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Experiences with Public Sector Clean Technology Programs in the OECD: Implications for Clean Technology Policy in Rapidly Industrializing Asia

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Acronyms

BAT	Best Available Technology
BATNEEC	Best Available Technology Not Entalling Excessive Cost
CSI	Common Sense Initiative
EPIQ	Environmental Policy and Institutional Strengthening Indefinite Quality
MCA	Marginal Cost of Abasement
MCCP	Marginal Cost of Clean Production
MEIP	Metropolitan Environmental Improvement Program
NEPP	National Environmental Protection Agency
OECD	Organization for Economic Cooperation and Development
TRI	Toxic Release Inventory
USEPA	United States Environmental Protection Agency

Executive Summary

The purpose of this paper is to answer two questions: What can be learned from experiences in the OECD countries about their government programs designed to promote clean technology alternatives to end-of-pipe firm- and plant-level industrial-environmental management? What are the implications of these findings for identification of a policy menu to promote clean industrial production in rapidly industrializing economies in Asia?

Development of a simple but powerful pollution management model and review of experiences in the OECD countries with policy initiatives to promote clean technology suggest that there are two overriding economic rationales for development of public sector clean technology programs. On the one hand, government action is necessary to overcome the policy failures associated with the bias toward end-of-pipe solutions in the industrial-environmental management systems prevalent in the OECD. On the other hand, government action is also needed to overcome market failures associated with incomplete information, high risks, and high transactions and learning costs of clean technology industrial-environmental management alternatives. Taken together, policy actions designed to overcome policy and market failures can shift plant- and firm-level industrial-environmental management practices away from costly end-of-pipe solutions toward what appear to be more effective clean technology alternatives.

Effectively promoting clean technologies in the OECD has not been easy, however Where it has happened, in at least limited ways, the following conditions have prevailed.

1. Governments, sometimes in close concert with business communities, developed clear long-run environmental goals and embedded them in well-defined and quantitative pollution reduction targets. This was seen as the only way to communicate to polluters that the government was serious about reducing the pollution intensity of industrial production. Clear, consistent, and stringent emissions standards provided the firm base on which to build successful clean technology programs. Without this base, reducing the pollution intensity of industrial production through clean technology is probably impossible.

2. Governments recognized that promoting clean technological change through environmental (and industrial) policy requires substantial reform in current command and control industrial environmental management systems prevalent in the OECD. Important reform elements included (a) a shift from single-media permitting to single-facilities permitting (integrated pollution control that emphasized prevention); (b) a shift from rigid BAT or BACTNEEC end-of-pipe emission standards in environmental management toward greater flexibility in how pollution reduction targets are met; (c) a shift from more or less adversarial relationships between regulators and polluters to more cooperative relationships as manifest, for example, in voluntary pollution reduction agreements; and (d) a shift from limited public participation in regulatory decision-making and limited public disclosure by polluters to substantially greater public participation by citizens and even greater public disclosure by polluters.

3. Governments believed that because of information failures, firms' tendency to underinvest in research and development, high risks, and high transactions and learning costs, public sector supply-side interventions in clean technology markets could be an important complement to regulatory reforms that emphasize a clean technology alternative to the existing regulatory system. But in the absence of these regulatory reforms, supply-side interventions are not likely to have much impact. Moreover, experience with these programs suggests that their success depends on (a) linking firm-level clean technology performance to access to publicly provided information and similarly provided fiscal and financial incentives; (b) integrating clean technology policies into broader industrial policies; and (c) embedding clean technology initiatives in national systems of invention, innovation, and diffusion of new technologies. So far, governments in the OECD have not been very successful at any of these. Because of this, their supply-side clean production programs probably have had limited impact.

The central message of these findings for development of a policy menu for clean production in rapidly industrializing Asian economies is clear.

1. Governments must develop clear, consistent, and stringent pollution reduction targets. They must also communicate these effectively to polluters.

2. Clean production policies can not be agnostic about the regulatory environment. Leapfrogging environmental regulatory systems in favor of strategies based on pollution prevention pays almost assuredly will not work. Because of this, it will be necessary to build effective environmental regulatory agencies in the newly industrializing economies of Asia. But how this is done matters. If it is done by mimicking the command and control end of pipe-based agencies of the OECD, the regulatory agencies could become impediments to the development of clean technology. The best chance for promoting clean production seems to be in creating regulatory agencies that: (a) focus on integrated pollution control and prevention; (b) emphasize cooperation between regulators and polluters; (c) build in flexibility in how firms meet stringent emissions standards; and (d) depend on public participation and disclosure to ensure accountability of both regulators and polluters.

3. Public sector information dissemination programs and programs offering lucrative fiscal and financial incentives for adoption of clean technologies must be performance-based if they are to be successful. This probably requires developing the kinds of performance-based linkages between the public and private sector used to promote the exports of labor-intensive manufacturers in East and Southeast Asia. This involves creating industry-specific government-industry task forces to identify and solve problems; engaging public sector and quasi-public sector industrial research institutes and ministries of industry in international searches for and domestic dissemination (through, for example, reverse engineering) of commercially viable new technologies; and allocation of lucrative investment incentives on the basis of firms' ability to meet mutually agreed upon quantitative performance targets.

4. Embed all of this in a real-world understanding of how Asian firms are acquiring capital, technology, and industrial competence. This requires embedding clean technology programs

in broader industrial policies and linking them with national systems of innovation and dissemination of new technologies.

5. Search for ways to incorporate international market pressures as evidenced by ISO 14000, greening the supply chain programs, and green labeling programs into clean technology programs. But recognize that these programs alone are probably not sufficient to spawn a "clean industrial revolution."

6. Because Asian firms are overwhelmingly dependent on firms in OECD countries for capital (new plant and equipment) and technology, work with OECD governments to ensure that their policies promote the development of cleaner production technologies.

And work with policy-makers in these countries to promote a more rapid dissemination of cleaner technologies.

7. Take care to do all these things in ways that take advantage of the unique differences among countries and the opportunities afforded by these differences. In addition, be sure to do so in ways that permit Asians to design the ultimate policy interventions. They have taught the world much about how to be institutionally creative to achieve public developmental ends. With limited help, they just might be able to do the same with respect to the environment.

Chapter 1: Introduction

The purpose of this paper is to answer two seemingly simple and straightforward questions: What can be learned from experiences in the OECD countries about their government programs designed to promote clean technology alternatives to end-of-pipe firm- and plant-level industrial-environmental management? What are the implications of these findings for the policy design of clean technology programs in rapidly developing Asia? what might a policy menu for clean industrial production look like for a rapidly industrializing and developing economy in Asia?

Answering these questions proves simpler and more difficult than expected Articulating the underlying economic theory and the policy implications of clean technology alternatives to "end-of-pipe" industrial-environmental management is fairly simple and straightforward. Finding empirical support for that theory (or empirically testing clean technology hypotheses) in the OECD countries is much more difficult. Because of this, much of what follows focuses on the first task. Where possible, empirical evidence on the economics of clean technology alternatives is examined and evaluated.

The paper is organized as follows. The next chapter develops a short historical and analytical policy model to explain why and how clean production alternatives emerged within the "command and control" industrial-environmental management systems prevalent in the OECD. This is followed by a brief review of what is known and not known about the economics of clean technology programs in the OECD countries. Next, a policy menu for clean production in rapidly developing Asia is explored. The paper closes by delineating what is to be done if clean production programs are to have a chance in emerging public sector industrial-environmental management systems in high-growth Asia.

Chapter 2:
The Simple Analytics of Clean Technology in the OECD

The post-1970 history of environmental management in the OECD countries shows that it is possible to delink population and income growth from environmental degradation at modest cost (Jaffe, Peterson, Portney, and Stavins, 1995; World Bank, 1992: 40; Jorgenson and Wilcoxen, 1990). How this was accomplished is, by now, well known (Lovie and Weiss, 1997). In large measure, governments were motivated to act in response to growing public and community pressure to reduce the environmental consequences of rapid, particularly urban-industrial, growth. They did so by creating environmental laws and what were to become strong public sector environmental agencies. Those agencies set emissions standards for individual polluters, monitored performance relative to standards, and rigorously enforced rather stringent standards. For the most part, the OECD's public sector environmental agencies relied on mandated technology standards (BAT or BACTNEEC) to meet environmental objectives. Because mandated technology standards were rarely tied to either the costs of environmental degradation (the benefits of cleanup) or to the most cost-effective means for achieving environmental goals, environmental management systems within the OECD were "command and control" oriented. They also focused on "end-of-pipe" solutions to pollution

Despite the success of public sector environmental management within the OECD, there is a growing consensus that "command and control" systems for industrial-environmental management may have outlived their usefulness (Beardsley, 1996; Hersh, 1996; Davies and Mazurek, 1996; Wallace, 1995). They are now seen as too costly and bureaucratic OECD, 1992:4, Hazilla and Kopp, 1990); too inhibiting of technological change (Wallace, 1995; Malueg, 1989; Milliman and Prince, 1988; Magat, 1978); too adversarial, too unable to sustain improvements in environmental quality in the face of continuing population and income growth (Hersh, 1996:29); and too focused on cleaning up pollution after it is created and too little focused on preventing pollution.

Because of this, governments and environmental agencies in the OECD are experimenting with a wide range of industrial-environmental management alternatives (Hersh, 1996; Davies and Mazurek, 1996; Beardsley, 1996). Some, most notably the U.S., are incrementally complementing the "command and control" system with market-based instruments (tradeable permits), public disclosure programs (TRI), and voluntary pollution reduction programs (33/50) (Davies and Mazurek, 1996). Others are engaged in more substantial reform of the relationship between regulators and polluters within the confines of established "command and control" systems. Two examples should suffice. The Netherlands is experimenting with a wide-ranging sectors specific quasi-voluntary pollution reduction program (environmental covenants) that permits it to take advantage of a more cooperative and flexible relationship between regulators and polluters (Wallace, 1995; Hersh, 1996; Consultative Group for the Chemical Industry, 1994, Commission of the European Communities, 1996). The U.K. is replacing its media-specific technology-mandated "command and control" environmental management system with a more flexible and integrated pollution control system that emphasizes prevention (Hersh, 1996). Still others (Ireland and Sweden), have rejected a "command and control" media-specific approach to environmental management in favor of a more cooperative, flexible, and integrated approach to pollution management that emphasizes prevention (Larkin, 1997; Hersh, 1996).

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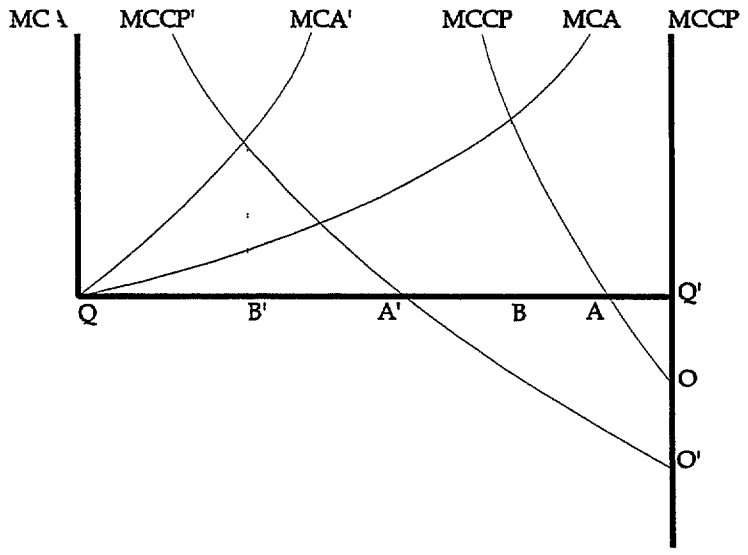
Virtually all of the OECD countries are complementing this experimentation with efforts to promote clean production or clean technology (OECD, 1992, 1994, 1995). These programs aim to reduce the production of pollution through source reduction, input substitution, production process changes, and fundamental technical change. Sometimes clean technology objectives are embedded in the new environmental management programs (such as the 33/50 program in the U.S. or its public disclosure program [TRI], the Dutch covenant system, or the British integrated pollution control system).

When this happens, the aim is to use the regulatory system to induce polluters to shift demand away from "end-of-pipe" environmental solutions toward clean production alternatives. Demand-inducing clean production incentives are frequently complemented by supply (cost-reducing) enhancing programs (OECD, 1994). Most commonly, supply augmentation consists of technical assistance, information sharing, and demonstration projects designed to demonstrate and disseminate clean technology alternatives to "end-of-pipe" industrial pollution management (OECD, 1994). These information-based programs are based on the assumption that "pollution prevention pays" but that markets fail to communicate this information to firms. Quite often, these information dissemination programs are complemented by several other cost-reducing programs (tax incentives such as accelerated depreciation or subsidized loans) (OECD, 1994). Because these are the purview of non-environmental agencies, they require cooperation between environmental agencies and finance agencies (treasuries and banks), among others. In this way, the shift toward clean technology environmental management has become more or less embedded in the broader industrial policy machinery. In economic terms, these subsidies are meant to compensate firms for the increased risks or the higher transactions and learning costs associated with clean production alternatives.

Taken together, demand-inducing clean technology programs and supply-augmenting clean production programs aim to alter the relative prices (and hence the cost-effectiveness of alternative pollution management strategies) firms face when considering pollution management alternatives. That is, they aim to increase the demand for clean production alternatives (at the expense of "end-of-pipe"pollution abatement) while reducing the cost of clean production alternatives.

This can be demonstrated by way of a simple diagram (Figure 1). Let QQ' equal the amount of pollution reduction desired to achieve some stated ambient environmental quality objective. The left vertical axis measures the marginal dollar cost of abating pollution (MCA) through traditional pollution abatement (end-of-pipe expenditures). The curve MCA reflects the traditional rising marginal cost of abatement associated with increasing reductions in pollution through post-pollution treatment. The right vertical axis measures the marginal dollar cost of reducing pollution through clean production (MCCP). This is reflected in a rising from left to right of the marginal cost of meeting pollution reduction targets by preventing pollution (clean production).

Figure 1



Two aspects of the MCCP curve deserve mention. First, the origin of the MCCP curve lies below the zero axis. This part of the curve (between point 0 and point A) reflects the conventional wisdom among clean production advocates that "pollution prevention" saves money. Second, how far below the zero axis MCCP is (that is, where point 0 starts) and over what range of pollution reduction through prevention MCCP stays (where point A crosses the zero, or horizontal, axis) below the zero axis are ultimately empirical questions.

For heuristic purposes, assume an MCCP given by the curve OAMCCP. Given the conventional marginal cost of abatement curve (MCA), the most cost-effective strategy for reducing pollution by QQ' requires firms or plants to reduce pollution through end-of-pipe control by QB and reduce pollution through clean production by BQ'. Note that as drawn most of the reduction comes from conventional end-of-pipe control. Advocates of clean production argue that this outcome is not the most cost-effective because markets fail to convey to polluters both the true (lower) marginal cost of clean production (denoted by the lower-cost O'A'MCCP' curve) and the true (higher) marginal cost of abatement (denoted by the higher MCA' curve). If the true costs of a clean production environmental management strategy were given by the O'A'MCCP curve and the true marginal cost of abatement curve were given by MCA', several important differences would result. First, the range of pollution prevention activities that pay (generate real savings) expands from area OAQ' to area O'A'Q'. This provides more win-win opportunities for polluters. It may also convey Porter-like "competitive" advantages to firms that shift in this direction (Porter and van der Linde, 1995). Second, cost-effective pollution reduction requires more clean production (an increase in prevention from B to B') and less end-of-pipe expenditure (a reduction from B to B'). Third, except in the case where the true O'A'MCCP' is less than the true MCA' for all levels of pollution reduction, firm- and plant-level cost-effective industrial-environmental management requires identification of optimal combination of end-of-pipe and clean production. This last conclusion tends to get lost in the all-or-nothing debate over clean production. Fourth, where these MCA' and O'A'MCCP' curves lie for any given reduction in pollution is likely to differ substantially by industry sector and plant.

But why might existing market forces generate pollution reduction management outcomes like QB and BQ' rather than the more cost-effective outcomes given by QB' and B'Q'? First, traditional "command and control" technology based industrial-environmental management systems favor end-of-pipe pollution reduction strategies over clean production pollution reduction strategies Because BAT-based or BACTNEEC-based technology standards underlying existing "command and control" industrial-environmental management systems identify the range of pollution reduction possible with best available end-of-pipe technologies, they are easier and less risky for both regulators and polluters. This biases pollution reduction strategies in an end-of-pipe direction. Combining this bias with increasingly stringent emissions standards provides incentives for the end-of-pipe pollution control industry to search for cost-reducing end-of-pipe technological change. In terms of Figure 1, this has the effect of pushing MCA' down and to the right. Assuming no change in O'A'MCCP', this biases cost-effectiveness toward more pollution reduction after the pollution has occurred.

If markets for clean production are characterized by information and coordination failures and/or high risks and high transactions and learning costs, O'A'MCCP' may be higher and to the right of the existing O'A'MCCP' curve in Figure 1. This reinforces the end-of-pipe policy bias. But why should clean production markets be characterized by information and/or coordination failures or high risks and high transactions and learning costs? There are several answers to this question.

To begin with, implementing a firm- or plant-level clean production industrial-environmental management strategy raises several important new problems for manufacturing firms and plants. Several examples should suffice to demonstrate this. Substitution of a less toxic input for a more toxic input may be perceived to change or actually change the quality of the final product (Laughlin and Corson, 1995:11). Even though it might pay to make this substitution, firms may be unwilling to take the risk of a negative customer reaction to this "new" final product. The same might be said about basic process modifications that "pay." In addition, before firms make these switches, they may have to invest scarce managerial and engineering time and even scarcer capital to identify clean production alternatives (Kiesling, 1994:15). Unless these expenditures have known or expected payoffs that are better than the alternatives, firms may be reluctant to make them (Panayotou and Zinnes, 1994). That is, it may simply be prudent to stick with more well-known end-of-pipe abatement alternatives. This is probably even more true for longer-term investments in technological invention, innovation, and dissemination of clean technologies. Despite the apparent routinization of research and development in universities, think tanks, and industrial firms, invention, innovation, and dissemination are still characterized by substantial risk (Nelson, 1993:8). Said another way, it may well be rational for long-run profit-maximizing firms to avoid the high risks and high transactions and learning costs of a new (and cleaner) industrial-environmental management strategy. If current "command and control" policies bias industrial-environmental management strategies in an end-of-pipe direction, and if risks, information failures, and transactions and learning costs undervalue the benefits of clean production alternatives, governments can intervene to correct these policy and market failures. But experience in other areas suggests this is easier said than done. Take the apparent policy failure in existing "command and control" end-of-pipe technology-based industrial-environmental management systems in the OECD. If environmental agencies and polluters are to move away from BAT and BACTNEEC end-of-pipe standards and toward clean production alternatives, environmental agencies and firms will have to be more flexible, cooperative, and willing to take more risks (Hersh, 1996).

Recent experiences in the OECD suggests what this might require. To begin with, if cross-media pollution transfers are to be avoided in firm- and plant-level clean production industrial-environmental management systems, permitting will have to shift from single media to single facilities level permitting (integrated pollution control). Doing this is not easy. In addition, if less cost-effective "end-of-pipe" solutions are to be avoided, integrated pollution control will also require an emphasis on environmental auditing that permits the identification of clean technology alternatives. Because of this, licensing a facility will require looking at facility design and redesign to eliminate emissions by materials substitution, process changes, and fundamental technology choices.

Experience in Ireland suggests how this might be accomplished (Larkin, 1997). Irish manufacturing plants are required to (1) produce an environmental management plan that identifies all inputs, describes the production process, and identifies all pollutants by volume and type; (2) undergo an environmental audit that corroborates while identifying opportunities for waste reduction and pollution prevention; (3) commit themselves to continuous environmental improvement by proposing specific quantitative pollution reduction targets; and (4) produce and publish annual progress reports on performance relative to targets. Within this system, the task of the environmental agency is to monitor progress relative to targets. This shifts emphasis from monitoring emissions to monitoring performance as outlined in a firm's environmental management plan. All of these change the nature of the relationship between regulators and polluters. As recent attempts to do this in the U.S. show, this is not easy.[1]

Interventions on the supply side (programs designed to reduce high risks and high transactions and learning costs of clean technology alternatives) raise other kinds of problems. Most important, supply-side interventions will fail unless there is sufficient demand for what these supply-side programs offer. What this means in practice is that as long as regulatory agencies base emission standards and monitoring and enforcement on end-of-pipe BAT or BACTNEEC technologies, no number of supply-side interventions will matter because firms and plants will not use or demand these alternatives. This means that the success of supply-side interventions to correct information and coordination failures and lower risks, transactions, and learning costs probably depend on regulatory reform (in the OECD) and on the design of new regulatory systems in the rapidly industrializing economies in Asia.

This is not the only problem, however, at least three other issues are included. Experience with supply-side interventions in other areas in both rich and poor countries suggest that they are often open to widespread abuse and rent-seeking This can happen, for example, if tax breaks (accelerated depreciation) and/or subsidized loans designed to reduce the risks, transactions, and learning costs associated with clean technology alternatives are captured by large firms that may not need them (Blackman, 1996:19). To avoid this, supply-side program administrators must be technically able to design, monitor, and evaluate the success of supply side interventions. They will also need to condition unrestricted access to supply-side subsidies on firm- and plant-level clean technology performance. For this to happen, program administrators must be pragmatic, technically competent,

[1] Both the Common Sense Initiative and Project XL are foundering over the difficulties associated with trying to do this (Davies and Mazurek, 1996 18-33)

relatively honest, fair in implementation, and insulated from political pressures. Many, if not most, governments tend to lack at least some of the institutional skills necessary for these kinds of selective interventions.

Equally important, clean technology alternatives are likely to be at least industry (sector) if not plant-level specific. This means that access to supply-side subsidies will probably have to be based on industry-specific and plant-specific information. This places an enormous burden on those in the public sector charged with implementing supply-side clean technology programs. Most important, success may well be predicated on the ability to break down the asymmetry in information between regulators and polluting firms. This will require development of mutual trust and cooperation. Where, as in the U.S., environmental regulation has been based on mistrust and an adversarial relationship, doing this may be difficult, if not impossible. Finally, supply-side programs will only work if highly targeted incentives are large enough to overcome the high risks, transactions, and learning costs associated with clean technology alternatives. Unfortunately, it appears that the incentives offered in most clean technology supply-side programs in the OECD are probably too small to have much impact.

Chapter 3:
The Design of Clean Technology Programs in the OECD

Despite the problems associated with managing and implementing clean technology programs, virtually every government in the OECD is experimenting with some kind of program (OECD, 1992, 1994, 1995). Their stated rationales are not difficult to identify. On the one hand, government actions are necessary to overcome the policy failures associated with the bias toward end-of-pipe solutions in existing industrial-environmental management systems. On the other hand, government actions are also needed to overcome market failures associated with incomplete information, high risks, and high transactions and learning costs of clean technology.

In addition to this common rationale, clean production programs in the OECD share several other common assumptions, including:

1. The need to develop clear long-run environmental goals and to embed them in well-defined and quantitative pollution reduction targets. This is necessary to communicate the right signals to polluters about the necessity of reducing the pollution intensity of industrial production. Said another way, clear, consistent, and stringent emissions standards provide the firm base on which to build successful clean technology programs. Without this base, reducing the pollution intensity of industrial production through clean technology is probably impossible.

2. A recognition that this can and has, to a large degree, been accomplished by existing "command and control" industrial environmental management systems that emphasize end-of-pipe solutions to pollution, but an equally firm recognition that this system no longer suffices because it inhibits technological change. This increases the cost of achieving environmental objectives and may limit the ability to sustain levels of environmental quality (Hersh, 1996:29, Warnick and Ausubal, 1997:1).

3. An assumption that promoting technological change through environmental policy, particularly fundamental technological change in facilities design (design for the environment and/or industrial ecology) that minimizes input use and maximizes yield, thus preventing pollution in the first place, is likely to be necessary to sustain, let alone improve, current levels of environmental quality.

4. The recognition that doing this requires substantial reform in current "command and control" industrial environmental management systems (Hersh, 1996; Davies and Mazurek, 1996; Beardsley, 1996; Wallace, 1995). Important reform elements include (a) a shift from single-media permitting to single-facilities permitting (integrated pollution control); (b) a shift from rigid BAT or BACTNEEC end-of-pipe emission standards in environmental management toward greater flexibility in how pollution reduction targets are met; (c) a shift from a more or less adversarial relationship between regulators and polluters to a more collegial and cooperative relationship as manifest, for example, in voluntary pollution reduction agreements; and (d) a shift from limited public participation in regulatory oversight and

limited public disclosure by polluters to substantially greater public participation by citizens and even greater public disclosure by polluters. If generally accepted environmental reporting practices can be developed similar to those used in financial accounting, public disclosure might be achievable by expanding nascent corporate environmental reporting systems (Ditz and Ranganthan, 1997).

5. A belief that because of information failures, firms' tendency to underinvest in research and development, high risks, and high transactions and learning costs, public sector supply-side interventions in clean technology markets can be important complements to regulatory reforms that emphasize a clean technology alternative to the existing regulatory system (OECD, 1995:22-28) But in the absence of these regulatory reforms, supply-side interventions are not likely to have much impact.

6. A recognition that because of the emphasis on clean production on invention, innovation, and dissemination of cleaner technologies, successful implementation of this strategy requires embedding this shift in industrial-environmental management in the broader machinery of industrial policy in each OECDcountry (OECD, 1992:6).

7. A recognition that because experience in other areas shows that the process of invention, innovation, and dissemination of new technologies tends to be costly, risky, and time consuming (particularly for dissemination which follows a predictable logistic curve with slow adoption at first followed by accelerating adoption and then slow adoption again as the adoption rate approaches saturation), progress will take time (Grubler, 1996:21-39).

How have these common assumptions affected the design of clean production programs in the OECD? First, with few exceptions, clean production programs complement clear and increasingly stringent environmental standards. Second, virtually everyone is experimenting with regulatory alternatives. Third, tough and stringent standards and regulatory experiments are being complemented by an impressive array of supply-side interventions designed to overcome information failures, risks, and high transactions and learning costs of clean technologies.

Evidence of each of these can be seen in the:

1. Codification of clear, quantitative, and stringent environmental regulations to stimulate firms level interest in pollution prevention

Two examples should suffice. In the U.S., cradle to grave joint, several, and unlimited liability for the environmental consequences of toxic chemical pollution has sent a clear signal to polluters that prevention may be cheaper than cleanup (Freeman, Harten, Springer, Randall, Curran, and Stone, 1992:620). This has been followed by passage of the Pollution Prevention Act of 1990, which made prevention the preferred option, and by a voluntary toxic chemical pollution reduction program (33/50) that required firms to reduce releases and transfers of 17 toxics chemical on the USEPA's Toxic Chemical Inventory by 33% in three years and 50% in five years (Arora and Cason, 1995). In the Netherlands, publication of an influential report (Concern for Tomorrow) concluded that even full application of existing end-of-pipe control technology would not prevent significant environmental degradation by 2010 (Hersh, 1996:29). Following this, the Dutch government

launched an ambitious dialogue with industry to significantly reduce a wide range of emissions. The resulting National Environmental Policy Plan (NEPP) called for drastic reductions in SOx, VOCs, NOx, heavy metals, and several other pollutants by 2010. The clear quantitative targets and broad-based political support for them within the Dutch political system signaled to polluters that the government was serious.

2. Shift from single-media permitting that emphasizes end-of-pipe solutions to cross-media, facility-wide (integrated pollution control) permitting that emphasizes preventing pollution through materials substitution, minor process changes, and facility redesign[2]

At the national level this is practiced most extensively in Ireland, the United Kingdom, the Netherlands, and Sweden (Hersh, 1996). In Ireland, a relatively new environmental agency has eschewed both end-of-pipe solutions and a single-media approach in favor of single-facility permits following environmental audits that emphasize design and redesign of facilities to eliminate pollution (Larkin, 1997). In the U.K., an environmental agency organized along single-media (air, water, land) lines has reorganized its pollution inspectorate and is now offering cross-media integrated pollution licenses that emphasize pollution prevention (Hersh, 1996: 18-25). In the Netherlands, a single-media approach to pollution has given way to a more flexible, quasi-voluntary integrated pollution reduction system known as environmental covenants. This system also emphasizes prevention. In the U.S., New Jersey, Massachusetts, and Minnesota, to name a few of the states implementing cross-media pollution prevention programs, are experimenting with an integrated pollution control approach to prevention, particularly for toxics (Beardsley, 1996; Becker and Geiser, 1997).

3. Greater reliance on citizen participation in regulatory design and on public disclosure by polluters

There are numerous examples of this. In the U.S., major new federal initiatives such as the Common Sense Initiative (CSI) and Project XL require greater citizen and public participation (Davies and Mazurek, 1996:22, 33). The CSI is aimed at moving away from a media-specific to a sector-based approach to regulation. To achieve this, sector councils, which include members from the public, have been formed to help identify and remove barriers to innovative pollution reduction strategies. Project XL is aimed at facilities rather than sectors and is designed to encourage "beyond compliance" environmental behavior by rewarding excellent environmental performers with greater flexibility in meeting emissions standards. To qualify, firms must show stakeholder (including community and public sector) support for their proposed innovations.

Increased public disclosure is paramount in virtually all of the regulatory experiments. The U.S.'s Toxic Release Inventory program is one manifestation of the shift toward increased disclosure. This has been extended in at least one important federal voluntary pollution reduction program in the U.S.

[2] Single-media permitting refers to separate permits for air, water, and solid waste This has been criticized for promoting cross-media transfers in pollution This can happen when, for example, power plants use electro-static precipitators to capture air pollutants but then dispose of the captured pollutants as sludge or solid waste Integrated pollution control forces polluters to search for a cost-minimizing way to minimize pollution from all sources (air, water, and solid waste).

(33/50), and it is an important element in state-level programs such as the Massachusetts Toxics Use Reduction Act (Becker and Geiser, 1997). Increased public disclosure is also an important element in programs outside the U S., including in countries where public participation and disclosure historically have been historically unimportant. This is true in Ireland, where integrated pollution control initiatives require firms to publish an annual environmental report that assesses progress. Irish firms are also required to report on emissions in public pollution registers (Larkin, 1997). This is also the case in the U.K., where firms seeking integrated pollution control permits must publish the details of their applications in local newspapers and public registers (Hersh, 1996:16). In the Netherlands, the environmental covenant system has resulted in detailed public reporting and in the creation of "right to know" pollution registers (Hersh, 1996:31).

4. Shift away from an adversarial relationship between regulators and polluters to one of cooperation

The best manifestation of this has been increased use of voluntary or quasi-voluntary environmental management programs. These voluntary or quasi-voluntary programs often involve protracted dialogue and cooperation among regulators, the public, and polluters. Voluntary compliance forms the basis for the USEPA's 33/50 program, the Common Sense Initiative, and Project XL. It is also an important component of toxics use reduction programs in Massachusetts, New Jersey, and Minnesota (Beardsley, 1996) The Dutch covenant system is also a quasi-voluntary pollution reduction program. Both Japanese (MEIP, 1997) and Swedish (Hersh, 1996) environmental policy have long accorded important roles to cooperation and voluntary compliance.

5. Proliferation of supply-side clean production programs designed to overcome information failures, the high risks, and the high transactions and learning costs of a clean technology industrial-environmental management system

Virtually all OECD countries have industry-specific information-based programs designed to overcome failures in information markets (OECD, 1994:17). As in the U.S., these often include some kind of clean technology or pollution prevention information exchange program and/or clean technology center. The programs include technical assistance to firms, clean technology/pollution prevention workshops, and publication and dissemination of waste reduction opportunities manuals (Arora and Cason, 1995:274). Quite often these efforts are complemented by small-grant programs for demonstration and dissemination projects (OECD, 1994:17). Many, but fewer, of the governments in the OECD complement these information-based programs with subsidized loan programs for clean technologies. Still fewer offer tax incentives for clean technologies. In those countries (Japan, Denmark, Sweden, and the Netherlands) where cooperative relationships exist between business and government, where industry and government leaders move back and forth between business and government, and where quasi-government research and development institutes have developed detailed understanding of the state of technology, including environmental technology in an industry (Wallace, 1995:25-41), subsidized loan programs and tax incentive programs appear to be targeted more closely to plausible clean technology alternatives.

But what has all this added up to? Is there any evidence that these clean technology programs are contributing to (a) a shift away from end-of-pipe solutions to pollution; (b) more cost-effective industrial-environmental management; and/or (c) quicker reductions in the pollution intensity of

output. Unfortunately, hard empirical evidence on these issues is woefully lacking. This is partially due to the fact that many of these programs are too new to evaluate and that it is difficult, if not impossible, to disentangle the effects of clean production programs from other influences.

Despite this lack of empirical evidence, there are growing, largely piecemeal, signs that industrial firms in the OECD are shifting their industrial-environmental management practices toward clean technology alternatives. There is little doubt that the combination of (a) cradle to grave joint, several, and unlimited liability for toxic chemical pollution in the U.S. (as embodied in the Resource Recovery and Conservation Act); (b) increased public disclosure (the Toxic Release Inventory); and (c) a voluntary pollution reduction program (33/50) has contributed to a decline in the toxic chemical intensity of industrial production among large firms that are heavy users of such chemicals (Arora and Cason, 1995; Davies and Mazurek, 1996:12-15). There is also some evidence that this combination has been achieved by a shift to cleaner production practices. At the regional level, there are several fascinating examples of how firms in different industries in the same locale can overcome coordination problems to exchange and reuse wastes that have the effect of limiting the use of new inputs and preventing pollution (Ehrenfield and Gertler, 1997). At the firm-specific level, there are a growing number of examples (Fisher, Mongan, and Ott, 1997; Nelson, 1994:371-383) of firms, at least in the U.S., that are shifting industrial-environmental management strategies towards clean technology.

For the most part, these successes have been limited to toxic chemicals and to materials substitution, good housekeeping, better inventory control, and minor process modifications. Clean production advocates and others claim that the shift in this direction has been much too slow and halting, but there is no systematic evidence to suggest either the extent of dissemination of individual clean technologies or of the time taken to achieve what has been accomplished. Said another way, little is known about whether dissemination is fast or slow.[3]

Uncertainty over the spread of the easier clean technology practices (materials substitution, minor process changes, good housekeeping, and better inventory control) does not extend to fundamental redesign of capital equipment and manufacturing facilities to limit initial resource requirements and generate recoverable and usable waste. Although there are isolated examples of this (technical change in pulp and paper-making [Wheeler and Martin, 1992], the drive toward zero emissions at Dupont (Mongan, 1997), and the design of zero emissions plants in high-tech electro-plating (interview with EMS manager at Amp Corporation, 1996), it appears that neither public sector science and technology institutes, nor research universities, nor industry-specific research laboratories in the OECD are grappling quite yet with this issue. Said another way, there is not much evidence that national innovations systems in the OECD are grappling with this problem. Some have suggested that this will not happen until universities that train the next generation of scientists and engineers start integrating clean production considerations into university curricula. Friedlander (1989:175-179) suggests that this might be done by (a) by including discussion of process-integrated pollution control into engineering design courses,; (b) by introducing concepts related to emissions, such as NO_x emissions, into discussions of power cycles in undergraduate engineering thermodynamics courses; and by (3) incorporating problems and examples related to the

[3] For a discussion about the pace of technological diffusion across a range of new inventions, see Grubler (1996)

minimization of pollution control into undergraduate courses in chemical engineering, particularly those related to courses in separation processes and chemical reaction engineering.

Chapter 4: Toward a Policy Menu for Clean Technology in Rapidly Industrializing Asia

What are the implications of findings reported here for the design of government policies to promote a "clean industrial revolution" in rapidly industrializing Asia? Or said another way, what might a public policy menu for clean industrial production look like for countries in rapidly industrializing Asia? Evidence reported on here suggests that three signal elements matter. They are:

1. **Establishment by governments, probably in concert with industry leaders, of clear, quantitative pollution reduction targets and clear, tough, and increasingly stringent emissions standards**

These targets and standards are necessary to communicate to firms that governments and the public are serious about reducing the pollution intensity of industrial production. Given the existing cooperative relationships between government and business in East/Southeast Asia (MacIntyre, 1994), these pollution reduction targets should probably be developed in concert with industry. They might even be modeled on the cooperative relationships used in East Asia (as in Korea, for example) in an earlier time to set quantitative exports targets by plant and firm (Rhee, Ross-Larson, and Pursell, 1984).

2. **Development of an environmental regulatory system and a public sector environmental agency that relies on (a) an integrated cross-media pollution control system that emphasizes prevention; (b) a flexible, cooperative relationship between regulators and polluters; and (c) citizen participation and public disclosure for accountability**

What this means is that advocates of a clean technology alternative to industrial-environmental management can not be agnostic about either the need for or the design of the environmental regulatory system. With respect to the former, evidence from the OECD suggests that it is probably not possible for governments in Asia to leapfrog over the need for a tough regulatory system by, for example, relying on a strategy based on the assumption that "pollution prevention pays " There are two reasons for reaching this conclusion. First, pollution prevention does not always pay. Second, in no country in the OECD has the shift toward clean production led to a relaxation in emission standards. If anything, standards are becoming more stringent.

That said, advocates of clean technology alternatives cannot afford to be indifferent to the design of the regulatory system. Unless care is taken to build such a system on the basis of integrated pollution control (which emphasizes prevention), trust and flexibility between regulators and polluters, and public participation and disclosure for accountability, it will be all too easy to slip into a "command and control" end-of-pipe industrial-environmental management system. In fact, much of the donor activity in Asia is doing just this. If successful, these donor activities could contribute to the development of an environmental management system that is an impediment to a clean technology alternative to end-of-pipe industrial-environmental management.

3. Promotion by central governments of a highly targeted public sector information exchange program for disseminating information about clean production alternatives; development by the public sector of similarly highly targeted fiscal and financial incentive program to overcome the high risks, transactions costs, and learning costs of firm- and plant-level clean technology industrial environmental management initiatives

To date, it appears that these kinds of programs have not been particularly effective in the OECD Making them more effective in rapidly industrializing Asia will require developing the kinds of performance-based linkages between the public and private sector used to promote the exports of labor-intensive manufacturers. This involved creation of industry-specific (such as men's dress shirts) government-industry task forces to identify and solve problems (Rhee, Ross-Larson, and Pursell, 1984); engaging public sector and quasi-public industrial research institutes and ministries of industry in international searches for and in domestic dissemination (through, for example, reverse engineering) of commercially viable new technologies (Mardon, 1990; Wade, 1990); and allocation of lucrative investment incentives (tax breaks and subsidized credit) on the basis of the firms' to meet mutually agreed upon quantitative performance targets (Rhee, Ross-Larson, and Pursell, 1984). In the case of East/Southeast Asia's export programs, all of this was more or less tethered to peak government-business committees of senior political leaders and business elites (Rhee, Ross-Larson, and Pursell, 1984; Wade, 1996; Rock, 1996; MacIntyre, 1994). These peak committees were used to communicate the importance of the export program to others in business and government and to identify common problems that needed to be addressed. They were also tethered to peak industry associations which became important conduits for transmitting information from firms to governments and from governments to firms.

Beyond this, four other issues deserve consideration. First, it needs to be recognized that the specific institutional design of clean technology policy programs must take into account the unique historical, institutional, and cultural differences among countries. They must also allow for the institutional creativity evidenced by the public sector in East/Southeast Asia in other areas. In other words, Asian policy-makers must be given the opportunity to lead the policy design for a cleaner industrial development strategy. Second, consideration needs to be given to how, or in what ways, international market pressures (ISO 14000, multinational greening of the supply chain programs, and/or green labeling programs) can be integrated into policy designs for clean technology. Third, clean technology programs in Asia will have be to tethered to a real-world understanding of how private sector firms in Asia acquire capital, technology, and industrial competence (Hone, 1974; Egan and Mody, 1992; Mardon, 1990; Wade, 1990; Westphal, Rhee, and Pursell, 1981). Finally, since countries in the OECD are the dominant suppliers of new plant and equipment and new technology, some thought needs to be given to how to promote the development of cleaner technologies within the OECD.

Several recent developments in industrial ecology and technology policy suggest how governments in the OECD might go about designing policies more conducive to the development of "clean" technical change (Heaton, 1997; Wernick, Herman, Govind, and Ausubel, 1996; Frosch, 1996; Friedlander, 1989). To begin with, low-cost reliable ways have to found for assessing changes in the pollution, energy, and materials intensity attending technological change in production processes for goods and services. Some significant progress has been made in this area (Wernick, Herman, Govind, and Ausubel, 1996), but much remains to be done. Most important, research in this area has

to be extended to more inputs, processes, and products. Second, the insights gained from applied research on trends in dematerialization in a wide range of production processes will have to be embedded into original design processes for new technologies and new plant and equipment. Because design engineers are likely to resist this, at least initially, accomplishing it probably requires restructuring of undergraduate engineering curriculum. Friedlander (1989) suggests how this might be accomplished. Finally, as Heaton (1997) suggests, biases in environmental regulatory statues and in the administration of environmental policy against new "dematerializing" technology will have to be removed if firms are to innovate in dematerializing directions. Overcoming these biases probably means shifting away from a single-media focus to integrated pollution control. It also means moving away from using best available technology (BAT) standards to judge a firm's environmental performance.

Chapter 5: Conclusion

It is now clear that the rapidly industrializing economies of Asia, like their counterparts in the rest of the world, have pursued economic growth (albeit more shared growth) at the expense of the environment. Each of the countries in this region is in the midst of correcting this omission by building an environmental policy infrastructure alongside and in conjunction with an existing industrial policy machinery that has more or less guided industrial development in this region. This process is in different stages in different countries It is occurring in a two-step-forward, one-step-back way, but it is occurring nevertheless.

The fundamental question addressed here is: How might this process be guided to promote a clean technology approach to industrial-environmental management that is more cost-effective than conceivable alternatives. The answers provided here have been simple and straightforward. Focus on communicating tough emissions standards to firms; build a regulatory system around integrated pollution control emphasizing prevention and cooperation between regulators and polluters; and emphasize accountability through citizen participation and public disclosure. Complement this with a performance-based clean technology information dissemination program and a performance-based fiscal and financial incentive program. Embed all of this in (a) the institutions of industrial policy; (b) a firm understanding of how Asian firms are acquiring capital, technology, and industrial competence; and (c) development of policies in the OECD that will ensure that the newest vintages of capital and technology developed there, which will ultimately find their way to Asia are as clean as can be. Take care to do these things in ways that take advantage of the unique differences among countries and the opportunities afforded by these differences. Also, be sure to do so in ways that permits Asians to design the ultimate policy interventions. They have taught the world much about how to be institutionally creative to achieve public developmental ends. They just might be able to do the same with respect to the environment.

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