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The precautionary principle stimulus for solutions- and alternatives-based environmental policy

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Abstract

The precautionary principle is increasingly discussed in debates over appropriate measures to address complex and uncertain risks. The principle has generally been defined as having two main components: preventive action in the face of uncertainty and reversing the burden of proof. In isolation, these two components would suggest that precaution is primarily reactive to potential problems rather than proactive. More recent statements have suggested that thorough assessment of alternatives is critical to the effective implementation of the precautionary principle. Alternatives assessment—also referred to as options analysis and facility planning—redirects environmental science and policy debates from characterizing problems to identifying solutions. In this commentary, we examine the rationale for a focus on alternatives assessment in implementing the precautionary principle. We examine methods and examples of alternatives assessment, as well as opportunities for the principle's integration in environmental policy. We argue that a greater focus on alternatives assessment can enhance the ability of decision makers to make truly precautionary decisions, stimulate innovation toward sustainable production, and more effectively place burdens on to those creating risks. Such a focus forms an essential component of a shift from ''problem-based'' environmental policy to ''solutions-based'' policy. This shift requires adequate research resources, tools, and a government commitment to a new paradigm of environmental protection. We conclude that we will only reach the goal of sustainable production if we change our environmental protection focus from figuring out how bad the situation will be to

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seeking alternatives to problematic activities and designing the conditions for a more sustainable future.

Keywords: Precautionary principle; Pollution prevention; Alternatives assessment; Options analysis; Planning

1. Introduction

It took the U.S. Occupational Safety and Health Administration (OSHA) nearly a decade to finalize an exposure standard for methylene chloride. Many of those years of debate—over a chemical known to be problematic—were focused on minutiae about how the chemical was transported through the human body and caused its toxic effects. While these debates occurred, workers continued to be exposed to a potential carcinogen. This approach to environmental science and policy making is not only inefficient, it can also be harmful to health and ecosystems. If scientific research had been focused on identifying, analyzing, and piloting alternatives to methylene chlorine in various industrial operations while simultaneously exploring the substance's mechanism of action, workers might have been better protected more quickly (and perhaps at less cost). We do need to invest in science to better understand the problems caused by toxic chemicals and hazardous activities, but we also need to invest in a science of solutions that focuses on developing cleaner and safer materials and processes as alternatives to the substances and activities we seek to avoid. This focus on alternatives assessment is one of the chief challenges that the precautionary principle offers to the field of environmental science and policy.

The precautionary principle is increasingly discussed in debates over appropriate measures to address complex and uncertain risks. While it is a controversial topic in such discussions, the idea of taking protective action in the face of uncertain risks is not a new concept. Precaution is at the heart of centuries of medical and public health theory and practice. Although it has its roots in German environmental policy (the Vorsorgeprinzip), over the past 20 years, the principle has served as a central element in international treaties addressing North Sea pollution, ozone-depleting chemicals, fisheries, climate change, and sustainable development. The principle was recognized as a central principle of international environmental policy with the 1992 Rio Declaration of the United Nations Conference on Environment and Development, which stated:

> To protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation (see Raffensperger and Tickner, 1999).

While there are multiple definitions of the precautionary principle (see Sandin, 1999), every enunciation of the principle to date contains the elements of anticipatory, preventive action in the face of uncertainty. In most analyses, the principle has been defined as having two main components: preventive action in the face of uncertainty and reversing the burden of proof (i.e., that those who create risks should have an obligation to understand them and demonstrate safety). In isolation, these two components would suggest that the precautionary principle is primarily reactive to potential problems rather than proactive. While it is crucial to identify and anticipate potential harms, focusing only on what level of harm and uncertainty should lead to action keeps the principle in the often contentious and exclusive realm of risk and scientific analysis. It also invites criticisms that the principle blocks innovation, since the "action" to be taken is not defined. The focus on shifting the burden of proof also engenders controversy because proving safety is a difficult task scientifically. Focusing only on these two elements omits an important intention of original enunciations of the precautionary principle, which were proactive and inherently linked to sustainable development.

More recent statements of the precautionary principle, such as the 1998 Wingspread Statement on the Precautionary Principle, have suggested an additional component that is critical to the effective implementation of the precautionary principle: assessment of alternatives.[1] Alternatives assessment, also referred to as options analysis, facility planning, source reduction planning, and pollution prevention planning, redirects environmental science and policy debates from describing problems to identifying solutions. Established, yet flexible, structures for assessing alternatives can ensure that a full range of information on both hazards and opportunities for preventing harm is incorporated into environmental decisions. The concept of alternatives assessment is not new to practitioners of environmental impact assessment (EIA); indeed, it is a central, although, unfortunately, underappreciated and underdeveloped, aspect of the EIA process (see Steinemann, 2001).

In this commentary, we examine the role of alternatives assessment in implementing the precautionary principle. Following a discussion of the rationale for alternatives assessment as a central element of precautionary policies, we examine some methodological frameworks for undertaking alternatives assessment. We then examine some examples of alternatives assessment in practice and opportunities for its integration in environmental policy.

Experience has shown that applying precautionary policies through alternatives assessment can lead to win–win economic and environmental health outcomes. For example, integrated pest management, a holistic approach aimed at understanding the root causes of pest infestations and utilizing a broad range of

[1] The Wingspread Statement also noted the importance of democratic process in decision-making. We will only peripherally touch on this component in the present article.

tools to manage pests (including use of least toxic pesticides as a last resort), has proven to have both long-term environmental and economic benefits (Hollingsworth et al., 2002; Cuperus et al., 1997). It has also proven a more effective means to control pests in that it focuses on the root sources of pest infestations and has the additional benefit of educating of a wide range of actors in understanding the ecology of pests, their sources, and management.

We conclude that to achieve more sustainable production methods and products, we need to increasingly focus on what we term solution-based policy.

2. Moving from analysis to solutions: seeking alternatives to potentially harmful activities

The vast majority of environmental science used to support government environmental policy has focused on understanding and characterizing environmental and public health problems. Millions of dollars are invested annually in investigating issues ranging from the mechanism of action of a small number of toxic compounds and the fate and transport of substances in environmental media to the effects of contaminants on environmental resources and the technologies for measuring, monitoring, and managing those pollutants. While much of this work is important and valuable, it focuses on problems often at the expense of investigations that focus on solutions. To explicate problems without a proportionate effort to find solutions sharply diminishes the efficacy of environmental policy. A precautionary approach to protecting public and environmental health requires a solutions-oriented policy framework that seeks to identify, assess, and implement alternatives to high-risk materials and activities. Such a policy must be a holistic, integrated policy designed to prevent risks at their source, avoid risk shifting, establish far-reaching long-term environmental goals, and stimulate innovation in safer and cleaner forms of production, products, and activities. Such an approach is inherent in the original conceptualization of the precautionary principle.

The solutions striving spirit that was inherent in the initial German formulation of the precautionary principle appears to have been lost in translation because there is no direct correlation between the English and German words that embody this idea. "Precaution" translates back to German as *Vorsicht*, which, in turn, translates back to English as "caution". *Vorsorge* means something more than precaution (forward looking caution) or even foresight, as it is usually translated. It contains the idea of "caring ahead" or planning. It was formulated to address environmental contamination (primarily air pollution) in the late 1970s through careful forward planning. *Vorsorgeprinzip* was a principle for taking the future into account, a principle that would drive aggressive planning and would stimulate innovation in environmental technologies and create jobs. Planning was to be linked to the economic and environmental goals of the state (Boehmer-Christiansen, 1994). This German conception for the precautionary principle is

not clearly evident in the main components of the precautionary principle discussed in the literature—action in the face of uncertainty and burdens of proof on proponents—that relate to scientific evidence of potential harm. As one analyst has described it, discussions of the precautionary principle to date have been "science rich and technology poor (Ashford, 2000)".

The role of the precautionary principle in stimulating a search for alternatives to prevent harm has been introduced in relatively few enunciations of the principle. The principle has therefore been seen to provide relatively little guidance about what actions to take in the face of uncertainty regarding adverse effects. Furthermore, taking action to avoid a particular serious risk does not ensure that other risks will not be created (e.g., incineration at sea to avoid land based disposal).

Some enunciations of the principle have linked its implementation to specific methods for preventing harm. For example, the Bamako Convention on Transboundary Hazardous Waste into Africa calls for "taking appropriate measures to implement the Precautionary Principle to pollution prevention through the application of clean production methods, rather than the pursuit of a permissible emissions approach based on assimilative capacity assumptions" (see Raffensperger and Tickner, 1999). The London Dumping Convention goes a step further in stating that dumping of certain priority materials should be prohibited and requiring that parties seek land-based alternatives to dumping materials at sea (International Marine Organization, 1996). Central to both the Bamako and London Dumping Conventions is a conviction that a search for alternatives to avoid potential harm is the most appropriate and effective form of implementing precaution.

2.1. Why examine alternatives to potentially harmful activities?

There are several reasons why examining alternatives is such a critical part of precautionary policies.

2.1.1. Focuses on solutions rather than problems

The most important aspect of alternatives or options analysis is that it reorients environmental protection discussions from problems to solutions. Rather than examining the risks of one bad option, alternatives assessment focuses on choices and opportunities (O'Brien, 2000). It draws attention to what a government agency or proponent of an activity could be doing rather than to determining the "acceptability" of a potentially harmful activity (Ashford, 2000). Such discussions consider what "service" an activity provides and whether that purpose can be served in a less harmful and more effective way. For example, chlorinated solvents provide a service of degreasing and cleaning. Once we understand this service, it is possible to think of a range of alternatives, such as ultrasonic cleaning or less toxic aqueous cleaners or even redesigning a metal part so that the need for cleaning is eliminated altogether.

Examining choices permits a broader range of questions and considerations about activities, including their need. It allows a more comprehensive range of information than do narrow cause–effect questions to be used in decision making, which, in turn, can lead to more precautionary, preventive decisions (see O'Brien, 2000).

2.1.2. Stimulating innovation and prevention

Research has shown that strong regulation and options analysis requirements can drive innovation and produce substantial cost savings for firms as well as for society, in terms of health benefits (Office of Technology Assessment, 1995; Massachusetts Toxics Use Reduction Institute, 1997). Alternatives assessment calls attention to current and "on-the-horizon" alternatives and focuses resources on them that might otherwise be directed solely to the expensive and time-consuming process of describing the problem. It allows different parties to identify and recognize a wider range of hazards. Ashford (1999b) notes that regulatory strategies aimed at stimulating technology innovation can optimize occupational health and economic goals, as well as environmental ones. Such successes create optimism and enthusiasm for solving other environmental risks, whether in a firm or government agency.

2.1.3. Multirisk reduction

Alternatives assessment can be a more efficient means of reducing risks in the long term. Problem-based approaches generally examine one risk or problem at a time and are met with one solution at a time. These solutions are often inflexible (e.g., pollution control equipment) and require successive investments of technology to meet each new problem and standard. Alternatives assessment exercises can examine a broader range of factors and options. For example, a traditional risk-based approach might narrowly examine the risks of a particular agricultural pesticide while an options-based approach might examine the availability of safer pesticides, alternatives to pesticides altogether (organic agriculture), or alternative structures, such as smaller farms that might reduce dependence on pesticides. In a specific firm, an alternatives assessment might examine technology options that would benefit both worker and environmental health or ways to reduce toxic substance, energy, and water use simultaneously. Moure-Eraso (1999) has noted the benefits that cross-agency coordination on pollution prevention can bring in terms of improving both environmental and occupational health and avoiding risk trade-offs between the two.

2.1.4. Greater public participation and burden shifting

Examination of alternatives can fundamentally change burdens on decision makers and the public. The public will see risks as unnecessary when there are safer alternatives, and decision makers will be more willing to take action (O'Brien, 2000). For example, in examining phthalate plasticizers used in PVC toys, the Danish government considered not only exposure and toxicity but also

the availability of alternatives (Seedorff, 1997). The fact that alternatives were available, coupled with the unique susceptibility of children to effects of toxic chemicals and the uncertainty involved, provided enough justification for the government to issue a ban on these chemicals in toys.[2] Rather than being paralyzed, as U.S. government agencies often are, by having to defend each decision in detailed quantitative estimates, decision makers could use alternatives assessment both to defend themselves against judicial challenges and those of regulated parties and to garner public support for sensible solutions.

Alternatives assessment also allows decision makers to make proponents of potentially harmful activities more responsible to examine and implement safer options, to prevent risks before a technology is introduced and to continuously improve safety. For example, through the New Chemicals Program of the Toxics Substances Control Act, the U.S. Environmental Protection Agency (EPA) sends signals on the types of chemicals that should be avoided and provides guidance and support so that firms examine and develop safer chemicals and syntheses. This shifts the burden onto manufacturers to develop alternatives even when there is only limited evidence that a particular chemical might pose a risk. Such a search for alternatives reduces the uncertainty faced by both decision makers and proponents of activities in that one can expect greater certainty about the merits (availability, viability, and potential effects) of an environmentally superior alternative than about the risks of a single option (Ashford, 2000).

Nonetheless, assessing alternatives will not eliminate the need to assess risks (since we will always need to compare options and sometimes define permissible exposures), but this can be done incorporating a broader vision for an appropriate science that considers that cumulative and interactive effects is more explicit about uncertainties and incorporates an interdisciplinary approach (see Kriebel et al., 2001). Furthermore, feasibility of alternatives—both technical and economic—will always be an issue that must be considered. An alternative that is not economically or technically viable is not a reasonable alternative, although this can change with time.

2.2. The nature of alternatives assessment

While alternatives assessment or options analysis has received little attention in the environmental literature, with the exception of discussions

[2] The Danish example can be contrasted with the U.S. experience in addressing this same risk. The U.S. Consumer Product Safety Commission conducted a detailed quantitative risk assessment to determine whether the exposure risk was "unreasonable" (U.S. Consumer Product Safety Commission, 1998). The Commission failed to consider the availability of alternatives in their decision. However, the Commission acknowledged the uncertainties involved in estimating risk to children and recommended a voluntary withdrawal of these products, which ultimately achieved the same results.

regarding environmental impact assessments, it is not new in firms, where it is often an economic exercise. Options analysis is a central aspect of decision theory (Clemen, 1991): analyzing a problem or issue, identifying options to address it; analyzing pros and cons of different options, examining trade-offs, and then implementing the best option, with feedback to ensure that the best decision was made. Although the development and practice of quantitative risk assessment and cost–benefit analysis for environmental decision making was initially based on earlier work on "decision-theoretical frameworks" the process of options analysis was lost in its development. If options are considered in conventional risk assessments or cost–benefit analysis, they are generally narrow in scope—for example, one pesticide replacing another.

There are three lines of theory of alternatives assessment that merit brief discussion in thinking about a broader application of the technique. These are facility planning for pollution prevention, technology options analysis (TOA) for chemical safety, and alternatives assessment. They are similar in focus, although somewhat different in application. These three theories, or models, of analyzing alternatives are described below and compared in Table 1.

Table 1
Comparison of three theories of alternatives assessment

Model	Range of issues addressed	Scope of alternatives	Scope of information	Citizen participation
Facility planning	Relatively narrow	Limited	Limited	Low/medium
	Waste/emissions	Technologies	Chemical risk	Right to know
	Toxic substances	Mgmt. Practice	Tech. feasibility	Late in process
	Energy	Product design	Cost	
	Water	Facility focus	Effectiveness	
Technology options analysis	Relatively narrow	Limited	Limited	Low/medium
	Safety	Technologies	Chemical risk	Right to know
	Waste/emissions	Mgmt. Practice	Tech. feasibility	Late in process
	Toxic substances	Product design	Cost	
		Facility/sector Focus	Effectiveness	
Alternatives assessment	Broad	Wide	Broad	Medium/high
	Waste/emissions	Technologies	Pros and cons	Right to know
	Toxic substances	Mgmt. Practice	Chemical risk	Scoping
	Energy	Product design	Cumulative Effects	Alternatives identification
	Water	Facility/society Focus	Direct/indirect Effects	Providing info.
	Natural resources	Broad policy Change	Cultural/social Effects	Weighing info.
	Behaviors		Feasibility/cost Effectiveness	

2.2.1. Facility planning

Facility planning has played a critical role in the development of pollution prevention (source reduction) practice over the past 15 years. In early 1985 Geiser (1985, p. 1), described a source reduction plan as "a document describing the means and timing by which corporations will reduce the risks of toxic chemicals in production". He described a process for instituting such plans: development of chemical inventories (understanding how and why chemicals are used), establishment of priorities and numerical goals for reduction, development of alternatives, and establishment of schedules, performance targets, and monitoring to link changes to actual reductions.

As there is little social incentive for source reduction planning, Geiser argued that laws to implement planning requirements were needed. Such laws should internalize a planning function, causing firms to develop an increased awareness of the cost and risks associated with toxic materials and how to reduce their use. This would both raise attention within the highest levels of the firm and lead to an exploration of options. These planning requirements should also be linked to public access to data, although without compromising trade secrets. This would provide a greater incentive for firms to implement changes. Such access and public discussion would be most effective at the local level, where environmental impacts from industrial facilities are most pronounced. Private facility level planning should be augmented with state and local level government prevention planning. This would permit government agencies to better monitor and encourage (or mandate) facilities to comply with their own plans and guarantee that pollution prevention efforts are comprehensive and do not unfairly burden any particular sector (Geiser, 1985).

Facility planning for pollution prevention can lead to a series of important benefits for the firm and public. Planning allows firms to examine both inefficiencies in production systems and liabilities posed by the risks they create. In addition, planning provides an opportunity for learning, experimentation, and iterative improvement that is not inherent in approaches dominated by required end-of-pipe technologies. As Geiser (1985, p. 2) concludes: "A source reduction plan becomes a guide for raising the level of attention about toxic chemicals, increasing motivation to change, presenting alternatives, guiding decision making, advocating for resources, and providing information to evaluate the consequences of change."

Today, facility planning is a well-accepted part of many state pollution prevention programs, and many firms acknowledge the importance of environmental planning. The notion of planning for pollution prevention is now being expanded to other aspects of environmental performance through environmental management system programs, such as ISO 14,000 and other voluntary initiatives.

2.2.2. Technology options analysis

Technology options analysis is a similar concept, although its origins are more in the technology innovation and chemicals safety literature than in the business

decision literature. Ashford et al. (1993) introduced the concept of technology options analysis (TOA) as a method for comprehensively improving chemical safety. TOA would provide a mechanism for implementing the chemical safety requirements of the Clean Air Act's Risk Management Plan Rule (Section 112r), which calls on firms to institute planning to prevent chemical accidents.

Technology options analysis searches for "off-the-shelf" and on-the-horizon technological options to reduce safety risks and compares them with existing technologies on the basis of performance, health, safety, and ecological effects, but without the need for absolute quantification (Ashford, 1999a). It can also be used to identify the types of technologies that should be developed to reduce risks. The process of conducting a TOA would establish a valuable source of information for the firm, which may not otherwise know about technological options (Ashford et al., 1993). The analyses would help identify opportunities for implementing "inherently safer" technologies, those that involve redesigning production systems to avoid accident risks.

Technology options analyses could be performed by individual companies or by whole sectors. Ashford et al. (1993) argue that technology options analyses should be mandated by government agencies to be conducted yearly. Groups of government technology experts from different agencies or constituencies could examine the TOAs to ensure that options have been adequately analyzed and considered (Ashford, 2000). TOAs, particularly information on alternative technologies, could be publicly disseminated through a data clearinghouse. Government agencies could then designate certain technologies or uses of certain chemicals in certain applications as clearly inferior or superior. This would give government agencies (and indirectly the public) the ability to question firms that do not incorporate technologically superior options, placing the burden on firms to defend technological decisions and creating potential liability risks as well.

While Ashford et al. (1993, p. VIII-4) do not argue that governments should require firms to choose alternative technologies, "the process of conducting the TOA and reporting the results of the TOA would ensure not only that the firm recognizes the hazards to which it is exposing its workers and the surrounding community but also that it recognizes superior technological options that are available". Technology options analysis is an important tool not only to chemical safety decision making but also for pollution prevention decisions, where the two can enhance each other (Ashford and Caldart, 1997).

2.2.3. Alternatives assessment

Biologist and analyst O'Brien (2000, p. 213). states, "One of the most essential, and powerful steps to change is understanding that there are alternatives." Alternatives assessment, as elaborated by O'Brien (1999, 2000), has a much broader scope than source-reduction planning or TOA, in that it should apply to all human endeavors that might adversely affect health or the environment, not just particular technologies. Alternatives assessment can apply to all decisions, with potentially damaging effects on health or the environment,

including development, products, technologies, farming, family planning, and so forth. According to O'Brien, TOA and planning are simply examples of a wider process of alternatives assessment that should be instituted at the individual, firm, and societal levels. Alternatives assessment holds that when potential adverse effects of an activity are acknowledged, it is critical to examine whether options exist that pose markedly fewer hazards than others do, while meeting identified needs. This process can encourage solutions to environmentally damaging behaviors because it is eminently reasonable, leads to innovation, places a high value on morals, and puts forward a positive vision. Alternatives assessment consists of three main components:

Presentation of a full range of options. O'Brien argues that the presentation of alternatives should be reasonable, yet comprehensive. Reasonable can be defined as already in use or practice, having been brought to the attention of an individual or agency, or having been known to that party. Comprehensiveness requires defining the problem with a wide enough lens to ensure a broad list of alternatives, even those that may not be feasible at the present time.[3] The need for a particular activity must not be regarded as inevitable.

Presentation of the potential adverse effects of each option. The examination of potential adverse effects should be wide in scope including direct and indirect effects, cumulative effects, social/historical effects, short- and long-term effects, magnitude, and irreversibility. These are, in fact, the effects that are to be examined under the National Environmental Policy Act (NEPA).

Presentation of the beneficial effects of each option. Finally, an examination of benefits should include ecological, aesthetic, economic, and social benefits of an activity. When completed, such an examination will likely further highlight negative aspects of a particular option (e.g., the benefits of solar versus nuclear power). While O'Brien lists numerous government and other initiatives that incorporate prevention of harm and alternatives as a primary priority, she points out that mechanisms to require alternatives assessments are generally lacking.

Most importantly, as the public is affected by both government and private decisions, O'Brien argues that the alternatives assessment process must be a public process. The public should be able to affect the breadth and content of the options analysis. Public involvement will confer three main benefits: those who are or may be adversely affected can raise potentially better alternatives, the assessment draws on a wide set of "experts" and sources of experience, and the public becomes aware that environmental impacts are choices, not inevitabilities,

[3] For example, an examination of alternatives to hazardous waste incineration should not consider generation of hazardous waste as an inevitability but rather consider options that would reduce waste in the first place.

and that options for preventing these impacts are both technically and economically feasible. Finally, the alternatives assessment process can provide an accountability measure—a shift of burden to those who create risks.

2.3. Examples of alternatives assessment in practice

There are many individual examples of alternatives assessment in practice (see O'Brien, 2000, for extensive examples), although the practice has rarely been formally built into legislation and policy. This is partly because environmental agencies, particularly those in the United States, tend to focus on risk analysis and quantification (due to the need to defend decisions in the courts) and because of a lack of expertise and resources to encourage alternatives (the vast majority of government environmental resources are targeted at more detailed assessment and characterization of risk, not the development of alternatives). Generally, proponents of potentially harmful activities resist examining opportunities for change, as this might appear to be an admission that an activity is dangerous and open it to greater scrutiny. Resistance to formalized alternatives assessment in federal regulation is exemplified by EPA's implementation of the Risk Management Plan rule requirements under the Clean Air Act Section 112r. In developing its final rule, EPA expressly ignored urging by academic, labor, and environmental experts that the agency implement alternatives assessment as an integral part of chemical accident prevention activities within firms (see Tickner and Gray, 1995).

In those countries that have explicitly espoused the precautionary principle, alternatives assessment has also not been widely integrated into policies, although it is inherent in many decisions. One notable exception is the Swedish Substitution Principle, built into chemicals legislation. The 1985 Act on Chemical Products States (see Wahlstrom, 1999, p. 52):

> Anyone handling or importing a chemical product shall take such steps and otherwise observe such precautions as are necessary to prevent or minimize harm to human beings or to the environment. This includes avoiding chemical products for which less hazardous substitutes are available.

This enforceable clause serves as a general duty, applicable to both enterprises and individuals, to examine alternatives to hazardous products. The Swedish Government views this obligation broadly, including effects throughout the lifecycle of a product. To support the alternatives assessment, the Swedish government has engaged in a comprehensive process of identifying problem chemicals whose use should be reduced. For chemicals of high concern, the government has called for a progressive elimination of their use, a process called "sunsetting".[4] Despite the well-formulated nature of the substitution principle, a

[4] Sunsetting has been defined as a process involving generic criteria for unwanted chemicals, ambitious but long-term targets—providing early warnings to industry and lead time to develop new process and products, and ultimate chemical phase-outs (Wahlstrom, 1999).

detailed analysis of its use found that it had not been widely institutionalized (Nilsson, 1997). Furthermore, the Swedish government has yet to develop a formalized method for alternatives assessment.

The substitution principle is often linked to the broader concept of goal setting, an increasingly important aspect of European environmental policy efforts and a strong stimulus for alternatives assessment. Goal setting is a common practice in public health and important to achieving sustainability. It involves the establishment of aggressive, preventive health goals (e.g., eradication of childhood smoking or sexually transmitted disease or reduction of body burden of substances) and development of policies and alternative measures to achieve those goals (as well as barriers to their implementation), while minimizing social disruption (also known as "backcasting"). Goal setting focuses not on what futures are likely to happen but rather with how desirable futures can be obtained (Dreborg, 1996). In Sweden, for example, Parliament passed a set of Environmental Quality Objectives for the millennium. The overarching goal of these objectives (see Table 2) is "to hand over to the next generation a society in which the main environmental problems have been solved". The goals include implementation steps and measures to track progress. The 1996 Esjberg Declaration on protection of the North Sea establishes a generational goal for reduction of hazardous substance inputs in the North Sea region. In some countries, such as the Netherlands, goal setting occurs at a firm or sector level where sectors establish five year environmental plans (including goals and metrics), and enter into "covenants" with regulators that provide firms in that sector flexibility to achieve the plan's goals unless they fail to do so, in which case regulations are imposed (see Tickner and Geiser, 2003).

Table 2
Swedish environmental quality objectives

Reduced climate impact
Clean air
Natural acidification only
A nontoxic environment
A protective ozone layer
A safe radiation environment
Zero eutrophication
Flourishing lakes and streams
Good-quality groundwater
A balanced marine environment
Flourishing coastal areas and archipelagos
Thriving wetlands
Sustainable forests
A varied agricultural landscape
A magnificent mountain landscape
A good built environment

Source: Swedish Environmental Protection Agency, http://www.internat.naturvardsverket.se/index.php3?main=/documents/objectiv/objectiv.htm (accessed March 16, 2004).

In the United States, perhaps the most comprehensive institutionalized example of a requirement for precautionary alternatives assessment at the national level is the Environmental Impact Statement (EIS) process under the National Environmental Policy Act (NEPA) and similar state programs. Under the NEPA, federal agencies and private entities involving public investments must undergo an EIS process for activities that might have a substantial effect on the environment. The goal of NEPA is to foster better decisions and "excellent action" through the identification of reasonable alternatives that will avoid or minimize adverse impacts (Council on Environmental Quality [CEQ], 1992).

NEPA regulations specify a process that the federal agency (or private entity) must follow before initiating an activity. Through an interdisciplinary approach, integrating the natural and social sciences, agencies must (1) comprehensively identify and examine environmental effects and values; (2) rigorously study, develop, and describe appropriate (reasonable) alternatives in comparative form, including not moving ahead with an activity; and (3) recommend courses of action. The analysis of alternatives is considered by some to be the heart of the EIS. Agencies are instructed to undergo a "scoping process" to broadly define potential impacts and to examine them in detail, including direct and indirect impacts, cumulative effects,[5] effects on historical and cultural resources, impacts of alternatives, and options to mitigate potential impacts. When information is incomplete or unavailable on "reasonably foreseeable" impacts, the agency is instructed to discuss uncertainties and to include potential catastrophic impacts if there is credible scientific evidence to support them, even if their probability of occurrence is low. Some analysts have indicated that despite the requirements for broad analysis of impacts and alternatives, these do not tend to occur in practice (Steinemann, 2001).

Some analysts have suggested modifications to the EIS processes to ensure that more precautionary decisions are made. Gullett (1998) has suggested that EIS recommendations be highly persuasive, making the EIA process more substantive rather than merely procedural. Under his proposal, where scientific evidence was insufficient to predict nonnegligible impacts, precautionary actions should be taken. If a project were predicted to have significant impacts, that project would not be allowed to proceed, unless the effects were justified. Lemons and Brown (1995) have also suggested that agencies might be required in some instances to choose the alternative most consistent with the goals of

[5] Cumulative impacts are defined under NEPA as impacts that result from "the incremental impact of the action, when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions". The Council on Environmental Quality (CEQ), which oversees implementation of NEPA, has viewed this definition broadly (Council on Environmental Quality, 1997). For example, the effects of subsequent development in an area following highway construction would be considered a cumulative effect. The CEQ believes that such an analysis will provide a more comprehensive estimation of adverse effects and can help refine potential alternatives and mitigation procedures.

sustainability. They note that the EIS process should ensure that science is used to search for best options, and not just to analyze hazards and justify acceptable proposals. All three analysts argue that the EIS process must be followed by regular monitoring and should be linked to the management and regulation of existing activities in addition to proposed projects.

Alternatives assessment forms an integral part of pollution prevention efforts in the United States, although it is not directly mandated in most cases. According to the 1990 Pollution Prevention Act, the Federal Government is to institute pollution prevention as a fundamental priority in environmental regulatory programs. Implied in pollution prevention is understanding impacts and seeking alternatives to reduce them. While the majority of U.S. states have instituted pollution prevention programs, most are voluntary, and only a few (e.g., New Jersey and Massachusetts) require firms to undergo detailed facility planning processes (see Appendix A). In its pollution-prevention efforts, the EPA has initiated several programs to develop and encourage the implementation of alternatives to hazardous chemicals and activities. EPA's sector-based programs attempt to identify and disseminate alternatives that can be widely applied in a particular sector (USEPA, 1997).[6] The Design for Environment and Green Chemistry programs seek to identify and disseminate information on cleaner product designs, safer chemicals, and cleaner synthesis processes.

Green chemistry has rapidly evolved into a legitimate subfield of chemistry with new research centers, conferences, textbooks, training programs, and an annual U.S. Presidential awards program. The initiative is all about the development of alternative chemical processes and products that reduce wastes and pollution, conserve energy and water, and reduce the use of dangerous chemical intermediaries and products. While the enthusiasm for green chemistry solutions has been high, particularly in the polymer and pharmaceutical industries, little effort has been made to link the solutions to a prioritized list of chemicals or processes that are targeted for substitution or to promote green chemistry as a part of more formal alternatives assessments (see Geiser, 2001).

2.4. Applying alternatives assessment to support precautionary decision making

Substantial changes in legislation and policy will be needed to institutionalize alternatives assessment and reduce hurdles to its implementation. These would need to be supplemented by a formalization of alternatives assessment procedures. Policies and procedures designed to stimulate alternatives assessment would need to ensure that the process of assessing alternatives is comprehensive

[6] These sector-based approaches include the Common Sense Initiative, the Cleaner Technologies Substitutes Analysis program, and the Sector Handbook program.

and linked to policies that support implementation of the most benign (yet viable) options. They would also need to ensure that alternatives assessments are broad enough to consider not just existing alternatives but also alternatives generation. There are various avenues that could be pursued to more formally integrate alternatives assessment into environmental policy making. These are discussed further.

2.4.1. Initiating legislative and policy changes to explicitly require alternatives assessment in environmental decision making

Legislative changes would address both private and government decision-making processes. They might include the following:

- extending NEPA's EIS procedures to all private activities expected to have significant environmental impacts;
- legislating the substitution principle in chemicals policy, as in Sweden;
- extending the Pollution Prevention Act to require pollution prevention planning for all manufacturing facilities that report under the Toxics Release Inventory;
- expanding the Federal Insecticide, Fungicide, and Rodenticide Acts to focus on integrated pest control and pesticide use reduction in addition to pesticide registration;
- requiring firms to institute product and service lifecycle environmental management systems and undertake regular reviews of the system; and
- rewriting the Clean Water Act to establish procedures for achieving the Act's goal of zero discharge to waterways;
- establishing broad national environmental health goals and developing processes and objectives to meet them.

While federal legislation mandating alternatives assessment is unlikely given current deregulatory tendencies in politics, opportunities for instituting alternatives assessment through agency rulemaking and guidance could be thoroughly explored. For example, agencies could incorporate alternatives assessment as a condition of permitting decisions. Permit writers have extensive knowledge about technology options and are in a position to negotiate with firms. Expanding the use of multimedia permitting would significantly expand the scope of the alternatives assessment process. Alternatives assessments could form a necessary element of all enforcement and compliance actions (e.g., Supplemental Environmental Projects). EPA could more effectively use its powers under the Toxic Substances Control Act to require alternatives assessments for existing substances that may pose a risk of harm to the environment. EPA and OSHA could require alternatives assessments be completed (generically or when a hazard is suspected) to comply with general duties under the Occupational Safety and Health Act and the Clean Air Act Section 112r. Agencies could also provide guidance on potentially dangerous technologies

that may be subject to future regulation, instituting deterrent signals. Finally, agencies could provide guidance on the most environmentally friendly technologies or products.

Changes to legislation, rules, and guidance alone clearly would not be enough to ensure effective implementation of alternatives assessment, given limitations in regulation and enforcement. Market-based pressures coming from leading companies to suppliers and advocates is also necessary. For example, following a major industrial disaster involving one of its projects, the Swedish construction firm Skanska (the third largest in the world) issued a list of chemicals that should be substituted in all projects they use. The company presented this list to suppliers, requiring that they provide alternatives at a comparable cost (Tickner and Geiser, 2003). The broad coalition of advocates, health professionals, and health care institutions, Health Care without Harm, has placed substantial pressure on major hospital suppliers (group purchasers) to substitute problem materials such as latex, mercury, and PVC plastics (see http://www.noharm.org).

2.4.2. Developing guidelines and procedures for conducting alternatives assessments

Such procedures should be flexible and allow a broad examination of alternatives and potential trade-offs (see Appendix B for a suggested alternatives assessment process). Experience with Toxics Use Reduction planning (see Appendix A) in Massachusetts indicates that if procedures are too narrowly defined and inflexible, firms may complete the required process without necessarily engaging in thoughtful alternatives assessment (Campbell, 1999). The NEPA EIS process provides one model procedure for alternatives assessment, which lays out the components and minimum requirements but does not provide such specificity.

Alternatives assessment procedures would incorporate goals for reducing impacts, established at the national (or state) and firm level, as a means of establishing priorities and targets and stimulating the search for alternatives and innovation. They would contain opportunities for government review and democratic participation to ensure the quality and breadth of alternatives assessments, particularly when an activity may involve significant impacts. The alternatives assessment process would be an iterative one, with feedback and monitoring to ensure that overall risks are reduced.

2.4.3. Determining situations when alternatives assessments should be required

As decisions that may affect health or the environment are made on a regular basis by firms and the government, determinations of when alternatives assessments are to be conducted would be needed. For example, under the Massachusetts Toxics Use Reduction program, planning is required when a firm uses a specific chemical over predetermined amounts per year. In the development of an EIS, a potential for significant impacts leads to alternatives assessment requirements. Alternatives assessment could be required through a

listing process of designated private or public actions (e.g., construction of a new facility or permit renewal). Or such assessments, like environmental audits, could be regularly required for all major activities on a specific time basis. Uncertainty about potential impacts could also be considered a trigger for alternatives assessment (Gullett, 1998). The goal of these "triggers" is to ensure that alternatives assessment is an inherent part of environmental decision-making processes.

2.4.4. Addressing barriers to alternatives assessment

An overarching barrier is the entrenchment of the problem characterization processes, largely stemming from agencies' need to quantifiably defend decisions. Another is the inevitability that economic forces bring to bear on public and private decisions. These can only be addressed through legislation and policy. These barriers relate primarily to what can be termed "motivation and facilitation" or what Ashford (1999b) has termed "willingness and opportunity". Several mechanisms can influence motivation:

- mandated procedures that require proponents to understand their impacts and expand knowledge about possible changes;
- government quality control review of assessments and incentives/disincentives to implement safer options; and
- public disclosure of impacts and available alternatives, to encourage accountability.

The latter two could, however, result in unintended consequences, in that proponents may purposely limit the exploration of options if they might be held accountable for their implementation.

Facilitation requires a mixture of training, technical assistance, expertise, and incentives. Training in alternatives assessment methods can provide the skills needed to examine options, broaden the way individuals examine environmental problems, and create a base of individuals who can motivate decision makers to change. Training was critical to the success of the Massachusetts Toxics Use Reduction program in that it rationalized the process of alternatives assessment, encouraged individuals to undertake assessments and change their thinking, and provided a vocabulary to talk about alternatives assessment and explain it to management. Public or privately funded technical assistance could be provided to examine impacts and new technologies. Government agencies will need to develop relevant expertise and experience in facilitating alternatives-based approaches, as well as provide funding to academic and private institutions to support technical assistance efforts. Sector-based alternatives assessments may provide one way to maximize resources. Regulatory and economic incentives for innovation and implementation of safer alternatives could supplement training and assistance processes.

3. Conclusion

The addition of alternatives assessment as an essential component of the precautionary principle can enhance the ability of decision makers to make truly precautionary decisions, stimulate innovation toward sustainable production, and more effectively place burdens on to those creating risks. Mandates for thorough alternatives assessment can also address barriers to precaution in the U.S. policy making system, where agencies are often required to quantify risk to create a defensible decision-making record and are hence reluctant to act unless sufficient evidence of harm exists. The availability of feasible alternatives (or the probability that they could be developed) may provide a sufficient rationale for an agency to act in the face of uncertainty and to shift burdens onto the proponent of an activity, or it may provide a basis for citizens to lobby for change.

Given the great uncertainty surrounding many environmental risks, experience with the often slow and resource-intensive risk-by-risk assessment process, which has resulted in attention to only a small universe of risks and increasingly limited budgets of environmental agencies, alternatives assessment can provide an efficient and effective policy tool. We believe that alternatives assessment forms an essential component of a necessary shift from primarily problem-based environmental policy to solutions-based policy. We define solutions-based policy as holistic, integrated policy designed to prevent risks at their source, avoid risk shifting, establish far-reaching long-term environmental goals, and stimulate innovation in safer and cleaner forms of production, products, and activities. Such a shift requires adequate research resources, tools, and a government commitment to a new paradigm of environmental protection. We will only reach the goal of sustainable production and consumption if we change our environmental protection focus from figuring out how bad the situation will be to seeking alternatives to problematic activities and designing the conditions for a more sustainable future.

Appendix A.: Example: toxic use reduction in Massachusetts

The Massachusetts Toxics Use Reduction Act (TURA) of 1989 is an example of how alternatives assessment can facilitate the implementation of the precautionary principle in industrial processes and toxic chemicals. The Act requires that manufacturing firms using specific quantities of some 190 industrial chemicals undergo a biyearly process to identify alternatives to reduce waste and the use of those chemicals. Companies come to understand what they are trying to achieve with the toxic chemical and how they are using it, measure impacts and progress, and systematically search for and analyze alternatives.

In its broadest sense, The Toxics Use Reduction Act does not instruct industrial facilities to identify the safe level of use, emissions or exposure to chemicals. Any amount of use is considered too much. The act instructs firms to identify ways to redesign production processes and products and provides six different methods that "count" as toxics use reduction. Several aspects of the toxics use reduction process make it a good example of alternatives assessment to stimulate precautionary action:

Goal-setting. The Commonwealth established a goal of a 50% reduction of toxic by-product (waste) through toxics use reduction techniques. The Act also instructs companies to set goals and priorities for toxics use reduction.
No trade-off risks. The definition of toxics use reduction requires that the implementation of options of result in trade-off risks.
Alternatives assessment required. Companies are required to go through a well-defined alternatives assessment process whereby they understand why they use a specific chemical (what "service" it provides) and how it is used in the production process. They also conduct a comprehensive financial, technical, environmental, and occupational health and safety analysis of viable alternatives. The firm is not required to undertake any particular option, but in many cases, the economic and environmental/health and safety benefits provide enough justification for action.
Training and support. Toxics use reduction plans must be certified by "planners" who have undergone a 48-h training course and subsequent continuing education, which seeks to give them the skills and mentality to comprehensively examine options. Technical and research support is provided to firms to complete the alternatives assessment and identify and examine potential options.
Follow-up. Companies are required to measure their progress yearly at reducing their use of toxic chemicals. This information is publicly available.

Between 1990 and 2000, the Toxics Use Reduction Program can demonstrate that some 550 firms that have continuously participated in the program have reduced the total amount of toxic and hazardous waste by 58% and the use of the targeted toxic chemicals by 40%, while the state has seen a 90% drop in Toxics Release Inventory releases. In 1997, the Commonwealth conducted an analysis of the Act demonstrating that the Act saved Massachusetts industry some US$15 million over a seven-year period. This figure does not include the public health and environmental benefits gained through the program (Massachusetts Toxics Use Reduction Institute, 1997). In reviews of the toxics use reduction planning experience, regulated companies noted the importance of planning in asking simple questions about processes and opening doors to other problems. Moreover, the materials accounting (problem characterization) process was a critical stimulus in driving alternatives assessment for toxics use reduction. It revealed

the mismanagement and inefficiency of materials use that many firms had not realized.

Analysts have identified some specific weaknesses in the toxics use reduction approach. First, successful identification and implementation of options was dependent on the culture of a firm and often the zeal of a particular individual in the right position. As a result, in many firms, producing the required plan was more important than a comprehensive analysis of options. This was reinforced by the law's language, which provides precise specifications for plan elements but little in the way of standards for preparation. Furthermore, regulatory authorities lacked procedures, measures, or expectations for reviewing plans or pressuring firms to implement options. Authorities focused on completion of plan elements but did not provide the inspection and oversight of quality and implementation (Campbell, 1999). Most firms focused on options that were the easiest and least costly in the short term and avoided examination of more far-reaching options that might achieve greater multirisk reduction. The law's prescription itself may not have driven alternatives assessment but rather successful options identification and implementation were often serendipitous. Finally, the options analysis exercise required under the Act is largely private, limiting accountability of firms and government, as well as opportunities for public pressure for change.

Appendix B.: A process flow for alternatives assessment

The goal of alternatives assessment is to identify and examine opportunities to prevent environmental health impacts from an activity. A secondary goal is to drive innovation toward more environmentally friendly and sustainable technologies, products, and practices. Thus, alternatives assessment should consider not only existing, easy, and feasible options, but also those that can be developed—that are "on the horizon". The most effective alternatives assessments start with a broad problem definition and address multiple risks at once (e.g., multiple chemicals, media, or facilities). Alternatives should be considered in terms of substitution, modifications to an activity that would prevent impacts (prevention opportunities), as well as stopping an activity or not allowing one to be initiated.

Alternatives assessments often have the most impact when undertaken early in a decision-making process. In general, the assessment should be carried out by the proponent of the activity but involve opportunities for public participation in the collection of information, identification of alternatives, and discussions leading to the ultimate decision.

Procedures for completing the alternatives assessment should be provided as flexible guidelines to ensure quality analysis and substantive, thoughtful results. Technical assistance should be available to those undertaking alternatives analysis to build capacity for more comprehensive and thoughtful analysis.

The quality of the analyses should be reviewed by appropriate authorities, third-party reviewers, or stakeholders, depending on the situation.

B.1. Steps of an alternatives assessment

B.1.1. Examination/understanding of impacts and purpose of the activity

The purpose of the activity is examined to better understand the "service" that the activity provides (e.g., a chlorinated solvent provides degreasing, a pesticide provides pest control). The range of potential adverse effects should be detailed at this point as well as any waste and inefficiencies. For example, a materials accounting process for a chemical would show how the substance flows through the economy (or an individual facility) and how much of it is converted into waste and emissions. Finally, benefits of the activity—production, health, socioeconomic—should be outlined.

B.1.2. Identification of a wide range of alternatives

The goal of this step should be the identification of clearly superior options from a health and safety perspective. Alternatives identification should be a brainstorming exercise to identify a broad range of existing and on-the-horizon possibilities, including stopping the activity all together. A broad problem scoping will help ensure that identification of alternatives is comprehensive and addresses the impacts of multiple risks. For example, in the case of a pesticide, options should not be narrowed to other pesticide choices but should include integrated pest management and nonchemical methods. The alternatives identification exercise should include as diverse a group of "experts" as possible, such as shop floor workers, management, affected citizens, engineers, purchasing agents, academics, and technical assistance providers. At this point, options should not be limited by economic or technical feasibility, but they may be screened to eliminate those that are clearly impractical.

B.1.3. Comparative analysis of alternatives

The goal of comparative options analysis is to thoroughly examine and compare the technical feasibility and economic, environmental, and health and safety impacts and benefits of the existing or proposed activity and identified alternatives. This analysis should consider uncertainties and potential errors, not only in understanding health impacts but also in the viability of the chosen alternative (Ashford, 1999a), bearing in mind that errors in costs or technical viability are more readily apparent and remediable than are errors in health impacts. Where options are limited and relatively similar to the existing/proposed activity, this analysis might be complex and uncertain, requiring comparative estimates of risk. In other cases, where clear environmental health benefits reside in an alternative (e.g., water as a replacement for a chlorinated solvent), the analysis will be more easily completed. Several methodologies have been

developed for these types of comparative analyses, although more extensive resources are needed.

B.1.4. Alternatives selection—including "no action"

This stage of the alternatives assessment should include a narrative of the identified options, results of the comparative analysis, uncertainties in the options, and criteria on which the alternative was chosen (cost, technical feasibility, reduction of impacts, etc.). A rationale should be presented for the final choice of alternative, as well as for discounting other options. It may be possible to institute interim alternatives while long-term alternatives with greater environmental health benefits are being developed.

The "alternatives plan" should contain a comprehensive description of how the alternative will be implemented, including cost limitations, how technical barriers will be addressed, how specific hazards associated with the chosen alternatives will be minimized, and how any trade-off impacts (worker dislocation, changes in workplace design) will be addressed. It should also contain a summary of how progress in reducing impacts will be measured and what type of monitoring will be put in place for early detection and action on potential impacts.

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