virtually all available chlorine comes from PVC plastic, which enters these facilities as packaging and in many disposable medical products. An estimated 9.4 percent of all "red-bag" waste is PVC [Marrack 1988].
- Municipal waste incinerators. The vast majority of available chlorine input comes from PVC. Though it accounts for only 0.5% of municipal waste by weight, PVC contributes at least 80 percent of organically-bound chlorine and more than 50 percent of the total chlorine in the trash stream. Numerous reports have found that burning PVC results in dioxin formation [Thiesen 1989, Christmann 1989, Ozvacik 1989]. Others have reported a direct relationship between the quantity of PVC burned and the amounts of dioxin emitted. The Danish EPA found that doubling the PVC content of an incinerator's wastefeed increases dioxin emissions by 34 percent [Danish EPA 1993]. And the Dutch Environment Ministry recently reported that reducing the PVC feed results in a corresponding reduction in dioxin emissions [Kanters 1993].
- Copper smelters. Copper recyclers are dioxin sources because they process large quantities of PVC-coated copper cables along with PVC telephone cases and other PVC-laden products [EPA 1994b].
- Lead smelters. The primary chlorine donor in these facilities is PVC separators in lead-acid batteries [EPA 1994b].
- Secondary steel smelters. These facilities have recently been identified as major dioxin sources, due to the presence of PVC residues in steel scrap, particularly from automobiles [EPA 1994b, Lahl 1993].
- Primary steel smelters. Dioxin is produced because of two possible chlorine donors: the use of chlorinated solvents and cutting oils in the production process, and the reintroduction of dusts and slag from recycling of PVC-containing scrap [Lahl 1993].
- Wood combustion. Dioxin formation in the burning of natural wood is negligible. In contrast, industrial and residential wood burning can become an important dioxin sources when wood with chemical additives or residues is burned. The major chlorine donors in this sector appear to be scrap wood with PVC residues, chip board with chloride-containing hardeners, and treated wood preserved with pentachlorophenol

[Wilken 1994, Vikelsoe 1993].

- Accidental fires. PVC is now ubiquitous in modern buildings in flooring, siding, pipes, furniture, wallpaper, and other materials. An average house contains 14 to 367 kilograms of PVC, depending on size and date of construction/remodelling [Carroll 1995]. Industrial and institutional buildings contain even greater quantities. Samples taken from fires in PVC-containing buildings have been found to contain dioxins in concentrations as high as 10,000 ng (TEQ)/m<sup>2</sup> on surfaces and 45 ppb TEQ in ash and soot [Fiedler 1993, UBA 1992]. There are hundreds of thousands of structural fires in the U.S. and Canada every year, and combustion conditions are far from optimized; the sum of these events may be a major dioxin source that has not yet been quantified.
- Hazardous waste incinerators and cement kilns. These facilities burn complex mixtures from a wide variety of sources. Major chlorine donors include spent chlorinated solvents and wastes from the manufacture of organochlorines in the chemical industry [Oppelt 1986, Dempsey 1993]. PVC manufacture is the largest use of chlorine -- accounting for more than half of all chlorine use within the organic chemicals industry -- and PVC use results in the generation and incineration of millions of tons of chlorine-rich wastes each year. Thus, PVC is an important indirect chlorine donor and dioxin precursor in hazardous waste incinerators, as well.

In some of the less important combustion-related dioxin sources, chlorinated products and by-products other than PVC are the major chlorine donors. For instance, automobiles and trucks are dioxin sources because of the deliberate addition of 1,2-dichloroethane and other organochlorines to some gasoline and diesel formulations [Marklund 1990]. Disinfection by-products from chlorination are the major dioxin feedstock in sewage sludge incinerators.

Some authors -- particularly those representing the chemical manufacturing industry -- have contended that the feed of chlorinated organic materials to a combustion unit does not determine the magnitude of dioxin emissions. Of course, chlorine feed is not the *only* factor involved in dioxin formation; facility design, operating conditions, and the presence of catalysts also play significant roles. Without the products and wastes from the chlorinated organic chemicals, only natural chloride-containing salts could serve as chlorine donors. But a host of studies indicates that dioxin is far less likely to form from chloride than from organochlorines in high-temperature processes:

- Extensive studies of an incinerator at the University of Florida have documented a clear relationship between emissions of dioxin-indicator compounds and the feed of PVC.

According to the authors, these "experimental, phenomenological and theoretical studies of toxic emissions from incineration all support the physically intuitive hypothesis that reduction of chlorinated plastics in the input waste stream results in reduction of aromatic chlorinated organic emissions.... We are convinced that, when all other factors are held constant, there is a direct correlation between input PVC and output PCDD/PCDF and that it is purposeful to reduce chlorinated plastics inputs to incinerators" [Wagner 1993].

- An extensive study for the German EPA found that combustion of organochlorine-containing plastics and other chemicals produced dioxin concentrations in ash residues ranging from 3.2 to 662 ppt TEQ, while combustion of chloride-containing but chlorine-free paper, wood, cotton, and wool resulted in dioxin concentrations below the detection limit of 0.1 ppt [Thiessen 1991].
- A recent Finnish study found that dioxin concentrations increased by a factor of 10 to 100 when PVC was added to a mixture of chloride-containing coal and bark; the more PVC added, the higher the dioxin concentration [Kopponen 1992].
- The Danish EPA found that doubling the PVC content of an incinerator's wastefeed increases dioxin emissions by 34 percent, while doubling the chloride content increases dioxin emissions by a much smaller margin [Danish EPA 1993].
- A 1993 study for the Dutch Environment Ministry reported that reducing the PVC feed results in a corresponding reduction in dioxin emissions, particularly when chloride concentrations are kept low [Kanters 1993].
- A recent German study found that the ash of incinerated PVC-containing wood products had dioxin concentrations 3 to 350 times greater than that found in the ash of wood treated with chloride hardeners, and 15 to 2400 times greater than that found in the ash of natural chloride-containing wood [Wilken 1994].
- Liberti [1983] showed that combustion of chloride-containing vegetable matter did not produce PCDD/Fs, while combustion of vegetable matter in the presence of chlorine gas or PVC plastic resulted in formation of chlorophenols and PCDD/Fs.
- Mahle and Whiting (1980) found that the combustion of coal in the presence of air or air and sodium chloride produced no detectable quantity of TCDDs and HxCDD and only very low quantities of HpCDD and OCDD. In contrast, combustion of coal in the presence of hydrogen chloride resulted in substantially increased dioxin formation, and combustion of coal in the presence of chlorine gas resulted in dioxin concentrations that were hundreds of times higher.
- Several studies have found that dioxin levels in the tissue of ancient humans exposed frequently to wood smoke are no more than one or two percent of the amount found in the tissue in modern humans [Schechter 1991, Ligon 1989]. According to EPA, "The

theory that much of today's body burden could be due to natural sources such as forest fires has been largely discounted by testing of ancient tissues which show levels much lower than those found today" [EPA 1994b]. Further, studies of sediments in the Great Lakes [Czuczwa 1986] and of vegetation and soils in the U.K. [Kjeller 1991] show that dioxin levels remained very low throughout the 19th century; they began to climb towards their current concentrations only in this century, with the greatest increases after World War II. This pattern corresponds to the development and expansion of the chlorine chemical industry.

Together, these data make clear that it is not inorganic chloride but organically-bound chlorine -- particularly PVC -- that is the predominant source of dioxin from combustion. As for the contrary position -- that combustion of chloride-containing materials free of organochlorines produces substantial amounts of dioxin -- EPA points out that there are no sound data to support this claim, since no studies have adequately insured that purportedly chlorine-free materials do not contain residues of the organochlorine contaminants that are now ubiquitous in air, water, and biological samples. One recent study prepared for the Chlorine Chemistry Council collated data from trial burns at scores of incinerators and found no statistical relationship between dioxin emissions and chlorine feed, but this is not surprising since the study did not adjust for the many other factors that affect dioxin emissions [Rigo 1995].

Thus, although some dioxin can be formed from the combustion of chloride containing salts, anthropogenic materials containing organochlorines produce much greater quantities of dioxin and are clearly the predominant dioxin precursors in combustion sources of dioxin. PVC, as the largest and most disposable use of chlorine, emerges as the dominant chlorine donor in virtually all of the major combustion-related dioxin sources identified by EPA.

In addition to the massive dioxin formation associated with PVC during disposal, recycling, and accidental combustion, dioxin is also generated during the manufacture of PVC products. A series of European studies have established that very large quantities of dioxins can be formed in the synthesis of the PVC feedstocks vinyl chloride (VCM) and 1,2-dichloroethane (EDC). Dioxin formation is particularly significant in the oxychlorination process, in which ethylene is combined with hydrochloric acid and oxygen in the presence of a copper catalyst to produce EDC.

The quantities of dioxin formed appear to be very large. A 1989 study by the University of Amsterdam found that 419 grams of dioxin (TEQ) are formed for each 100,000 tons of EDC produced [Evers 1989]. Norsk-Hydro has estimated that a single EDC/VCM plant it operates in Sweden produces 321 grams of dioxin (TEQ) per year [HydrPlast 1992]. Analyses conducted in 1994 at a modern EDC/VCM plant in Germany found dioxins in process sludges at concentrations as high as 414 ppb [Lower Saxony 1994]. Dioxins, furans and PCBs have been identified in oxychlorination wastes from the Vulcan Chemical plant in Louisiana at concentrations as high as 6 ppm TEQ [Costner et al 1995]. These levels suggest that oxychlorination wastes are among the most dioxin-contaminated wastes ever identified, with concentrations in the same range as wastes from the production of Agent Orange. In 1994, the Swedish EPA found that the PVC product itself contains PCDDs, PCDFs, and PCBs in concentrations ranging from 0.86 to 8.69 ppt (TEQ) [SEPA 1994].

The largest portion of the dioxin formed in PVC manufacture is found in hazardous wastes, which are typically disposed of by incineration. At least some of these dioxins, then, will be discharged via incinerator air emissions, ash residues, and treatment sludges. Dioxins, furans, PCBs, hexachlorobenzene, and other dioxin-like compounds have also been identified in the air emissions and effluent discharges from EDC/VCM plants [SFT 1993]. As for environmental samples, studies in the Netherlands, Sweden, Germany, and the U.S. have all found elevated levels of dioxins in sediments, water, and biota downstream from EDC/VCM discharge points [Evers 1988, Evers 1993, Cato 1992, Costner et al 1993, Lower Saxony 1994, Verhoog 1988]. In the Rhine and certain areas of the North Sea and Baltic, EDC/VCM synthesis appears to be the primary source of environmental dioxin contamination.

Based on this evidence, it appears that PVC is the single most important source of dioxin known. Dioxin is produced in large quantities throughout its life-cycle -- in manufacture, recycling, disposal, and accidental combustion. Moreover PVC is the primary chlorine donor in virtually all of the major dioxin sources that have been identified. Sources in which PVC is the predominant chlorine donor are responsible for 86.5 percent of identified dioxin emissions into the Great Lakes, based on Commoner and Cohen's inventory. In EPA's inventory, these PVC-related sources account for discharges of 3,900 to 26,000 g TEQ/yr -- over 90 percent of all identified emissions.

TABLE 4

Summary of PVC-related Dioxin Sources

| Dioxin source                      | Great Lakes Loading <sup>1</sup> (%) | Associated PVC product                 |
|------------------------------------|--------------------------------------|--|
| <b>PVC Disposal</b>                |                                      |  |
| Medical waste incinerators         | 48.7                                 | Packaging, medical products            |
| MSW incinerators                   | 20.1                                 | Consumer products, packaging           |
| Wood combustion                    | 1.9                                  | PVC-wood composite products            |
| <b>PVC Recycling</b>               |                                      |  |
| Steel recycling/sintering          | 10.6                                 | Automobiles                            |
| Copper recycling                   | 4.2                                  | Casings for cables and electronics     |
| Lead recycling                     | ND                                   | Battery casings                        |
| <b>PVC Production</b>              |                                      |  |
| Chemical industry discharges       | ?                                    | By-products of EDC/VCM synthesis       |
| Hazardous waste incinerators/kilns | 8.0                                  | Wastes from EDC/VCM synthesis          |
| <b>PVC Use</b>                     |                                      |  |
| Accidental fires                   | ?                                    | Construction products, furniture, etc. |

Source: Commoner and Cohen 1995.

In addition, PVC appears to cause the generation of very large quantities of dioxin in two other major sources that are not quantified in either the CBNS or EPA inventories: structural fires and chemical manufacturing.

The dominance of PVC in dioxin formation is not a surprise, considering the huge quantity of PVC produced each year, its role as the largest use of chlorine, and its frequent use in disposable, recyclable or fixed applications destined for intentional or accidental combustion.

5.4. PVC Sunset: A Case Study for Transition Planning

Sunsetting some dioxin sources will not entail extensive social and economic disruption. For instance, converting a pulp mill to chlorine-free bleaching requires an initial investment, but chlorine-free bleaching eventually can lower costs and increase efficiency. Most importantly, after conversion to chlorine-free bleaching, a mill continues to produce paper, in the same location, with at least the same number of employees.

Sunsetting PVC, however, will result in social and economic disruption. Although effective alternatives are available now for all major PVC uses, workers and communities involved in the production of PVC will be affected by a shift to alternative products. PVC manufacture is a large industry that employs a substantial number of persons, so a sunseting program must provide careful planning to address the social and economic impacts of conversion.

PVC provides an excellent case study for a discussion of Transition Planning as part of a virtual elimination program for two reasons. First, PVC is the largest single source of dioxin, so it must be a high priority for phase-out. Second, that phase-out carries with it the possibility of significant effects upon workers and communities, making careful Transition Planning particularly important.

## 6. Timeliness of the PVC Sunset Case Study

In recent months, there has been a debate in the chemical industry trade press over the future of PVC. Some suggest long-term problems for PVC and predict declines due to environmental pressure in markets such as packaging, medical supplies, autos and others.

*Modern Plastics*, however, replying in November 1994: "Despite calls for a PVC phase-out, the outlook is bullish." They point to "a proactive PVC industry defense on the dioxins issue," and detail several markets that are growing fast enough to replace those markets coming under green pressure. A "Chemical Week" editorial of January 18, 1995, counters by stating that:

"The buoyant prospects of the rigid PVC sector and the fact that this is primarily a European phenomenon does not mean these issues [PVC phase-out] can be discounted. Wasn't chlorine a European issue two years ago?"

The IJC was among the first respected agencies in North America to understand the importance of chlorine chemistry as a source of persistent toxic pollution. Now, as the primary focal point of world concern about chlorine chemistry shifts to polyvinyl chloride, making PVC the object of a Transition Planning case study is timely and provides a constructive framework for dialogue.

There are a number of indications that concern about PVC will be growing in North America.

### 6.1. Green Pressures on PVC

The reports of the International Joint Commission, and subsequent attention by the health community including the Michigan State Medical Society and the American Public Health Association have legitimized concerns about the possible health threats posed by exposure to persistent toxic compounds. Health activist groups have seized on the issue and will likely use their considerable networks to raise awareness and activism, and to drive policy changes. Concerns about health are sure to fuel green market pressures and public policy initiatives which will impact PVC markets in the U.S. and Canada.

The source of growing concern about PVC is likely to be centered around several issues:

### Health Effects Associated with Dioxin and PVC's Central Role in Dioxin Formation

The recent release of the Environmental Protection Agency's draft "Dioxin Reassessment" [U.S. EPA, 1994] has focused renewed attention on a subset of persistent toxic compounds -- dioxins and dioxin-like toxins. The evidence of harm, although not definitive, is suggestive and alarming. Public pressure to decrease exposure to compounds which may already be contributing to fertility problems, developmental abnormalities, immune system suppression and cancer could escalate dramatically.

At each stage in its life-cycle, PVC is associated with the generation and release of persistent toxic compounds, most notably dioxins. PVC plastic may be associated with more dioxin formation than any other product. Attention to PVC will increase as its role in dioxin formation becomes more widely understood. PVC production and disposal are large, identifiable, and likely targets for action.

### Consumer Product Safety

Concerns about the safety of consumer products have led to a number of dramatic initiatives in the past, including the banning of products or materials. New data on the leaching of contaminants and additives and the outgassing of PVC products could spark consumer campaigns which would impact PVC market share.

### Home and Industrial PVC Fires

The widespread use of PVC now insures that almost every accidental fire involves PVC. Burning PVC poses hazards to firefighters and the public because of the toxic and highly acidic fumes that are released [JAMA, 1975]. A few well-publicized PVC fires could escalate concerns. Emergency responders and firefighters will be naturally allied with efforts to address concerns about PVC in fires. The contribution of home and industrial fires to overall dioxin deposition may also invigorate an anti-PVC

campaign.

### **Difficulty of Disposal**

#### *Incineration*

The EPA's Dioxin Reassessment has focused attention on the role of incineration in the ubiquitous dioxin contamination of the population. Regardless of the extent to which PVC in the waste stream is directly predictive of dioxin emissions, PVC is a major source of chlorine in the waste stream, and thus a target for removal.

Given increasing pressure on incinerators from regulators and a strong grassroots anti-incineration movement already activated around the issue of dioxin, PVC will be a prime target for source separation, reduction or removal from the waste stream.

Emerging evidence of PVC's contribution to the release of other persistent toxic compounds will support this trend. For instance, the German Federal Office of the Environment estimates PVC is responsible for 20-30 percent of all cadmium entering incinerators [Johnson, 1992a].

One estimate suggests that less than 10 percent of energy consumed in the production of PVC can be thermally recovered [Johnson, 1992a]. Other plastics provide greater recoverability and therefore greater life-cycle cost effectiveness, further disadvantaging PVC.

#### *Recyclability*

Additives in PVC and blends with other materials make recycling of PVC difficult. The trend to increase the recyclability and recovery of all materials in the waste stream has already led product designers away from PVC in a number of applications, including auto parts like dashboards and trim. Recyclability requirements are likely to increase.

Additives introduced to PVC to vary its properties include persistent toxins like heavy metals, chlorinated hydrocarbons and phthalates. The majority of plasticizers used in the plastics industry, for instance, are used in PVC products. The most common plasticizer is an endocrine disruptor and when heated releases a heart toxin [EBN, 1994]. Not only do these crucial additions to the finished PVC product pose hazards to workers and the environment, they also necessitate downcycling and limit the number of cycles possible when recycling PVC. A number of pilot recycling projects are attempting to automatically sort PVC waste to increase the quantity and quality of recycling. To date, the efforts are expensive and still do not allow widespread recycling of most PVC products. In July 1992, only 0.2 percent of all post-consumer PVC was recycled in the U.S. [SWM, 1993].

#### *Landfilling*

In the U.S. and Canada, most PVC plastic is landfilled. The structure of some polymer plastics makes them biodegradable, even in anaerobic landfills. Additives or impurities like heavy metals may be released by microbial activity, by corrosive liquids or when the material is shredded, causing contamination of leachate. At least one Superfund site is attributable to auto "fluff," a foam and vinyl material left after car salvaging [EPA, 1993].

Accidental fires pose another threat from landfilled PVC, with the possibility of large releases of dioxin.

Because the majority of PVC products are durable goods, the first generation of PVC products will soon be reaching the end of their lifespan. Disposal problems will grow, and so likely will concerns about PVC. In a Financial Times report, "*The Future of Plastics*", the plastics industry is warned that "if the response of the plastics industry [to environmental concerns about disposal] is insufficient, whole segments of the business could be severely curtailed or even wiped out" [Johnson, 1991].

## 6.2. Market Pressures

The following areas represent PVC sectors where environmentally driven market pressures on the PVC industry are emerging or will likely emerge in the near future:

### **Packaging, Toys, Housewares and Other Non-Durables**

The ready availability of alternatives and the short-term nature of non-durable products make them easy targets for consumer action and likely targets for immediate PVC bans.

A study by the Tellus Institute compared the relative environmental impacts of the production, use and disposal of various packaging materials. Costs associated with PVC are the highest of any packaging material.

Evidence of migrating vinyl chloride monomer from PVC packaging into fatty and alcohol-based foods led the Food and Drug Administration (FDA) to limit food contact with PVC containers in the mid-1970s. That regulation was reversed in 1986 based on industry studies showing reduced migration of VCM and a reduced cancer risk [Environmental Action Foundation, 1993]. New studies demonstrating dioxin contamination in pure PVC, and the leaching of plasticizers from PVC products may renew calls in the U.S. and Canada for a review of the safety of consumer products, particularly PVC packaging.

A Swedish Environmental Protection Agency study found dioxin contamination in samples of pure PVC from two manufacturers [SECC, 1994]. Another study, in Italy in 1991 documented the migration of vinyl chloride monomer from PVC bottles into drinking water [Benfenati et. al., 1991].

The French mineral water producers Evian and Vittel recently announced they would be switching to PET plastic for their bottled water products. This move affects about 12 percent of the French PVC market [Chemical Week, 1995]. Similarly, according to

*Chemical Week*, PVC use in food packaging is in the decline in the U.S. and Canada [Chemical Week, 1995].

About 7 percent of PVC sold in the United States is used for packaging. The recycling rate for PVC plastic in 1991 was only 0.1 percent compared with 38 percent for PET plastic. Only 0.2 percent of PVC packaging is recycled, compared with an overall plastic package recycling rate of 4 percent [Environmental Action Foundation, 1993].

Local recycling targets for recyclables, including plastics, are becoming common. Failure to reach targets, points out one industry source, can mean bans or taxes [Johnson, 1991].

Contamination of the plastic waste stream by PVC poses problems which discourage its inclusion in recycling programs. For instance, increased use of PVC for beverage containers has hindered PET recyclers because the two resins are virtually indistinguishable and therefore difficult to separate. PVC's lower melting point means PVC contaminants in the PET waste stream will burn at the temperature required to melt PET, thus contaminating the PET resin [EBN, 1994].

Several cities in the U.S., including Newark, New Jersey, and seven other New Jersey cities have passed packaging ordinances which ban PVC and other plastic packaging from retail food establishments [Local Solutions to Global Pollution, 1991]. Several other cities are considering ordinances. Proctor and Gamble, responding to pressure for a greener image, testified that it is voluntarily phasing out PVC packaging [Environmental Action Foundation, 1993].

In June 1992, 18 environmental and public interest groups issued a ten-point "*Environmental Challenge to the Plastics Industry*" to spell out the issues the industry must face to improve its eco-profile. Among the challenges was a call to phase-out rigid PVC packaging [Environmental Action Foundation, 1993].



The move away from the use of PVC in non-durable goods is advanced in Europe. Dutch food producers and supermarkets voluntarily agreed to ban PVC packaging from all products. A Danish supermarket chain has achieved a 99 percent reduction of PVC in all its product lines, and PVC packaging has been phased out entirely in all Austrian and Swiss supermarkets [Johnson, 1991]. PVC packaging is also being phased out in Sweden and Australia [Fishbein, 1994].

#### **Disposable Hospital and Health Care Products**

According to the U.S. EPA's draft reassessment of dioxin, medical waste incinerators are the largest combined dioxin source in the U.S. [U.S. EPA, 1994]. The EPA has already released draft regulations which will bring medical waste incinerator emissions under federal control for the first time. The result of impending regulations will be major changes in hospital waste handling practices. Many hospitals cannot afford expensive retrofits for existing incinerators and will be forced to contract out waste handling. Others will seek to reduce emissions by source separation and additional controls.

Significant cost savings can be realized in the estimated 70 percent reduction-by-weight possible with the substitution of recyclable durables for disposable linen, paper and plastic surgical waste [Tieszen, 1992].

Heightened sensitivity to environmental and health concerns among health professionals may speed change in this area. Activities related to life saving and enhancement have now been implicated in possible population-wide health threats. This sensitivity makes the growth of alternatives to PVC likely in health care settings.

Numerous examples in Europe provide evidence of alternatives which perform well for all major uses of PVC. A newly opened hospital in Vienna is virtually PVC-free, and essentials like infusion bags and tubings have been replaced with chlorine-free plastics [Thorpe, 1992]. Other hospitals in the area have adopted PVC-free policies. A

number of hospitals in Denmark and Germany have also begun to adopt PVC-free policies for building materials and hospital supplies. Several U.S. hospital initiatives, modeled on European PVC policies, are currently being developed [Thorpe, 1992].

#### **Automotive Parts**

According to Chemical Week, problems with the recyclability of PVC are motivating Detroit automakers to look at alternative materials, and chemical manufacturers are responding [Chemical Week, 1995]. Further, the current lack of a plastics recycling infrastructure for car parts, the inferior performance of PVC in a number of applications, and problems related to PVC disposal will also encourage the move away from PVC. For instance, PVC cabling and sealant are a major source of dioxin emissions from steel mills. PVC fluff from cars is hazardous because it can leach when landfilled, and is highly toxic when ignited. The current steel market probably would not support the added costs required to remove residual coatings from shredded steel.

On average, an automobile manufactured in 1995 will reach the end of its life in 2001 and thus, disposal problems associated with PVC will be shifted a decade into the future. Problems associated with PVC disposal will grow as its percentage in automobiles grows.

PVC use in cars for some interior uses has already been eclipsed by alternative plastics because of their superior performance and recyclability. Requirements within the auto industry to increase the recyclability of the automobile may accelerate this trend. Major pilot projects to improve PVC's recyclability do not yet offer much promise.

A number of voluntary initiatives in the U.S. aimed at preventing pollution by the auto industry may encourage PVC substitution. Those initiatives, which are beginning to emphasize a "life-cycle" approach to identifying opportunities for pollution prevention, will likely find PVC problematic both upstream (in production) and downstream (at the point of disposal).

The trend is accelerating in Europe, where a number of auto manufacturers have announced plans to reduce or eliminate PVC use. BMW, based on the results of a life-cycle analysis of product inputs, has set a goal of the elimination of PVC. Opel (a subsidiary of General Motors) has committed itself to eliminate PVC in some applications. Volkswagen has stopped using PVC in all its products. The globalization of auto manufacturing means trends in Europe could have impacts on U.S. and Canadian products.

### **Building Materials**

Building materials applications account for up to 75 percent of all PVC manufactured in the United States [Johnson, 1991]. A 1990 Danish study found that 60 percent of PVC building materials could be replaced within a three-year period, and the remainder within five years [Christiansen et al, 1990].

U.S. architects and builders have begun to respond to calls for more environmentally sound materials by investigating alternatives and reviewing the hazards of PVC products. Interest in this use sector has been slow in the U.S. but appears to be picking up steam. The extent to which European hospitals and building projects have been able to eliminate PVC indicate the possibility of increasing pressure on contractors and architects to consider more environmentally sound alternatives. Local building code changes and labelling requirements may be employed to select for PVC alternatives. Again, Europe is far ahead in PVC-free construction practices. Tarkett, the second largest European flooring manufacturer, announced last year plans to eliminate PVC from its products [Thorpe, 1992]. The city of Bielefeld in Germany has achieved a greater than 90 percent substitution of PVC in construction projects [Thorpe, 1992]. Their use of traditional materials has reduced repair costs. At least 80 other local authorities in Germany, including Berlin and Munich, two states, and half the regional capitals in Austria have PVC phase-out policies in public construction, although they differ in the degree to which they are implemented [Thorpe, 1992]. The recently constructed Vienna public transportation system is virtually PVC-free. The extent to which Europe has been successfully developing alternatives will increase pressure for

similar changes in the U.S. and Canada.

### **Other PVC Products**

Efforts to eliminate PVC in furniture and appliances are gaining momentum in Europe. AEG, a manufacturer of appliances and electronic goods and Herlitz, a manufacturer of office supplies have eliminated PVC in their product lines. Swedish furniture maker IKEA has announced a PVC phase-out policy [Thorpe, 1992]. These trends can be expected to reach the U.S. and Canada eventually.

The trend toward multi-stakeholder voluntary pollution prevention initiatives may also impact PVC use in the U.S. and Canada. Increasingly, pollution prevention initiatives are attempting to integrate the concept of a life-cycle analysis into production decision-making. Variously called "product stewardship," or "extended product responsibility," this emerging principle of pollution prevention and resource conservation advocates a life-cycle approach to identifying pollution prevention opportunities. Because PVC's toxicity is primarily during production and disposal, a life-cycle approach by users of PVC will invariably create a bias against PVC use.

The implementation of a life-cycle approach to pollution prevention could include a variety of regulatory and non-regulatory initiatives, each of which could impact PVC use, including:

- mandatory or voluntary labelling or "green seals" to quantify environmental attributes;
- voluntary or mandatory take-back systems after exhaustion of a product's useful life;
- corporate or industry product stewardship programs;
- leasing systems; government subsidies and tax credits;
- voluntary or mandatory disclosure of product life cycle information;
- materials or product taxes on polluting materials; and
- mandatory return requirements for consumers and deposit/refund systems.

A Swedish EPA-led multi-stakeholder group, including plastics industry representatives, recommended that polyvinyl chloride be phased out by the year 2001. The group also recommended labelling of PVC plastic products as an interim measure. The chair of the panel noted this meant "in practice, a total phase-out of PVC...PVC is a material that does not belong in an ecological society..." [SECC, 1994].

The toxic nature of the PVC life cycle and its high energy requirements and low energy recovery will influence purchasing decisions away from PVC. PVC users and governing bodies have already started phasing out its use after initiating life-cycle and product analyses.

### PART III - SUNSETTING PVC: TRANSITION ISSUES AND MECHANISMS

#### 7. Structure of the PVC Industry and Impacts of a PVC Phase-Out

The PVC industry is composed of five principle segments:

- Chlor-alkali chemical companies that produce chlorine used to produce PVC.
- Chemical companies that use this chlorine to synthesize ethylene dichloride (EDC) and vinyl chloride monomer (VCM), the precursors from which PVC is made.
- Plastics manufacturers that produce pure PVC polymer from vinyl chloride monomer.
- Plastics formulators that prepare mixtures of PVC and various additives for specific uses.
- Product manufacturers that make/sell the final PVC-containing product.

At the base of the chain of materials processing, economic activity is highly concentrated in a few very large facilities. At later stages, there are a much greater number of facilities, each of smaller size, located over a much greater geographical area.

Only thirteen very large chemical companies produce EDC/VCM, almost all of which produce their own chlorine. Eleven of these are located in Texas and Louisiana, with one each in Kentucky and Alberta. There are 26 large polymerization plants in the U.S. and four in Canada. In contrast to this very concentrated activity, there are assumed to be hundreds of PVC formulators in the U.S. and Canada. At the final stage -- the manufacture of PVC-containing products -- there are some 2,530 facilities in the U.S. and 215 in Canada, scattered throughout all states and provinces, according to the chlorine industry [CRA 1993]. According to the chlorine industry, PVC sales total \$3.8 billion per year in the U.S. and Canada [CRA 1993].

A PVC phase-out will have very different effects on the different segments of the PVC industry. The latter two categories, formulators and product manufacturers, which account for the greatest number of facilities, will have the most promising opportunities to switch to alternative activities. In particular, product manufacturers simply use PVC as part of their products. In most cases, a PVC phase-out will require these companies to use alternative materials in place of PVC but will not pose fundamental challenges to the nature of these enterprises. For instance, as Tarkett phases PVC out of its line of flooring products, it is assumed that workers at existing plants will continue to make flooring out of substitute

materials, such as polyolefins and linoleum. Replacement of certain PVC products with traditional materials may pose more fundamental challenges to some manufacturers.

PVC formulation involves a simple process by which additives (plasticizers, fire retardants, colorants, etc.) are physically mixed with PVC polymer. In the event of a PVC phase-out, many formulators will have the opportunity to formulate other products and mixtures, requiring some modification of equipment but no fundamental change in the nature of business. For some PVC use-sectors, chlorine-free plastics are likely to be used as substitutes; formulators currently involved in the preparation and distribution of PVC should be able to find opportunities in the preparation of PVC-free materials for these uses. The use of traditional materials such as wood and metal, however, will not present easy conversion options for formulators.

The most significant and unavoidable impacts of a PVC phase-out will be at the earliest stages of the PVC chain, where economic activity is most concentrated and easy conversion to alternative processes is least likely. Facilities that produce EDC, VCM, or PVC polymer, along with the chlor-alkali facilities that supply the chlorine used in PVC, are considered highly reliant on continued sales of PVC. A PVC phase-out will entirely eliminate demand for the products these firms produce.

Phasing out PVC will presumably result in some growth in the manufacture of alternative materials, such as some chlorine-free plastics. Companies formerly involved in the manufacture of PVC and its feedstocks may be in a position to convert to the manufacture of these materials. For example, production of metallocene-based polyolefin replacements for PVC is now a major growth area for Dow Chemical, which is also the largest U.S. producer of EDC and VCM.

Nevertheless, it is likely that a PVC phase-out will cause significant economic impacts for corporations, workers, and communities that are highly involved in the production of PVC and its precursors. Table 5 lists manufacturers of EDC and VCM and annual production capacity for each facility in the U.S. No data were available on the number of jobs associated with EDC/VCM manufacture at these facilities, since most produce other

chemicals, as well.

Tables 6 and 7 list chlor-alkali plants producing chlorine used in PVC; most are located on same sites as the facilities producing EDC/VCM. No estimates of the number of employees involved in PVC-related chlorine production are available.

Table 8 lists PVC polymer producers in the U.S., along with an estimate of total sales and jobs associated with PVC production. Based on the total number of employees in each division and the fraction of total business represented by total PVC production, an estimated 5600 jobs are associated with PVC polymerization at these 26 facilities. Table 9 lists PVC producers in Canada; no data on sales and jobs were available for these facilities. If the jobs/capacity ratio is roughly the same in Canada as in the U.S., these four facilities would employ about 650 workers.

Some producers, such as Goodyear and Union Carbide, are not particularly reliant on PVC, which represents only a minor part of their total product lines. But four companies -- Geon, Shintech, Vista, and Westlake -- are highly dependent on PVC, which accounts for more than 50 percent of total sales. Divisions of two other producers -- Occidental and Goergia-Gulf -- are also very reliant on PVC, with a significant percentage of total division sales tied to PVC. For these facilities, significant economic disruption must be expected. Again, there may be some opportunity for conversion to polymerization of alternatives to PVC, demand for which is expected to grow in the event of a PVC phase-out; the extent to which these alternatives will mitigate economic disruption is not known.

**TABLE 5**  
**U.S. Producers of**  
**Ethylene Dichloride and Vinyl Chloride**

| Company           | Location         | Production Capacity<br>million lbs/yr (% of total) |               |
|-------------------|------------------|--|---------------|
|                   |                  | EDC  | VCM           |
| Borden Chemical   | Geismar, LA      | 745 (3.4)  | 950 (6.9)     |
| Dow Chemical      | Freeport, TX     | 2820 (12.8)  | -             |
| Dow Chemical      | Oyster, TX       | -  | 900 (6.5)     |
| Dow Chemical      | Plaquemine, LA   | 2100 (9.5)   | 2150 (15.6)   |
| Formosa Plastics  | Baton Rouge, LA  | 1195 (5.4)   | 1280 (9.3)    |
| Formosa Plastics  | Pt. Comfort, TX  | 1205 (5.5)   | 800 (5.8)     |
| Geon Vinyl        | LaPorte, TX      | 1705 (7.7)   | 1400 (10.1)   |
| Georgia-Gulf      | Plaquemine, LA   | 2075 (9.4)   | 1280 (9.3)    |
| Occidental        | Convent, LA      | 800 (3.6)  | -             |
| Occidental        | Deer Park, TX    | 1587 (7.2)   | 1100 (8.0)    |
| Oxymar            | Ingleside, TX    | 2310 (10.4)  | 1400 (10.1)   |
| PPG, Inc.         | Lake Charles, LA | 2700 (12.2)  | 625 (4.5)     |
| Vista Chemical    | Lake Charles, LA | 1250 (5.7)   | 900 (6.5)     |
| Vulcan Chemical   | Geismar, LA      | 300 (13.6)   | -             |
| Westlake Monomers | Calvert City, KY | 1300 (5.9)   | 1000 (7.2)    |
| <b>TOTAL</b>      |                  | <b>22,092</b>                                      | <b>13,785</b> |

Sources: Stanford Research Institute, "Directory of U.S. Chemical Producers," 1992; and Chemical Week, 1 February 1995, p. 9.

**TABLE 6**  
**Canadian Chlor-Alkali Plants Affected by a PVC Phase-Out**

| Company                       | Location              | Capacity<br>(kT/year) | % of<br>total |
|-------------------------------|-----------------------|-----------------------|---------------|
| Dow Chemical                  | Fort Saskatchewan, AB | 550                   | 46.2          |
| Total Canadian Capacity, 1993 |                       | 1191                  |               |

Source: SRI 1993.

**TABLE 7**  
**U.S. Chlor-Alkali Plants affected by a PVC Phase-Out**

| Company                                    | Location           | Capacity<br>(kT/year) |
|--|--------------------|-----------------------|
| Dow Chemical                               | Freeport, TX       | 1987                  |
| Dow Chemical                               | Plaquemine, LA     | 1050                  |
| Formosa Plastics                           | Baton Rouge, LA    | 180                   |
| Formosa Plastics                           | Point Comfort, TX  | 585                   |
| Georgia-Gulf                               | Plaquemine, LA     | 386                   |
| GEON Corp.                                 | Calvert City, KY   | 109                   |
| Occidental Chemical                        | Convent, LA        | 279                   |
| Occidental Chemical                        | Corpus Christi, TX | 417                   |
| Occidental Chemical                        | Deer Park, TX      | 347                   |
| Pioneer Chlor-Alkali                       | St. Gabriel, LA    | 160                   |
| PPG Industries                             | Lake Charles, LA   | 1126                  |
| Vulcan                                     | Geismar, LA        | 243                   |
| <b>TOTAL U.S. Chlorine Capacity (1993)</b> |                    | <b>11,078</b>         |

Source: SRI 1993.

TABLE 8

## PVC Producers - U.S.

| Company<br>(location)        | PVC capacity,<br>in million lbs/yr<br>(% of U.S. total) | PVC sales<br>(U.S. \$million) | PVC-related<br>jobs (est.) |
|------------------------------|---|-------------------------------|----------------------------|
| Borden Chemical and Plastics |   | 250                           | 420                        |
| Geismar, LA                  | 375 (4.4)   |                               |                            |
| Illioopolis, IL              | 300 (3.5)   |                               |                            |
| Certainteed Corp.            |   | 94                            | 500                        |
| Lake Charles, LA             | 200 (2.3)   |                               |                            |
| Formosa Plastics             |   | 174                           | 320                        |
| Delaware City, DE            | 280 (3.2)   |                               |                            |
| Point Comfort, TX            | 700 (8.1)   |                               |                            |
| Georgia-Gulf                 |   | 312                           | 360                        |
| Delaware City, DE            | 140 (1.6)   |                               |                            |
| Plaquemine, LA               | 700 (8.1)   |                               |                            |
| BFGoodrich/GEON              |   | 590                           | 1,150                      |
| Avon Lake, OH                | 380 (4.4)   |                               |                            |
| Deer Park, TX                | 285 (3.2)   |                               |                            |
| Henry, IL                    | 185 (2.2)   |                               |                            |
| Louisville, KY               | 275 (3.2)   |                               |                            |
| Pedricktown, NJ              | 340 (4.0)   |                               |                            |
| Plaquemine, LA               | 185 (2.2)   |                               |                            |
| Goodyear Tire and Rubber     |   | 30                            | 225                        |
| Niagara Falls, NY            | 115 (1.3)   |                               |                            |
| Keysor-Century               |   | 30                            | 125                        |
| Saugus, CA                   | 60 (0.7)  |                               |                            |
| Occidental Plastics          |   | 530                           | 1500                       |
| Addis, LA                    | 300 (3.5)   |                               |                            |
| Burlington, NJ               | 270 (3.2)   |                               |                            |
| Pasadena, TX                 | 750 (8.7)   |                               |                            |
| Pottstown, PA                | 200 (2.3)   |                               |                            |

TABLE 8 - Continued

## PVC Producers - U.S.

| Company<br>(location)                                  | PVC capacity,<br>in million lbs/yr<br>(% of U.S. total) | PVC sales<br>(U.S. \$million) | PVC-related<br>jobs (est.) |
|--|---|-------------------------------|----------------------------|
| Shintech Corp.<br>Freeport, TX                         | 1000 (11.6)   | 375                           | 125                        |
| Union Carbide<br>Texas City, TX                        | 125 (1.4)   | 62                            | 190                        |
| Vista Chemical<br>Aberdeen, NS<br>Oklahoma, OK         | 450 (5.2)<br>350 (4.1)                                  | 250                           | 550                        |
| Vygen Corp.<br>Ashtabula, OH                           | 120 (1.4)   | NA                            | NA                         |
| Westlake Monomers<br>Calvert City, KY<br>Pensacola, FL | 290 (3.4)<br>200 (2.3)                                  | 180                           | 200                        |
| <b>TOTAL</b>   | <b>8,595</b>  | <b>2,877</b>                  | <b>5,674</b>               |

Sources: Stanford Research Institute. "Directory of U.S. Chemical Producers." Menlo Park, CA: SRI, Inc., 1992. Employment and sales information from R. Ginsburg, Midwest Council for Labor Research, Chicago, Il.

TABLE 9

Canadian PVC Producers, 1990

| Company    | Location             | capacity (kt/yr) |
|------------|----------------------|------------------|
| Esso       | Sarnia, ON           | 100              |
| BFGoodrich | Shawinigan, QB       | 60               |
| BFGoodrich | Niagara Falls, ON    | 184              |
| BFGoodrich | Ft. Saskatchewan, AB | 100              |

Source: Camford Information Services, PVC Product Profile, 1990.

7.1. Current Uses of PVC

In the U.S. and Canada, over 50 percent of PVC is used in construction applications, such as pipes, fittings, siding, and window profiles. Other PVC uses include furniture, wall and floor coverings, automobiles, electronic equipment, wire and cable coatings, packaging, and medical devices. PVC use patterns in the U.S. and Canada are shown in Table 10.

TABLE 10  
PVC Use Patterns

| PVC Use                    | % of total PVC consumption (1990) |        |
|----------------------------|-----------------------------------|--------|
|                            | U.S.                              | Canada |
| <i>Rigid PVC</i>           |                                   |        |
| Pipe and fittings          | 40.3                              | 38.6   |
| Siding and window profiles | 10.5                              | 26.9   |
| Blow moulding              | 3.0                               | 1.2    |
| Rigid film and sheet       | 2.2                               |        |
| Other rigid PVC            | 14.1                              | 2.2    |
| <i>Flexible PVC</i>        |                                   |        |
| Flexible film and sheet    | 3.7                               | 9.7    |
| Floor coverings            | 5.0                               | 4.0    |
| Synthetic leather          | 2.2                               |        |
| Wire and cable             | 5.4                               | 8.0    |
| Other flexible PVC         | 13.8                              | 9.2    |

Source: SRI 1993.

7.2. Overview of PVC Alternatives

The most appropriate substitute for a given PVC application depends upon the qualities required for the given use. A detailed discussion of every PVC use and its alternative is beyond the scope of this document. Nevertheless, existing information indicates that effective substitutes are available now for all major PVC uses. These include traditional

materials -- wood, metal, paper, glass, ceramics, etc. -- as well as chlorine-free plastics. Preliminary information on alternatives for a number of PVC applications is presented in Table 11.

A recent study by the consulting firm Prognos AG for the German state of Hessen found that 95 percent of all PVC uses can be easily substituted using available alternatives. Further, Prognos found that while some alternatives were slightly more expensive, 50 percent of PVC uses could be substituted with a net rise in costs of just four percent and a corresponding increase in employment of four percent, and 70 percent of PVC uses could be substituted with a net rise in costs of 36 percent [Plimke 1994].

The Enquete Commission of the German Bundestag also concluded that alternatives were available for virtually all PVC uses:

"Except for special products with particular characteristic requirements, such as blood packs or electrically conducting flooring for clinically clean rooms, it is safe to assume that there are materials able to replace PVC in all its uses, these in many cases being marketed by the same manufacturers as those producing PVC" [Enquete-Kommission 1994].

A large number of communities, manufacturers and hospitals have begun or completed successful efforts to eliminate PVC from their product lines or facilities. For instance, over 100 communities in Europe -- including large cities in Austria and Germany -- have policies to avoid the use of PVC in public construction projects; many have successfully built major new buildings without PVC. In transportation, the new Vienna subway system is PVC-free; Volkswagen has stopped using PVC in its products, and Mercedes, BMW and Opel have adopted similar policies. Sony-Europe, AEG, IKEA furniture, Herlitz, and Tarkett have adopted PVC phase-out policies for their lines of appliances, furniture, office equipment, and flooring, respectively. As for medical uses, the SMZ-Ost Hospital in Vienna is now virtually PVC-free.

TABLE 11  
Alternatives to Selected PVC Uses

| PVC use                                     | Alternative   |
|---|---|
| Window profiles<br>Pipes                    | Wood, aluminum<br>Concrete, steel, galvanized iron, copper, clay, chlorine-free plastics, including high-density polyethylene (PE), polypropylene (PP), acrylonitrile-butadiene-styrene (ABS), and polyisobutylene. |
| Flooring<br>Cable coatings                  | Linoleum, wood, stone, rubber, PE and PP. PE, ethylene-vinylacetate copolymer (EVA); polyamide, silicone, and other thermoplastic elastomers.   |
| Packaging                                   | No packaging at all, glass, paper and cardboard, PP, PE, and polyethylene terephthalate (PET).  |
| Wall coverings<br>Roof-sheeting             | Paint, tiles, paper-based wallpaper.<br>Synthetic rubber, polyolefin sheeting, traditional materials made from tar, wood, and other materials.  |
| Gutters<br>Shutters and blinds<br>Furniture | Galvanized iron.<br>Wood, aluminum, and chlorine-free plastics.<br>Wood, metal, textiles, leather, and chlorine-free plastics such as butadiene-polyamide copolymer.  |
| Office supplies<br>Automobiles              | Metal, wood, PP, PE.<br>Metal, textiles, chlorine-free plastics, including polyolefins and ABS.   |
| Medical uses                                | Glass, latex, chlorine-free plastics including PP, PE, PET, EVA, polybutylene terephthalate, and silicones.   |

Sources: Belazzi 1993, Enquete Kommission 1994, CRA 1993.



## 8. Transition Planning for Sunsetting PVC

This section will explore Transition Planning as it applies to the specific PVC sunset case study.

It is important to distinguish between the Sunset Mandate and the Transition Planning process. The Sunset Mandate is the decision to phase-out PVC by a particular sunset date; Transition Planning is a process to establish mechanisms that help achieve the mandate in a manner that maximizes benefits, minimizes costs and attempts to equitably distribute both.

In practice, of course, the sunset mandate and Transition Planning are not easily separable. The sunset date will certainly be informed by some estimate of what transition mechanisms are available and the time needed to ensure a fair and orderly transition to them. The sunset date can not depend only on ecological considerations, but must also take into account whether appropriate alternatives can be put in place quickly enough to avoid irrational or unnecessary dislocations.

Still, it is important that sunset dates and targets be set before the formal Transition Planning process begins. Otherwise, debates over setting the dates and targets too easily degenerate into a surrogate debate over whether the phase-out itself should be pursued.

### 8.1. Establishing Legally Enforceable Sunset Dates for PVC

The specific mandate to sunset PVC should be an enforceable decision to set the year 2010 as the sunset date. The actions required by that date include:

- ban all further production in the United States and Canada of the basic PVC feedstock chemicals -- ethylene dichloride and vinyl chloride monomer -- for use in the manufacture of PVC and related plastics.
- ban all imports into the United States and Canada of these substances, or of plastic products derived from them.

The mandate should also include instructions to the Transition Planners to establish interim measures that will:

- prohibit new facilities or capacity expansions in existing facilities that produce EDC/VCM or that produce PVC itself.
- ban as quickly as practical the oxychlorination process for producing EDC since this process directly produces large quantities of dioxin.
- establish a short to mid-term sunset date for the introduction of PVC containing materials into incinerators or any other combustion device, and for PVC application that are particularly susceptible to fire.
- establish intermediate sunset dates for various PVC applications. Early sunset might be applied to PVC in:

packaging, disposable products, toys, copper cables, lead batteries and automobiles. Mid term sunset date might be applied to durables with relatively easily available alternatives such as furniture, appliances and siding. Longer term sunset dates may then be applied to more difficult or currently expensive to replace (and very large) applications such as piping and window frames.

Canada and the United States should also work for international agreements with our major trading partners that establish similar sunset policies and dates.

### 8.2. Transition Planning for PVC Sunset: Scale, Stakeholders and Process

Once the mandate has been established, it becomes possible to start exploring the Transition Planning process. The general framework for Transition Planning was outlined in Part II of this report. It defines a mission that includes maximizing benefits and minimizing costs; it also defines guidelines that include predictability, stability, parsimony, an open process, among others.

#### Toward a North American Transition Plan for PVC

As proposed in this paper, a Transition Plan is the product of a Transition Planning process. Participation of stakeholders is an essential element of this process. It therefore would be inappropriate for the authors of this paper to go very far towards defining the details of a

final plan without full access to stakeholder knowledge, insights and creativity. Still, some broad outlines of a plan can be explored.

The first issue to consider is scale. Should Transition Planning apply only to specific facilities, or should it apply to the whole industrial sector that produces PVC? As noted above, the most efficient and effective intervention point for sunseting PVC is the PVC feedstock producers. Tables 5 to 9 indicate that producers of PVC and its feedstock chemicals in North America are located throughout the continent, but particularly in the Gulf Coast region of the U.S. It should also be noted that PVC is not produced for local or regional markets, but rather for national and global markets. Hence, it is suggested that a binational (and possibly a broader international) transition plan is appropriate.

This scale, of course, presupposes there that: (1) there is a binational agreement outlining the sunset mandate between the two countries; or (2) there is a consistent approach in both countries with respect to a sunset mandate for PVC.

The binational transition plan should concentrate on the transition mechanisms associated with sunseting the production of PVC and its feedstock chemicals. While the Transition Planning process should also address PVC formulators, PVC user industries, and other affected interests, it is suggested that supplemental Transition Planning programs be developed for them.

In the event that there is a failure to develop a binational plan, or there is not a consistency in approach between Canada and the United States, transition plans in each country where there is a sunset mandate would be the appropriate course of action.

#### **The Stakeholders**

The next issue is the nature of the Transition Planning process and the constituencies that need to be involved. The transition plan should be developed by a PVC Transition Task Force. This task force would be given a mandate that specifies the end date for sunseting production of PVC and its feedstock chemicals; a mission, guidelines and other terms of reference to develop a transition plan for producers of PVC and its feedstock chemicals.

The PVC Transition Task Force should fully represent the following constituencies:

- PVC producer and user industries;
- labour;
- community leaders (both citizens and civic officials); and
- environmental and public health constituencies.

There should be roughly equal representation from each constituency, although there may be some flexibility providing that all interests have a full opportunity to contribute and to make certain their concerns and interests are addressed.

There must be a full array of resources, including access to technical and organizational staff who can provide fair and impartial assistance in gathering and analyzing data and information needed to develop the transition plan, and in helping to formulate scenarios and options. These resource people may include engineers, economists, labour experts, and informed members of the general public.

The Task Force should have an impartial chair or co-chairs responsible for making certain an effective plan is produced consistent with the terms of reference. If consensus proves impossible, the chair or co-chairs would make final determinations. Consensus should be actively sought, however, and it is important that the task force be a high-level body whose members have the capacity to develop a transition plan that will address controversial and sensitive matters.

Once the process has been initiated, it can be expected that the stakeholders themselves can develop the more routine kinds of operating principles, so long as they conform to the broader principles mentioned above.

It is vitally important that the process yields results. Hence, the task force must be given clear terms of reference, reporting dates, and an assurance that its findings and recommendations will be acted upon by government. These latter requisite are important for the process to be undertaken in a serious manner and then taken seriously once completed.

### 8.3. Transition Fund

The PVC Transition Planning task force should be encouraged or instructed to develop economic instruments that can help both drive the transition and fund the costs associated with it. An appropriate mechanism to accomplish this would be a generators tax applied to the production of ethylene dichloride (EDC) and/or vinyl chloride monomer (VCM) for use as PVC feedstocks. The tax should also be applied to imports of these substances or of products derived from them.

Generally, this paper endorses the proposals contained in the position paper "Orderly Transition Required for any Chemical Sunsetting Program," by Richard Miller and Sanford J. Lewis, written on behalf of the Oil, Chemical and Atomic Workers Union (OCAW), published in *New Solutions*, Fall, 1994. We urge the IJC to give serious consideration to this proposal and make a generators tax an element of any PVC sunset proposal. In our view:

- The generators tax need not be the sole mechanism driving the phase-out, but should be one element of any larger program.
- Guidelines for establishing and changing the rate for transition fund contributions should be established by the Transition Planning process. While the projected financial needs of the fund is an important consideration, it should not be the primary criterion. The most important consideration should be the rate's projected market impact on the transition. It should be set and periodically increased so that it is high enough to make appropriate alternatives economically attractive, driving the transition. But the rate cannot start out so high or escalate so quickly that it creates irrational dislocations or inappropriate substitutions.
- Transition Assistance Funds for workers should be one of several programs paid for out of the transition fund. Others may include: technical assistance, research and information, Transition Planning, aid to impacted communities, and others. Actual programs and the percentage of funds allocated to each should be determined in the Transition Planning process.
- The highest priority in providing assistance to displaced workers should be help in finding a comparably paying job, in the same company, in the same industry, or in a different industry.
- When implementation of a chemical sunset policy leads to net job loss in one industry, but net job gain in others, the growth industries should be offered incentives to locate in the community where job loss occurs.

### 8.4. Other Mechanisms

A range of other mechanisms and procedures must also be developed.

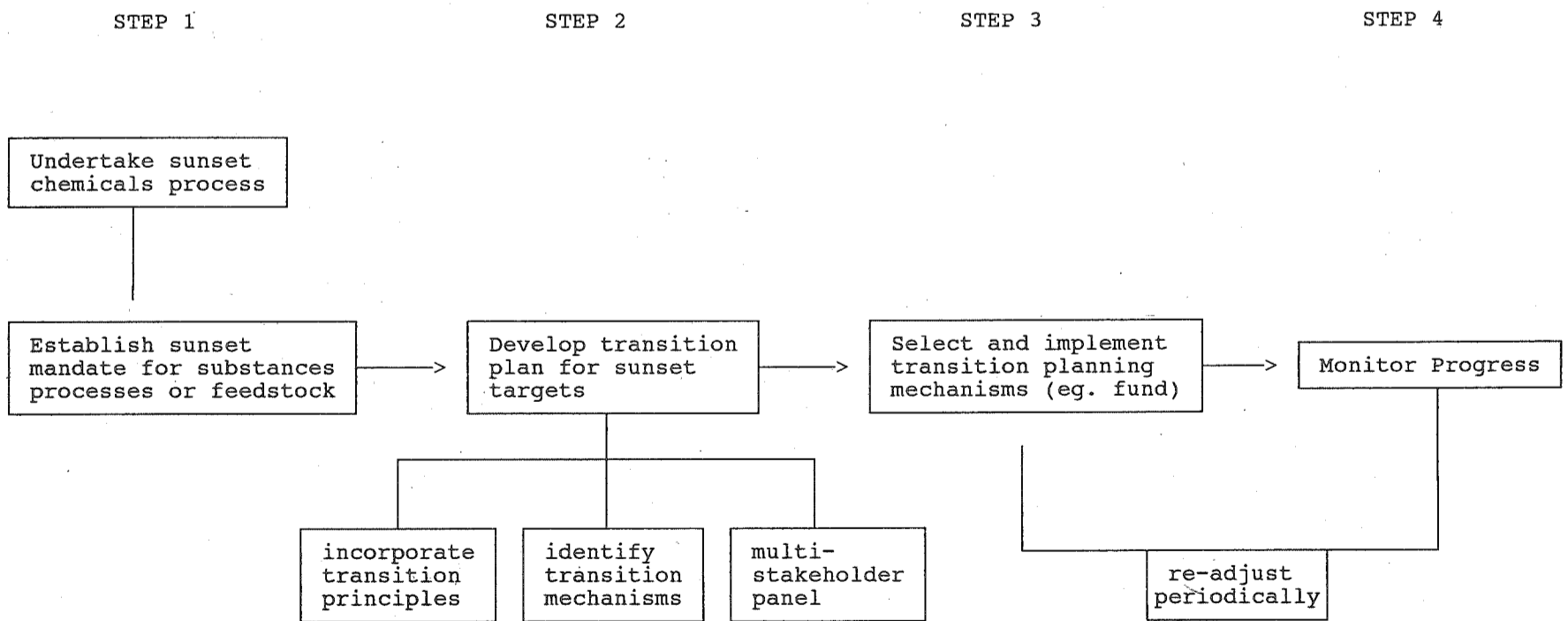
The most difficult and controversial mechanisms would probably be the establishment of interim sunset dates for specific PVC uses and applications as well as for specific disposal or production practices. It would be best that some guidance or framework for this be specifically included in the PVC Transition Planning task force's terms of reference.

Other mechanisms might include:

- Research and development on appropriate alternatives to PVC;
- Technical and transitional assistance for firms wishing to produce products or materials that serve as alternatives to PVC (with preference given to facilities that now produce or use PVC and/or its feedstocks);
- Public education as well as training to help create viable markets for products or applications that formerly contained PVC;
- Job creation programs targeted at communities that would otherwise suffer net job loss from PVC sunsetting; and
- Transitional assistance, including relocation pay, educational benefits, and interim income supplements, for workers who are displaced by sunsetting PVC and who lack access to equivalent job opportunities.

It is beyond the scope of this paper to fully develop the range of potential mechanisms that can drive a responsible and rational PVC sunset transition. It may be productive, however, to develop this further. To this end, we recommend that the IJC, during its next biennial cycle, sponsor a roundtable that can further explore this topic.

GENERIC TRANSITION PLANNING PROCESS



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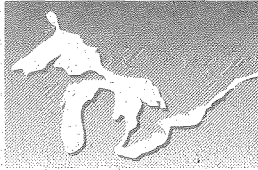
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