Government and Environmental Innovation in Europe and North America

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ABSTRACT

This article challenges certain tenets of the theories of reflexive law and ecological modernization. While far-sighted prevention-oriented and structural changes are needed, some proponents of these theories argue that the very industries and firms that create environmental problems can, through continuous institutional learning; the application of life cycle analysis; dialogue and networks with stakeholders; and implementation of "environmental management systems," be transformed into sustainable industries and firms. While useful, these reforms are insufficient. It is not marginal or incremental changes that are needed for sustainability, but rather major product, process, and system transformations – often beyond the capacity of the dominant industries and firms. This article also questions the alleged failure of regulation to stimulate needed technological changes, and identifies the conditions under which innovation for sustainability can occur. Finally, it discusses differences in needed policies for industrialized and developing countries.

KEYWORDS: ecological modernization, reflexive law, technological innovation, environmental regulation, voluntary agreements, negotiation

INTRODUCTION

While ecological modernization theory has its theoretical origins in continental Europe (Andersen & Massa, 2000; Mol & Sonnenfeld, 2000a; Mol & Spaargaren, 2000), paradoxically some of its effects have been felt perhaps most strongly in the United States (US). There, some of its tenets have arguably been incorporated into the anti-regulatory and anti-government Reagan ideological revolution, and into social and environmentalist responses to that revolution. It can be argued that ecological modernization has not been adopted as a theory of environmental governance per se in the US.[1] Various "articles of faith" have arisen there, however, about the best way to achieve improvements in environmental quality. These include the use of economic instruments, exploiting industry's potential to engage in technological innovation, encouraging more voluntarism and stakeholder participation in governance, and promoting demand-side policies focused on green consumer behavior (cf. Fiorino, 1999).

These articles of faith have been endorsed by government, industry, and mainstream environmentalists alike. Each was dissatisfied with the gridlock in environmental policy, and the opportunity to try a different approach was appealing – though different actors were more attracted to some initiatives than to others. After two decades of experience with such new approaches, the need for a strong, directive government in fostering sustainable industrial transformations requires examination.

Not being a social theorist by training or inclination, I was at first humbled by reading the complexity, richness, and sophistication of the works and reviews of the numerous serious contributors to the theory. Upon further reflection, it became apparent that different "schools" exist within the broad range of ideas labeled reflexive law (Teubner, 1983) and ecological modernization (Mol, 1995).[2] Far-sighted prevention-oriented and structural changes as advocated by numerous scholars in these approaches are certainly needed. The weakest feature in the more neo-liberal ecological modernization formulations, however, is that they implicitly argue that the "problem industries/firms" – the very industries/firms that create environmental, health, and safety problems – can transform into "green or sustainable industries/firms." This can be accomplished, it is argued, through continuous institutional learning; the application of life cycle analysis; dialogue and networks with suppliers, customers, environmentalists, and workers; and the commitment to implement "environmental management systems." In all ecological modernization approaches, efforts can be found to influence governmental regulation through consensus, dialogue-driven processes and to encourage governments to use economic instruments. But it is not clear to what extent the different branches of ecological modernization theory see these policy and regulatory innovations as a complement to, rather than as a substitute for, so-called "command and control" regulation.

Further, rather than fostering more effective regulation through using consensus and dialogue-driven processes as an adjunct to regulation, there is increasing evidence that "cooperative" approaches may often actually impede the needed changes and transformations -- especially if governmental processes are unduly influenced, or even captured, by the problem industries (Coglianese, 1997; Caldart & Ashford, 1999). The remainder of this essay, explains why I believe this to be so, and why dialogue and consensus, while useful, on their own are likely not sufficient to transform the industrial system into a sustainable one. At the core of this analysis is the argument that it is not marginal or incremental changes that are needed (Andersen

& Massa, 2000), but major product, process, and system transformations -- often beyond those dominant industries and firms are capable of developing easily.[3]

ECOLOGICAL MODERNIZATION AND ITS PROBLEMS

Ecological modernization theory apparently arose in response both to those who argue for a transformation of society/the industrial system according to the anti-development formulations of deep ecology -- and alternatively to those who were convinced that while historic regulatory approaches were incapable of adequately addressing remaining or new environmental problems, other options might be successful. What emerged as tenets of present formulations of the still-evolving theory are several lines of thought which begin differently in different disciplinary domains, but have since been melded into the theory:

1) unregulated capitalism is responsible for the present ecological and environmental problems, and this is partly because the prices of goods and services do not adequately represent the social costs of production and consumption;
2) historically, "command and control" regulation has been only partly successful in correcting market failures, because it proved inflexible, it under-utilized economic instruments, and it focused on end-of-pipe approaches, rather than on preventive or precautionary "cleaner technologies"; and
3) under thoughtful "reflexivity"(Teubner, 1983), the present and enlightened industrial actors can succeed in advancing the material well-being of citizens, contribute to their nation's competitiveness, and can also contribute to the necessary scientific and technological changes (innovations) in products, processes, and services to adequately meet the environmental challenges -- especially if a broad array of stakeholders are involved.

My purpose here is not to weigh in on one side or the other of the sustainable development/anti-development debate or to address the subtleties of connecting these trains of thought, but rather to argue that some forms of ecological modernization theory as it is developing have the danger of not offering a solution to the problem. In a too narrow or strict or one-sided application, these basic tenets alone are unlikely to be strong enough to guide the policies needed to more closely approximate a sustainable industrial system.

Even if we take comfort from the fact that the eco- or energy efficiency of products and services have made dramatic improvements over the last decade, the fact of the matter is that the rate at which the best technologies are diffused into the world economy and the rate at which consumption is increasing will not be sufficient to address the environmental problems we now face (Andersen & Massa, 2000).[4] Not only are eco-systems seriously endangered by destruction of the ozone layer, global warming, and the global diffusion of pesticides, but new threats are now suggested related to endocrine disruption compromising the reproductive systems of all species at levels of chemical exposure in the parts-per-trillion, rather than parts-per-million range (Colborn, Dumanowski & Myers, 1996). Evidence is increasing that diseases heretofore unconnected with chemical exposures, such as autoimmune disease, attention deficit hyperactivity disorder, and childhood cancers, are in fact consequences of the chemicals-based industrial production and consumption (Ashford & Miller, 1998).

Regarding unregulated capitalism, getting the prices right will help, but it will only address market imperfections, not the fact that for some problems, such as global warming, even a perfectly working market is insufficient to address the problem -- because of both the disparate time horizons over which present costs and future benefits are distributed, and because equity concerns are not adequately reflected in market decisions.

Some commentators have simply read the history incorrectly or too narrowly with regard to the limitations of command and control environmental regulation. For neo-liberal economists, for instance, command-and-control regulation is too often a conveniently-constructed straw man; it is alleged that most regulation requires specific technologies to address environmental hazards. In the US, regulation has, in fact, mostly been definitive on targets, but flexible on means. Where it has been stringent enough and designed thoughtfully -- which as ecological modernization theorists rightly claim has not always been the case -- regulation has spurred technological innovation of the kind desired by the ecological modernization theorists (Strasser, 1997). In Europe, regulation reflects a softer, less-confrontational, and hence less technology-forcing situation (Gouldson & Murphy, 1998; Wallace, 1995). This demonstrates the need for a less generic and more context-specific idea of ecological modernization.

Finally, inviting industry to solve the problems by operating in a more modern and enlightened manner, can be a viable addition to conventional ideas of environmental regulation. But counting only or mainly on existing industries for environmental transformation ignores increasing evidence that it is not just willingness and opportunity that is required for such change, but that a third crucial condition -- the ability or capacity to change -- is essential (see below). This is unlikely to be present or within grasp of the dominant technological firms (Ashford, 2000). Dominant technologies rarely if ever displace themselves in product markets (Christensen, 1997), or in general (Schumpeter, 1939). In some situations they may do so because society or market demand sends a strong signal, but not in all or even in most of the cases. This belief has, so far, turned out to be mostly wishful thinking.

If rather modest improvements in the eco- and energy efficiency of products, processes, and services were sufficient to address the problems that we now face, then the more neo-liberal, market-oriented and technocratic forms of ecological modernization in the industrialized nations might be of great interest for fashioning solutions to world-wide sustainability.[5] Unfortunately, this is not the case. On the other hand, in developing countries -- which to an increasing extent follow, copy, and adapt technologies from the developed world, rather than develop new ones -- a theory of governance which involves the stakeholders and provides the most receptive environment possible for technology diffusion -- does have merit, especially where traditions of government intervention and regulation are weak.[6] But, the developing world needs something good to copy or adapt. Ecological modernization, at least in its neo-liberal incarnation, does not produce the technological and social innovations necessary to do the job.

The remainder of this essay addresses the alleged failure of regulation, the evidence that cooperative approaches by themselves offer more promise, the conditions under which innovation needed for sustainability can occur in industrial firms, and approaches to resolving the apparent dilemmas in environmental policy and governance.

HAS REGULATION FAILED?

The justification for government intervention in activities of the private sector is cited by neo-classical economists to be based on "market failure," the inability of the unregulated market

to internalize the social costs of production. These market failures are legend and are manifested as environmental degradation, resource depletion, and compromises to worker and consumer health and safety. In the 1970s, traditional end-of-pipe regulation significantly improved industrial emissions to air, effluents to water, and waste disposal and treatment. In recent times, progress in environmental improvements appears to have been slower. In addition, industry's objection to so-called "command-and control regulation" has been increasingly vocal, especially in the US. At the same time, in both the US and Europe, concerns with increasing levels of unsustainable production and consumption have lead to the realization that major changes in industrial practices are needed "beyond compliance" with current environmental standards and current levels of energy production and use.[7] Thus, frustration has been voiced by both the regulated industries and environmentalists about traditional regulatory approaches. However, US and European responses to this frustration have been different.

In the US, the anti-regulatory climate of the 1980s -- and continuing to this day -- argued for reducing the burdens on industry who "knew better" than the government bureaucrats how to handle responses to environmental challenges. Those observers who were disillusioned with government's inability to deliver better protection argued that "we have exchanged market failure (the original justification for government intervention) for bureaucratic failure limits in central regulatory capacities)" (Fiorino, 1999, p. 451). A closer reading of regulatory history gives a different interpretation. Markets are inherently unable to internalize (unpriced) social costs without intervention. Bureaucracies, while not perfect, are not inherently flawed. In the US, it was national leadership that failed since the 1980s to streamline regulatory processes[8] and to promulgate the kinds of standards that stimulated technological changes that could lead to significant change and win-win scenarios (Ashford, 1993). While the US Pollution Prevention Act was enacted in 1990, no serious effort followed at translating this act into meaningful requirements. Industry "picked the low-hanging fruit" and worked at the margin of undertaking housekeeping changes, rather than implementing serious technological change (Ashford, 1993; EPA, 1991; Hirschhorn, 1995). The truth is that there were plenty of unexploited win-win opportunities for pollution prevention/cleaner production. Industry was not very interested in pursuing them, given other interests, reduced pressure from a reluctant, beleaguered, and underfunded regulatory system, and the fact that serious pollution prevention efforts take time, are disruptive to an industry struggling to meet inventory demands, and risky – even with saving of costs and increasing profits in the longer run.

The US Environmental Protection Agency (EPA) understood the need for bureaucratic reform, much in line with more sophisticated and less neo-liberal ecological modernization ideas. It established the multi-stakeholder National Advisory Council on Environmental Policy and Technology (NACEPT) as a sister advisory board to its Science Advisory Board to work on accelerating progress and reducing perverse incentives for the adoption of cleaner production and pollution prevention technologies. The Council subscribed to a win-win philosophy, believing that changes in technology could provide better compliance at lower costs. The author chaired the core committee of that council – the Technology, Innovation, and Economics Committee -- which issued a series of reports resulting from multi-stakeholder working groups in the early 1990s, laying out the strategies for streamlining and reducing barriers to environmental technology diffusion and innovation, mostly within the existing regulatory structure (NACEPT, 1991-1993). Eventually these ideas were transformed in the US EPA's Technology Innovation Strategy. Unfortunately, because standards promulgated in the decade prior to these efforts were

not stringent or demanding, industry was not interested in taking advantage of a streamlined regulatory approach to environmental protection.[9]

The strategic question is whether and how we can re-conceptualize the regulatory approach which has as its focus the deliberate stimulation of innovative solutions, rather than the historical defining of environmental problems and "acceptable risk" (Finkel & Golding, 1994), or whether we should retreat from the traditional path of regulation and only or mainly trust on market actors and consensual styles of environmental reforms.

"Command-and-control" regulations have been the whipping boy of economists and government critics, often with a misconception of what these regulations actually require. The implication of the term is that both the targets and the means for compliance are specified by regulation. In fact, this is only occasionally the case. Many environmental standards are health-based standards, without reference to the means of compliance. Most so-called technology-based standards require the adherence to pollution levels that reference technologies can achieve, but the standards do not require that these reference technologies actually be used. The use of more innovative or cost-effective technologies are, in fact, possible and there are statutory provisions allowing their adoption (Ashford, Ayers & Stone, 1985; Becker & Ashford, 1995), although – as discussed above – environmental authorities such as the US EPA could do more to encourage their use.

In a number of studies at the Massachusetts Institute of Technology (MIT) beginning in 1979, it was found that in the US, regulations in the chemical producing and using industries did stimulate significant fundamental changes in product and process technology, which also benefited the industrial innovator, provided the regulations were stringent and focused (Ashford et al., 1985). This empirical work was conducted fifteen years earlier than the emergence of the much weaker Porter Hypothesis which argued that firms on the cutting edge of developing and implementing pollution reduction would benefit economically through "innovation offsets" by being first-movers to comply with regulation (Porter & van den Linden, 1995a, 1995b). Analysis of the US situation since the earlier MIT studies reinforces the strategic usefulness of properly designed and implemented regulation, complemented – but not replaced – by economic incentives (Strasser, 1997).

Perhaps paradoxically, in Europe where regulation was arguably less stringent and formulated with industry consensus, regulation was not found to stimulate much significant innovation (Kemp, 1997). In the Netherlands, for instance, a concern with future sustainability heralded a series of National Environmental Policy Plans which were characterized by mandated clear future targets for environmental performance, coupled with a cooperative partnership involving government, industry, and NGOs to achieve those targets through flexible means. Far-future environmental goals were subjected to "backcasting" to determine what changes needed to be put into practice now to achieve those goals (Vergragt & van Grootveld, 1994). The Dutch researcher, Kemp, whose views are informed mainly by European environmental regulation (Kemp, 1994 and 1997) acknowledges that regulation can be an important tool both to stimulate radical (or disrupting) and environmentally superior technology and to yield economic benefits to innovating firms. However, he also expresses faith in evolutionary, stepwise change within the original 'technology regime' to eventually bring about the needed transformations. In contrast, a comparison of the Dutch and UK regulatory systems (Gouldson & Murphy, 1998) concludes that stringent regulation, without yielding to the pressure of the regulated firms common in the UK system, is <u>essential</u> to bring about significant technological changes. Kemp argues that for a technology regime to shift – i.e., to transform – there has to be a unique/new

niche for a radical alternative (Kemp, 1994). What Kemp may not fully appreciate is that regulation may be essential to create that niche and such niches are unlikely to be created by incumbent firms. New entrants, rather than the regulated or "problem industries/firms" will be the responders, and it may be that technological innovation by new entrants is what is needed for sustainable development, consistent with the central theses of both Christensen (1997) and Reinhardt (1999). In his later work, Kemp has come to accept the view that outsiders are essential (Kemp and Moors, 2002).

HAVE CONSENSUS-BASED APPROACHES SUCCEEDED?

Consensus-based, cooperative approaches have been promoted both in the US (Susskind & McMahon, 1985) and Europe (COWI, 1997; EEA, 1997). It is argued that alternative dispute resolution (ADR) or negotiation can be a useful tool in the establishment, implementation, and enforcement of environmental and occupational safety and health policy. Negotiation can facilitate a better understanding of issues, concerns, facts, and positions among adversaries. It can also promote the sharing of relevant information, and can provide an opportunity for creative problem-solving.

While there is little doubt that constructive dialogue among the stakeholders can reduce misunderstandings, facilitate an appreciation of common ground, and generate solutions that are mutually-advantageous in the context of a clear set of established performance criteria or environmental goals, the superiority of self-regulation or "voluntary regulation" as a replacement for government protection is another matter (Harrison, 1999). Of course, as ecological modernization theorists have argued, negotiation can be a valuable tool used as an adjunct to regulation, e.g., in apportioning financial responsibility among a large number of polluters in toxic waste clean-up operations. Alternative dispute resolution seems to work best applied to the means by which targets and goals are achieved, rather than in establishing the targets themselves (see also Mol, Lauber, & Liefferink, 2000). In that sense, negotiations and consensus building can complement direct regulation, although the extent to which very much depends on the prevailing policy styles and culture rooted in historical developments. Negotiation can, however, not be viewed as an overall panacea for all the various difficulties that typically confront the regulatory policy-maker.[10]

Both Coglianese (1997) and Caldart & Ashford (1999) have reviewed the record of negotiated rulemaking in the United States and are critical of the outcomes of this approach. Aside from not delivering on the promise of faster and less litigious rulemaking, in general the approach appears to offer less protection and inhibit technological innovation. Capture of regulatory agencies by dominant regulated firms remains a serious limitation of the extent to which major innovation occurs as a result of negotiated rulemaking, implementation, and compliance (Caldart & Ashford, 1999). In the international context, it is widely acknowledged that the Montreal Protocol, an international agreement to phase out ozone layer destroying chemicals such as chlorofluorocarbons (CFCs), was ultimately supported by a desire of CFC producers to protect their markets by fashioning an agreement that favored their own substitutes (Reinhardt, 1999), that were not as protective of the ozone layer as those that emerged from other firms, later than might have been the case.

It is useful to note that "reinvention" initiatives by the US EPA are generally acknowledged not to be successful, notwithstanding rhetoric to the contrary by the agency. Many

of these same concerns as are voiced in the context of negotiated rulemaking are apt when negotiation is used in an extra-statutory sense, as it is now being used in US EPA's Project XL and Common Sense Initiative, in an attempt to change regulatory policy. Where there is no meaningful incentive for industry negotiators to move away from the status quo -- that is, where there is no impending "default" standard or requirement that they perceive as onerous -- they may well be interested only in those regulatory changes that save them money (Caldart & Ashford, 1999).[11]

Industry has also created unilateral voluntary programs, such as Responsible Care, that boasts of modest success, but their effectiveness is unclear. Firms tend to respond at their own pace, in their own way, and mechanisms for trade-association monitoring and sanctioning are weak (King & Lenox, 2000; Howard, Nash, & Ehrenfeld, 2000). There is evidence that these programs tend to inure to the advantage of large firms over small firms (Nash & Ehrenfeld, 1996), possibly favoring undesirable increased industry concentration.

There are also examples where cooperative approaches that include environmental and labor stakeholders have yielded positive outcomes resulting in the adoption of better, but not development of new, technologies. In the context of the existence of clear mandated government targets, labor union participation can help firms comply with environmental requirements (Kaminski et al., 1996). Since workers are often also the residents of the communities surrounding industrial facilities, they are in a unique position to influence technological changes that improve both worker health & safety and the environmental consequences of production. They are often silent partners with community groups in the latter's negotiation of "good neighbor agreements" with local industry (Lewis, 1993).[12] Labor contributes technical knowledge about plant technology to the local environmental groups who in turn press industry for improvement. Unfortunately, mechanisms improving access to information concerning toxic substances, known generally as right-to-know laws and policies, have not provided either labor or the community access to information about alternative technologies of production (Orum, undated). Thus, both informational avenues concerning technology options and the means to act (the right to act) upon that knowledge is required in order to empower workers and communities to press for technological change.

In Europe, two comprehensive studies of "voluntary agreements" conclude that where there are no regulatory requirements to "back up" cooperative, negotiated agreements, little real progress at improving environmental and energy efficiency performance has been achieved (COWI, 1997; EEA, 1997). The exception is noted to be the "Dutch Covenant," which is much more than a voluntary agreement between industry and government. It is, in its best form, an enforceable contractual promise by the firm, with participation by environmentalists, and milestones and oversight with legal power to back up the agreement. But these approaches can be seen in line with more sophisticated ecological modernization ideas, where intelligent combinations of consensual negotiations and direct government regulation are made.

CONDITIONS FOR ADEQUATE INNOVATION

It is clear that firms need to adopt or develop technologies (and work practices) different from those currently being used in order to significantly improve their environmental performance. Depending on the particular environmental challenge, the needed technological change could be off-the-shelf available technology, technology available in a different industry, technology that needs to undergo minor development and adaptation, or major new approaches.

These different types of changes are known as diffusion, technology transfer, incremental innovation, and either radical or disruptive innovation respectively.[13] In any case, there are three elements that are necessary and sufficient for technological change to occur: willingness to change, the opportunity to change, and the capacity to change (Ashford, 1993 and 2000).

Current ecological modernization approaches focus mostly on enhancing the capacity to change though cooperative efforts that also influence willingness and opportunity. When implementing ecological modernization for capacity-building, the question of "capacity building for what?" must be addressed. Neglecting this question has been a major omission in several branches of ecological modernization -- especially in failing to take into account the degree of innovation and the distinction between radical and disrupting innovation (Christensen, 1997).

Willingness, opportunity, and capacity affect each other, of course, but each is determined by more fundamental factors. Therefore, policy approaches need to be chosen and designed for their ability to change these more fundamental factors. Willingness is determined by both (1) the firm's attitudes towards changes in production technology and products in general and by (2) its knowledge about what changes are possible. Improving the latter involves aspects of technical capacity building, while changing the former may be more idiosyncratic to a particular manager or alternatively a function of organizational structures and reward systems.[14] The syndrome "not in my term of office" describes the lack of enthusiasm of a particular manager to make changes whose benefit may accrue long after (s)he has retired or moved on, and which may require expenditures in the short or near term.

Opportunity involves both supply-side and demand-side factors. On the supply side, technological gaps can exist between (1) the technology used in a particular firm and the already-available technology that could be adopted or adapted (known as diffusion or incremental innovation, respectively), and (2) the technology used in a particular firm and technology that could be developed (i.e., major or radical/disruptive innovation). On the demand side, four factors could push firms towards technological change -- whether diffusion, incremental innovation, or major innovation -- (1) regulatory requirements, (2) possible cost savings or additions to profits, (3) community or public demand for a less polluting and safer industry or products, and (4) worker demands and pressures arising from industrial relations concerns.

Technical capacity or capability can be enhanced by both (1) increases in knowledge or information about cleaner and inherently safer opportunities, partly through formal Technology Options Analyses,[15] and partly through serendipitous or intentional transfer of knowledge from suppliers, customers, trade associations, unions, workers, and other firms, as well as reading about environmental and safety issues, and (2) improving the skill base of the firm through educating and training its operators, workers, and managers, on both a formal and informal basis.

Capacity to change may also be influenced by the inherent innovativeness (or lack thereof) of the firm as determined by the maturity and technological rigidity of particular product or production lines (Ashford et al. 1985; Utterback, 1987). The heavy, basic industries, which are also sometimes the most polluting and unsafe industries, change with great difficulty, especially when it comes to core processes. It deserves emphasizing that it is not only technologies that are rigid and resistant to change. Personal and organizational inflexibility is also important (Coriat, 1995).

Finally, it should be realized that those policies that work to maximize win-win outcomes using (1) diffusion of presently available technology, might be different than those needed to stimulate (2) incremental innovation or those necessary for (3) radical innovation or (4)

disrupting innovation. Policies of the first and usually second type strive for static efficiency; leveraging the firm's self-interest through consciousness-raising, continuous learning, and other techniques of ecological modernization may be helpful here. Other policies aiming at creating new dynamic efficiencies require much more than incremental learning and technological change (Ashford, 2000).

RESOLVING THE APPARENT POLICY DILEMMAS

Recalling that a sustainable future requires technological, managerial, and social/cultural changes, it is likely that an evolutionary pathway is insufficient for achieving factor ten or greater improvements in eco- and energy-efficiency (McDonough & Braungart, 1998), and reductions in the production and use of, and exposure to, toxic substances (Ashford, 2000). Such improvements require more significant and revolutionary changes (Andersen & Massa, 2000; Reijnders, 1998). The capacity to change can be the limiting factor -- this is often a crucial missing factor in optimistic scenarios.

Significant industrial transformations occur less often from dominant technology firms, or in the case of unsustainable practices, problem firms' capacity-enhancing strategies,[16] than from new firms that displace existing products, processes and technologies. This can be seen in examples of significant technological innovations over the last fifty years including transistors, computers, and PCB replacements (Ashford, 1994 and 2000; Ashford & Heaton, 1983; Strasser, 1997).

Especially in industries which are "flexible" and always changing their products, we may be justifiably enthusiastic about existing firms' ability to move towards sustainable production. In this case, closer relations with customers and NGOs may be particularly helpful. But where the product line is "rigid" or mature -- as was the case of PCBs, and is the case with several other unsustainable technologies -- change is not easy, and Schumpetarian revolutionary "waves of creative destruction" replace the product via new entrants to the market.

Christensen (1997) discusses the relatively rare successful management of disruptive product innovation by the dominant technology firms. In these disruptive product innovations:

- managers align the disruptive innovation with the "right" customers.
- the development of those disrupting technologies are placed in an organizational context that is small enough to get excited about small opportunities and small wins, e.g., through "spin-offs" or "spin-outs."
- managers plan to fail early, inexpensively, and perhaps often, in the search for the market for a disruptive technology.
- managers find new markets that value the [new] attributes of the disrupting technologies.

Since, this is rarely done in the commercial context of product competition, it is unlikely to occur for many sustainability goals without either strong social demand or as a result of regulation.[17] This reinforces the view that disrupting innovations are necessary and the policy instruments chosen to promote sustainability need to reflect these expectations.

Rigid industries whose processes have remained stagnant also face considerable difficulties in becoming significantly more sustainable. Shifts from products to "product services" rely on changes in the use, location, and ownership of products in which mature product manufacturers may participate, but this requires significant changes involving both managerial and social (customer) innovations. Changes in socio-technological "systems", such as

transportation or agriculture are even more difficult (Vellinga & Herb, 1999). This suggests that the creative use of law is a more promising strategic instrument for achieving sustainable industrial environmental transformation, than the reliance of the more neo-liberal forms of ecological modernization on firms' economic self-interest.

This is not to say that technical assistance by government; enhanced analytic and technical capabilities on the part of firms; cooperative efforts and improved communication with suppliers, customers, workers, other industries, and environmental/consumer/community groups are not valuable adjuncts in the transformation process. And that is of course the value that ecological modernization scholars have brought into the discussion on major transformations in product, processes and socio-technical systems. But in most cases these means and strategies are unlikely to be sufficient by themselves for significant transformations, and they will not work without clear mandated targets to enhance environmental, safety, and health performance of the private sector. Nor will streamlining regulatory processes by itself be sufficient for the transformations that are needed.

Government has a role to play in providing the opportunity for technological transformation/sustainable development through the setting of clear standards and policy goals, while allowing flexible means for industry to achieve those goals. Care must be taken to avoid dominant technological regimes from capturing or unduly influencing government regulation or negotiation processes. New entrants and new technologies must be given a chance to evolve to address environmental problems. Direct support of research and development, tax incentives for investment in sustainable technologies, and other technical assistance initiatives that fall under the rubric of "industrial policy" are other areas where government can make a difference (Nelson & Rosenberg, 1993). Ideally, an "industrial policy for the environment" would include provisions relating to not only production and the environment, but also consumption, employment, and trade. Regulatory and other policy design and implementation are largely in the hands of government. The government can not simply serve as a referee or arbiter of competing interests because neither future generations nor future technologies are adequately represented by the existing stakeholders.

FINAL COMMENTARY

Two different approaches are vying for the preferred pathway to address environmental problems. Ecological modernization approaches ask the question, How can we best encourage the creative forces of different sectors of society to make the necessary changes through cooperative involvement of stakeholders, continuous learning, innovative governance, regulatory streamlining, etc.? A technology-focused regulatory approach asks, How do we identify and exploit the opportunities for changing the basic technologies of production, agriculture, and transportation that cause damage to environment and health? In the latter approach, a policy choice has to be made for each environmental problem of (1) whether we want to effectuate a transformation of the existing polluting or problem industrial sectors or (2) whether we want to stimulate more radical and disrupting innovation that might result in technology displacement. Considerations of risks, costs, equity, and timing are relevant to all these questions.

Historically, the US EPA and most economists, scientists, and risk analysts have explored avenues of implementing the first approach. On the other hand, activists and others interested in significant industrial transformations have focused on the second approach and argued for application of political will and creative energy in changing the ways that industrial systems are

constructed. The first effort promotes rationalism within a more or less static world; the second promotes dynamic transformation of the industrial state as an art form.

In a January 1994 report, the US EPA reveals a clear evolution of thinking, from a preoccupation with risk, to a concern for fundamental technological change. That report's introduction states:

> Technology innovation is indispensable to achieving our national and international environmental goals. Available technologies are inadequate to solve many present and emerging environmental problems or, in some cases, too costly to bear widespread adoption. Innovative technologies offer the promise that the demand for continuing economic growth can be reconciled with the imperative of strong environmental protection. In launching this Technology Innovation Strategy, the Environmental Protection Agency aims to inaugurate an era of unprecedented technological ingenuity in the service of environmental protection and public health...This strategy signals EPA's commitment to making needed changes and reinventing the way it does its business so that the United States will have the best technological solutions needed to protect the environment. (EPA, 1994, p. 4)

Unfortunately, this article of faith has not been followed up with action, and neither the US nor Europe has come to grips with just how much major technological innovation should be encouraged, especially if it means the displacement of dominant technologies and even firms. If factor ten (or greater) is what is desired in pollution or material/energy use reduction, limiting policy initiatives to those involving cooperation with existing firms could limit success -- especially if the targets, as well as the means and schedule for reaching the targets, are negotiated between government and those firms.

Finally, it must be realized that the choice of approaches are context-specific. It matters in a particular national environment whether there are (1) strong regulatory traditions and institutions, weak traditions and/or institutions, or (complete) absence of regulatory structure and culture; (2) strong trusteeship vs. arbitration traditions on the part of government; and (3) whether government is independent of capture or undue political influence by incumbent regulated firms. Current ecological modernization approaches might be best applied in regimes where diffusion, rather than innovation is likely to occur, as for example in the context of some developing countries.[18] But these same approaches could limit needed advances in industrialized countries. Involving a broader group of stakeholders and encouraging minor structural changes may not suffice; more radical and far-reaching institutional changes are needed, within the framework of "command-and-control" environmental governance.

NOTES

[1] This is in contrast to the Netherlands (cf. Spaargaren & Mol, 1992).
[2] Different scholars make different distinctions in ecological modernization schools of thought. See for instance, Christoff (1996) and Dryzek (1997) who distinguish radical and reformist versions of ecological modernization, and Mol & Sonnenfeld (2000a) who suggest that ecological modernization theory has developed in three historical phases, each with its own dominant tradition.
[3] This argument is centered on the idea of "the winds of creative destruction" developed by Joseph Schumpeter (1939) in explaining technological advance. The distinction between incremental and radical innovations – be they technological, organizational, institutional, or social – is not simply line drawing along points on a continuum. Incremental innovation generally involves continuous improvements, while radical innovations are discontinuous (Freeman, 1992), possibly involving displacement of dominant firms and institutions, rather than evolutionary transformations. Christensen (1997) distinguishes the former as "sustaining innovation" and uses the term "disrupting innovation" rather than radical innovation, arguing that both sustaining and disrupting innovations can be either incremental or radical. See the later discussion below. In contrast, Kemp (1994 and 1997) argues that 'technological regime shifts' brought about by 'strategic niche management' can result in radical [i.e., disrupting] innovation through a stepwise evolution in learning and experimentation by dominant firms.
[4] See McDonough & Braungart (1998), who argue that more than "eco-efficiency" is required in the sense advocated by Schmidheiny (1992). Fundamental redesign is required.
[5] For a discussion of the industrial firm's motivations for making modest improvements of an evolutionary or "sustaining" nature, see Reinhardt (1999).
[6] For a discussion of the transferability of environmental regulatory systems from developed countries to developing countries in the context of the experience in Poland, see Brown (2000).
[7] See Porter & van den Linden (1995a,b) and Reinhardt (1999) for a discussion of the conditions under which industrial firms might be motivated to go beyond compliance.
[8] For example, "innovation waivers," allowing more time for compliance in return for innovative approaches on the part of industry, were permitted in statutory provisions in environmental laws. These might have encouraged better and cheaper environmental technologies, but they had hardly ever been used because of the lack of proper incentives for agency personnel to get involved with complex issues (Ashford et al., 1985).
[9] One justified criticism of traditional regulation is that it is fragmented on a media-specific basis. Air, water, and waste regulation evolved as separate systems and uncoordinated regulatory requirements do create disincentives for holistic, prevention-oriented technological change. In the US, coordinated, facility-based permitting, while not commonplace, is increasingly implemented to meet this criticism, as are some of the "regulatory reinvention" strategies discussed below. In Europe, some voluntary agreements are multi-media in nature, but most continue to be single-media (or energy) focused. Thus, the fragmentation of efforts across problem areas continues to plague whatever approach to improving environmental quality is currently in vogue.
[10] For an international study that makes this point, see Gouldson & Murphy (1998).
[11] EPA continues to pursue cooperative approaches. EPA's National Performance Track was launched in June 2000. It consolidates and builds on several previous "reinvention" initiatives. It

promotes "beyond compliance" by rewarding firms, depending on their (voluntary) placement in a tiered approach to enforcement. Firms are placed in one of three levels: status quo, achievement track, and stewardship track (Speir, 2001). The higher the classification, the greater the firms are relieved of intense regulatory scrutiny.

[12] See also Lewis (2000) and Lewis & Henkels (2000).

[13] In this paper, radical innovation is a major change in technology along the lines that technology has been changing historically, for example a much more efficient air pollution scrubber. As noted previously, in the context of product markets, Christensen (1997) calls this type of innovation "sustaining" and documents that it is usually pioneered by incumbent firms. Major innovation that represents an entirely new approach – characteristic of a 'technology regime shift' to use Kemp's terminology -- even if it synthesizes previously invented artifacts, is termed "disrupting" and it almost always is developed by firms not in the prior markets or business. The replacement of Monsanto's PCBs in transformers by Dow-Silicone's dielectric fluid is a stark example. The new transformer fluid was based on an entirely different molecular model and pioneered by a firm not formerly in the dielectric fluid business. Unfortunately, the terminology used in the literature is not uniform; by the term 'radical' both Freeman (1992) and Kemp (1997) mean 'disrupting' as defined by Christensen (1997) who reserves 'radical' for major innovation *within* a technology regime.

[14] In an excellent discussion of capacity building, Weidner (this volume) explores the conditions and requirements for changing the attitudes and practices of incumbent polluting (problem) firms through learning, interactions with cooperative networks, etc. to undertake changes that vary from incremental to radical innovation. In the context of sustaining innovations, and for encouraging the diffusion or technology transfer to developing countries, his insights are invaluable. What his discussion of capacity building does not capture is the regime-shifting, disrupting changes that may be required for sustainable development.

[15] Technology Options Analysis, as distinct from Technology Assessment, identifies what technologies could be adopted, or developed, to address a particular health, safety, or environmental problem (Ashford, 1993 and 2000). In a similar vein, also see O'Brien (2000) for a discussion of the need for "alternatives assessment" in responding to environmental challenges.

[16] Such as continuous learning, using life cycle analysis, change and niche management, and environmental management systems.

[17] For a more optimistic view that large firms in established product markets can sufficiently transform, see Hart & Milstein, 1999.

[18] This contradicts to some extent the findings in most branches of the ecological modernization literature (cf. several contributions in Mol & Sonnenfeld, 2000b).

REFERENCES

Andersen, M. S., & Massa, I. (2000). Ecological Modernisation: Origins, Dilemmas, and Future Directions. *Journal of Environmental Policy and Planning* 2(4), 337-345.

Ashford, N. A. (1993). Understanding Technological Responses of Industrial Firms to Environmental Problems: Implications for Government Policy. In K. Fischer and J. Schot (Eds.), *Environmental Strategies for Industry: International Perspectives on Research Needs and Policy Implications* (pp. 277-307). Washington, DC: Island Press.

—. (1994). An Innovation-Based Strategy for the Environment. In A. Finkel and D. Golding (Eds.), *Worst Things First? The Debate Over Risk-based National Environmental Priorities* (pp. 275-314). Washington, DC: Resources for the Future.

—. (2000). An Innovation-Based Strategy for a Sustainable Environment. In J. Hemmelskamp, K. Rennings, F. Leone (Eds.), *Innovation-Oriented Environmental Regulation: Theoretical Approach and Empirical Analysis* (pp. 67-107). ZEW Economic Studies. Heidelberg, New York: Springer Verlag.

Ashford, N. A., Ayers, C., & Stone, R. (1985). Using Regulation to Change the Market for Innovation. *Harvard Environmental Law Review* 9(2), 419-466.

Ashford, N. A., & Heaton, G. (1983). Regulation and Technological Innovation in the Chemical Industry. *Law and Contemporary Problems* 46(3), 109-157.

Ashford, N. A., & Miller, C. (1998). Low-Level Exposures to Chemicals Challenge Both Science and Regulatory Policy, *Environmental Science & Technology*, 32(21), 508A-509A, November.

Becker, M., & Ashford, N. A. (1995). Exploiting Opportunities for Pollution Prevention in EPA Enforcement Agreements, *Environmental Science & Technology*, 29(5), 220A-226A, August. Washington, DC: American Chemical Society.

Brown, H. S. (2000).Environmental Regulatory Reform in Poland: Lessons for Industrializing Economies. *Environmental Science and Technology*. 34(18), 3849-3856.

Caldart, C., & Ashford, N. A. (1999). Negotiation as a Means of Developing and Implementing Environmental and Occupational Health and Safety Policy, *Harvard Environmental Law Review*, 23(1), 141-202.

Christensen, C. (1997*). The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*, Harvard Business School Press.

Christoff, P. (1996), "Ecological Modernization, Ecological Modernities", *Environmental Politics* 5(3), 476-500

Coglianese, G. (1997). Assembling Consensus: The Promise and Performance of Negotiated Rulemaking. *Duke Law Journal* 46, p. 1255.

Colborn, T., Dumanowski, D., & Myers, J. P. (1996*). Our Stolen Future*. New York: Dutton Press.

Coriat, B. (1995). Organizational Innovations: The Missing Link in European Competitiveness. In L. E. Andreasen, B. Coriat, F. de Hertog, and R Kaplinsky

(Eds.) *Europe's Next Step: Organizational Innovation, Competition and Employment* (pp. 3-32). London: Frank Cass & Co.

COWI Consulting Engineers And Planners. (1997). Study on Voluntary Agreements Concluded Between Industry and Public Authorities in the Area of the Environment, Final Report to the European Commission, DG-XIII, Soeborg, Denmark, January.

Dryzek, J. (1997), *The Politics of the Earth: Environmental Discourses*. Oxford, UK: Oxford University Press

EEA = European Environmental Agency. (1997). *Environmental Agreements: Environmental Effectiveness*, Environmental Issues Series No.3 -- Vol. 1, Copenhagen.

EPA = US Environmental Protection Agency. (1991). *Pollution Prevention: Progress in Reducing Industrial Pollutants.* EPA 21P-3003. Washington, DC: US EPA.

—. (1994). *Technology Innovation Strategy*. EPA 543-K-93 002. Washington, DC: US EPA.

Finkel, A., & Golding, D. (Eds.). (1994). *Worst Things First? The Debate Over Risk-based National Environmental Priorities*. Washington, DC: Resources for the Future.

Fiorino, D. J. (1999). Rethinking Environmental Regulation: Perspectives on Law and Governance*, Harvard Environmental Law Review* 23(2), 441-469.

Freeman, C. (1992). *The Economics of Hope*. London: Pinter.

Gouldson, A., & Murphy, J. (1998) *Regulatory Realities: the Implementation and Impact of Industrial Environmental Regulation*. London: Earthscan.

Harrison, K. (1999). Talking with the Donkey: Cooperative Approaches to Environmental Protection. *Journal of Industrial Ecology*. 2(3), 51-72.

Hart, S., & Milstein, M. B. (1999). Global Sustainability and the Creative Destruction of Industries. *Sloan Management Review*. 41(1), 23-33.

Hirschhorn, J. (1995). Pollution Prevention Comes of Age, *Georgia Law Review* 29, p. 325.

Howard, J, Nash, J, & Ehrenfeld, J. (2000). Standard or Smokescreen? Implementation of a Voluntary Code, *California Management Review* 42(2), 63-82.

Kaminski, M., Bertelli, D., Moye, M and Yudken, J. *Making Change Happen: Six Cases of Companies and Unions Transforming Their Workplaces*. Washington, DC: Work and Technology Institute.

Kemp, R. (1994). Technology and Environmental Sustainability: The Problem of Technological Regime Shift. *Futures*. 26(10), 1023-1046.

—. (1997) *Environmental Policy and Technical Change: A Comparison of the Technological Impact of Policy Instruments*. Cheltenham, UK: Edward Elgar.

Kemp, R. and Moors, E. H. M. (2002) Modulating Dynamics in Transport for Climate Protection, forthcoming in Kyoto and After: Institutions and Instruments to Control Global Environmental Change, M. Faure, J. Gupta and A. Nentjes (eds.), Edward Elgar, Cheltenham.

King, A., & Lenox, M. (2000). Prospects for Industry Self-Regulation Without Sanctions: A Study of Responsible Care in the Chemical Industry *The Academy of Management Journal*, 43(4), 698-716.

Lewis, S. J. (1993) The Good Neighbor Handbook, A Community-based Strategy for Sustainable Industry, New York, Apex Press.

Lewis, S. J. (2000). What's Next for Labor-Neighbor Cooperation on Pollution Prevention and Chemical Accident Safety? [Online September 3, 2000.] Available: <http://www.envirolink.org/orgs/gnp>.

Lewis, S, & Henkels, D. (2000). Good Neighbor Agreements: A Tool for Environmental and Social Justice, *Social Justice* 23(4). [Online.] Available: <http://www.envirolink.org/orgs/gnp>.

McDonough, W., & Braungart, M. (1998). The NEXT Industrial Revolution. *The Atlantic Monthly*. October, 282(4): 82-90.

Mol, A. P. J. (1995*). The Refinement of Production: Ecological Modernization Theory and the Chemical Industry*. Utrecht, The Netherlands: Van Arkel.

Mol, A. P. J., Lauber, V., & Liefferink, J. (Eds.) (2000). *The Voluntary Approach to Environmental Policy. Joint Environmental Policy-making in Europe*, Oxford: Oxford University Press

Mol, A. P. J., & Sonnenfeld, D. (2000a). Ecological Modernisation Around the World: An Introduction. *Environmental Politics*, 9(1), 3-14.

Mol, A. P. J., & Sonnenfeld, D. (Eds.) (2000b). *Ecological Modernisation Around the World: Perspectives and Critical Debates*. London: Frank Cass Publishers.

Mol, A. P. J., & Spaargaren, G. (2000). Ecological Modernisation Theory in debate: a review. *Environmental Politics*, 9(1), 17-49

NACEPT (National Advisory Council for Environmental Policy and Technology). (1991). Permitting and Compliance Policy: Barriers to U.S. Environmental Technology Innovation. Report and Recommendations of the Technology Innovation and Economics Committee of the National Advisory Council for Environmental Policy and Technology. Washington, DC: US EPA.

—. (1992). *Improving Technology Diffusion for Environmental Protection.* Report and Recommendations of the Technology Innovation and Economics Committee of the National Advisory Council for Environmental Policy and Technology. Washington, DC: US EPA.

—. (1993). *Transforming Environmental Permitting and Compliance Policies to Promote Pollution Prevention.* Report and Recommendations of the Technology Innovation and Economics Committee of the National Advisory Council for Environmental Policy and Technology. Washington, DC: US EPA.

Nash, J., & Ehrenfeld, J. (1996). Code Green: Business Adopts Voluntary Environmental Standards. *Environment* 38(1), 16-20, 36-45.

Nelson, R. R., & Rosenberg, N. (1993) *National Innovation Systems: A Comparative Analysis*. New York: Oxford University Press.

O'Brien, M. (2000). *Making Better Environmental Decisions*. Cambridge, MA: MIT Press.

Orum, P. Working Group on Community Right-to-Know. [Online September 3, 2000]. Available: <http://www.rtk.net/wcs/>.

Porter, M. E., & van den Linden, C. (1995a). Green and Competitive: Ending the Stalemate. *Harvard Business Review*. September/October 1995, 73:120-134.

Porter, M. E., & van den Linden, C. (1995b) Towards a New Conceptualization of the Environment-Competitiveness Relationship. *Journal of Economic Perspectives* 9(4), 97-118.

Reinhardt, F. (1999). Market Failure and the Environmental Policies of Firms. *Journal of Industrial Ecology*. (3)1, 9-21.

Schmidheiny, S. (1992). *Changing Course*. Cambridge, MA: MIT Press.

Schumpeter, J. (1939). *Business Cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process*. New York, McGraw-Hill as discussed in J. Niehans, *Joseph Schumpeter in A History of Economic Theory: Classic Contributions 1720-1980*, p. 448. Baltimore: Johns Hopkins University Press, 1990.

Spaargaren, G., & Mol, A. P. J. (1992), Sociology, Environment and Modernity. Ecological modernization as a theory of social change, *Society and Natural Resources* 5(5), 323-345.

Speir, J. (2001). EMSs and Tiered Regulation: Getting the Deal Right. In C. Coglianese, & J. Nash (Eds.), *Regulating from the Inside: Can Environmental Management Systems Achieve Policy Goals*? Washington, DC: Resources for the Future Press, 198-219.

Strasser, K. (1997). Cleaner Technology, Pollution Prevention, and Environmental Regulation. *Fordham Environmental Law Journal* 9(1), 1-106.

Reijnders, L. (1998). The Factor X Debate: Setting Targets for Eco-Efficiency. *Journal of Industrial Ecology* 2(1), 13-22.

Susskind, L., & McMahon, G. (1985). The Theory and Practice of Negotiated Rulemaking. *Yale Journal on Regulation* 3, pp. 133-165.

Teubner, G. (1983). Substantive and Reflexive Elements in Modern Law*, Law and Society Review* 17, p. 239-285.

Utterback, J. (1987). Innovation and Industrial Evolution in Manufacturing Industries? In B. Guile and H. Brooks (Eds.), *Technology and Global Industry: Companies & Nations in the World Economy*. National Academy of Engineering. Washington. DC: National Academy Press.

Vellinga, P., & Herb, N. (1999). Industrial Transformation Science Plan, IHDP Report 12, Bonn, Germany. [Online September 3, 2000]. Available: <http://www.vu.nl/ivm/research/ihdp-it>.

Vergragt, P. J., & van Grootveld, G. (1994). Sustainable Technology Development in the Netherlands: The first phase of the Dutch STD program, *Journal of Cleaner Production*, 2 (3-4), 133-139.

Wallace, D. (1995). *Environmental Policy and Industrial Innovation: Strategies in Europe, the US and Japan*. London: Earthscan.