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Fulfilling the Promise of Environmental Technology

Well-designed government policies can spur innovation that is good for the environment and good for the economy.

It is generally assumed that environmental initiatives act as a brake on economic development. But if relevant policies are artfully designed to stimulate technological innovation, adapting to environmental constraints should *enhance* economic growth. Opportunities for environmentally useful new technologies are broad, varied, and extraordinarily promising.

In transportation, for example, new technologies for measuring pollution levels may lead to more cost-effective regulatory strategies. In manufacturing, new techniques for separating post-consumer metals may allow manufacturers to produce high-value recycled goods, making recycling more profitable. In energy, new technologies based on biomass, wind, and photovoltaics may provide competitive substitutes for coal- or nuclear-based electricity.

All too often, however, the promise of such technological innovations is not recognized or given adequate weight in environmental policymaking. And sometimes environmental policymaking actually thwarts the development of new technology.

Two deep cultural problems may be responsible for this pattern. First, U.S. business managers tend not to take the lead in formulating environmental goals and regulations; instead, they often pursue an adversarial approach. This is unfortunate because they are often in the best position to know what can be achieved with new technology and where the pitfalls lie.

Second, environmentalists are sometimes uncomfortable with new technology, which, after all, has been the source of many environmental problems. Moreover, some environmentalists are wary of advocating a public policy aimed at new technology for fear that it will delay achievement of environmental goals. They believe that environmental problems are primarily social in nature and can be solved with present technology.

Fresh approaches to environmental regulation can

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help to break this cultural deadlock. In particular, there are five ways to design environmental policy so as to elicit new technologies: clever standard setting; well-informed technology-forcing regulations; expanded markets that incorporate pollution costs; research and development focused on seemingly mundane but environmentally critical technologies; and collaborative international projects.

Prescriptive vs. performance standards

There are three approaches to regulatory standards. The most constraining requires the use of specific technology or the incorporation of specific design characteristics; a broader approach requires the passing of a preset test; the most flexible one measures actual in-use performance. The first approach is usually the easiest to administer, but is notorious for its tendency to inhibit the introduction of new technology. Indeed, one of the few general prescriptions one can rely on in formulating environmental policy is to avoid prescriptions.

An extraordinary example of the first approach is a new, politically driven regulation in the Clean Air Act Amendments of 1990 establishing the minimum oxygen content of "clean" motor vehicle fuel. Underlying this requirement is the dubious assumption that putting additional oxygen atoms into fuel is the preferred way to achieve additional oxidation of carbon monoxide to carbon dioxide. There are many other ways to reduce carbon monoxide emissions, however, such as changes in engine design, alternative fuels (including "reformulated" gasoline), and adjustments in fuel-air mixture in interaction with catalysts. Innovations in each of these directions will now be discouraged.

The second approach to regulation requires the development of standardized tests that mimic in-use performance. But such tests have their own serious disadvantages. Consider fuel use and emissions testing for new vehicles, both of which are regulated with the help of the Environmental Protection Agency's Federal Test Procedure (FTP). Some new vehicles are designed to do well on the test, but show lower fuel economy and higher emissions in routine driving. In addition, changes in driving patterns, such as much higher speeds on open highways and stop-and-start driving in increasingly congested metropolitan areas, are beginning to render the FTP obsolete.

The Clean Air Act Amendments fail to provide for an overhauling of the FTP, which the manufacturers know inside and out and are reluctant to see changed. Congress should direct EPA to undertake a thorough update of test parameters and test technology, with the cooperation of manufacturers, and use the modernized version as the basis for future regulation.

The third approach to environmental regulation is built around measured in-use performance. Of the three, it is by far the best targeted—as long as performance can be measured in a cost-effective manner. In-use measurement is also the most accurate way to communicate societal goals to the scientists and engineers involved in developing new technology.

Modern instrumentation is making the goal of cost-effective measurement of in-use performance achievable, but much development lies ahead. For instance, automotive emissions could be measured by on-board devices or by roadside detection equipment that checks each passing car. Those approaches may offer major opportunities for improving air quality by pinpointing the most serious offenders. With strong support for development, such technologies could become available in a few years.

In a pioneering venture, the Clean Air Act Amendments of 1990 adopt in-use measurement as a cornerstone of the new market-based policy governing sulfur dioxide emissions from power plants. The legislation requires continuous measurement of stack emissions and provides an interesting incentive for plant operators to keep measurement devices in good working order: In the event of instrument failure, regulators assign a default value for emissions that is higher—and therefore more costly to the operator—than the expected measured value.

Technology-forcing regulations

Another way to stimulate the development and adoption of new technology is to enact technology-forcing regulations—policies that set performance standards exceeding the capabilities of currently available equipment. A good example was the enactment of strict automotive emissions standards in the 1970s, which led to the development of the catalytic converter. The Clean Air Act Amendments of 1990 have been designed to push technology further by establishing targets for additional reductions in emissions.

Fuel economy provides another example. Auto manufacturers found ways to double fuel economy between the mid-1970s and 1988 in order to meet increasingly stringent federal standards—without reducing the interior volume or acceleration performance of the average car. Technologies for further substantial increases in fuel economy are within grasp. But in the absence of any intervention, market failures will prevent most of this desirable progress from occurring in the coming decade. Tighter fuel economy regulations would spur manufacturers to develop and adopt these technologies.

Tighter fuel economy regulations would spur manufacturers to develop and adopt improved technologies.

There is a subtle conflict between accelerating the introduction of new technology and having the patience to allow enough time for its development. In designing technology-forcing regulations, it is essential to get the manufacturers involved and to encourage them to focus on the engineering, as opposed to the legal, arena. Regulators can foster a productive dialogue by allowing business managers to put forward proposals for delaying compliance with certain regulations until innovative technologies are in place—on the condition that they accelerate the schedule for compliance with other regulations that require no new technology. For example, federal authorities are eliciting such proposals by encouraging individual firms to differentiate among the many toxic air emissions newly regulated by the Clean Air Act Amendments of 1990.

Poorly designed technology-forcing standards can discourage promising technologies. For example, most standards separately regulate each of several emissions without permitting the balancing of benefits. Consider the effect on diesel engine technology of the nitrogen oxide emission regulations in the Clean Air Act Amendments of 1990. Diesel engines potentially offer good fuel efficiency and durable emissions performance, relative to gasoline engines. On the other hand, their nitrogen oxide emissions are more difficult to control. In order not to discourage diesel engine development, the Act provides that emissions of nitrogen oxides from lightweight vehicles with diesel engines will not have to be reduced as quickly as those from gasoline engines. This variance, if extended, will permit the substantial development and testing needed before diesel technology can realize its full potential. In general, however, effective policymaking ought to complement a variance in one area with an explicit quid pro quo in another. For example, the variance in emissions of nitrogen oxides for automotive diesels might be coupled with stricter fuel-economy requirements.

There are cases where technology forcing appears to be premature. Just because auto manufacturers lack credibility when they say they can't improve fuel economy, doesn't mean that they ought to be ignored when they say that they cannot do everything we want them to do. Among the ambitious air pollution initiatives for motor vehicles being undertaken in southern California is a measure requiring the introduction of large numbers of electric vehicles in the period 1998–2003. By the latter year, electric vehicles are to comprise 10 percent of the market. The advantage of electric cars is that most of the pollution is created at power plants remote from population centers, where vigorous centralized efforts should more readily reduce total pollution; the electric car itself is relatively efficient and emissions-free. The primary disadvantage of electric cars is in the service they provide: The practical range between charges of their batteries is about 100 miles, and several hours are required for full charging.

Battery technology has made remarkable progress, but vehicle range will not increase enough in the next decade to fundamentally alter the market picture. Although some special classes of vehicles, such as delivery vans, would function well on battery power, most general-purpose vehicles would be much less useful than they are now. To require the introduction of a large number of expensive electric commuter cars therefore appears to be unwise unless supported by strong planning efforts. More flexible regulations could encourage the development of hybrid electric vehicles that use fluid fuel for long trips, or the creation of an infrastructure to allow drivers to exchange battery sets at service stations instead of waiting for recharging.

It is important for environmental policy to extend technology forcing into new areas. One example is newly proposed cradle-to-grave regulations for consumer products that are toxic or difficult to dispose of, such as batteries and tires. In one version, these regulations would require consumers to make refundable deposits on the purchase of these products and to return them to the manufacturer for reuse or disposal. In another version, the manufacturer retains ownership of the product and leases it to the consumer. By shifting the responsibility for disposal from consumers to manufacturers, policymakers can spur industry to develop new, safer products and product-life-cycle systems.

Market mechanisms

Economists have long advocated the use of market mechanisms to achieve pollution control. They argue that these kinds of incentives give the polluter the freedom to exercise a full range of responses, such as changing product mixes or choosing among available technologies. Market mechanisms will also encourage technical innovation, although this is often overlooked.

A few regional ventures have established markets that allow firms to trade air-pollution "rights" within a "bubble"—for example, an airshed like the Los Angeles Basin. Firms that need to increase emissions, perhaps in order to open a new plant, must arrange for equivalent emissions reductions inside the bubble, either by their own firm or others. Up to the present, these markets have not been very active. Manufacturers that have reduced pollution and thus acquired pollution rights have preserved or banked those rights instead of selling them.

Market mechanisms come into unprecedented prominence in the Title IV sections of the Clean Air Act Amendments of 1990, which deal with sulfur dioxide emissions from the nation's electric power plants. Previous Clean Air Act regulations, now about to be supplemented, effectively mandated scrubber technology on new plants. But there are, or will be, good alternatives to scrubbers—both new technologies (which promise to reduce emissions to less than one percent of uncontrolled levels, and to lower capital costs as well) and low-sulfur coals.

The new amendments require that the total annual emissions of sulfur dioxide from the nation's electric power plants be cut roughly in half by the year 2000. But instead of specifying how these reductions should be achieved, the amendments create a market in sulfur-dioxide emission allowances. This market gives firms an incentive to introduce innovative technology that reduces emissions well below the point where regulations would have set a threshold, since deploying that technology will give them more allowances to trade.

To be even more effective, markets in emissions should be complemented by incentives that directly reward firms for scrapping the most poorly performing technology and replacing it with innovative equipment. Examples are found in the Clean Air Act Amendments of 1990, which allow an electric utility to delay compliance with more rigorous emissions standards in return for installing new technology. Other incentives should be tried, including tax credits and accelerated depreciation mechanisms. These "scrap-and-build" incentives, as they are called, should be targeted at old factories and old cars as well as old power plants.

Another market-based policy that acts directly on investment decisions is the Drive-Plus proposal being considered in California. When consumers purchase a new car, they are either granted a rebate or assessed a fee, depending on whether the car's emissions and fuel use are more or less than the state's sales-weighted average. Providing time-of-purchase incentives is important because, in a way not easily captured by economic models, consumers pay far more attention to initial costs than to operating expenses.

R&D on base technologies

Our current understanding of environmental problems is incomplete, and the missing pieces may be crucial. A program of fundamental and applied research is needed to ensure that efforts to create new technology are informed by the deepest possible understanding of environmental objectives.

The rate at which understanding is deepened depends on the levels of support and coordination. In the United States, the federal government has been almost the exclusive patron of research in pure science, in military areas, and to a large extent in medicine, agriculture, and electricity supply. The government has also helped fund the development of certain high-technology products such as supercomputers. But it leaves to the private sector most of the research and development in areas related to the core activities of society, where technology has great impact on the environment—areas such as ground transportation, materials production, housing, the food system, waste treatment, and population planning.

The private sector does not take up the slack; its underinvestment in research is well documented. With certain notable exceptions such as in electronics and pharmaceuticals, individual firms are deterred from investing in research, for several reasons: because they cannot prevent competitors from capturing many of the benefits that result, because they are operating with short time horizons, or because their earnings are cyclical.

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The academic research community also neglects environmental science and technology. Environmental problems are primarily found in the core activities, listed above, that lack the glamour and novelty of, say, space exploration or advanced medical treatment. Yet a look beneath the surface reveals that core technologies often have a glamour of their own, with connections to advanced high-technology materials and components and rigorous analytical methods.

The poor state of applied science in many environmentally important areas of civilian base technology impedes the development of new products and processes. An example of an environmentally important base technology is cleaning, as needed in manufacturing. The area is important because such cleaning is now widely accomplished with chlorinated hydrocarbons, many of which are carcinogens. Research is needed on the fundamentals of cleaning—for example, on how ultrasonics, electromagnetic radiation, thermal shock, and specially designed surface materials affect the adhesion of impurities to surfaces. Similarly, the study of the fundamentals of friction could lead to improvements in the performance of automobile engines and a wide variety of other machines. And advances in separations technology could facilitate the sorting of waste metals and plastics for recycling, the closing of aqueous cycles in the paper industry, and many other pollution-prevention strategies.

Two programs supported by the Department of Energy to improve civilian base technologies demonstrate how the federal government can help. The Combustion Research Program at Sandia National Laboratories, begun in 1975, is engaged in activities that range from fundamental studies of combustion chemistry to applied research on engines and furnaces. It promotes basic and applied research, improved instrumentation, and state-of-the-art user facilities. A smaller program at the Lawrence Berkeley Laboratory has laid the fundamental groundwork for innovation in a variety of advanced lighting products. To foster improvements in base technologies, the federal government should create additional centers for research in several other areas of manufacturing process and product technology.

International collaborations

The development of new technology can be enhanced through international environmental policy. Here, policy design must acknowledge several difficulties. The same free-rider problem that leads private corporations to underinvest in R&D operates among nations: Each country is concerned that other countries will gain the benefits of its programs without carrying the costs, or decides that it can hold back and wait for work to be done by others. For smaller countries, as for smaller firms, the development of new technology may appear daunting. To overcome these obstacles, countries could apportion several modest-sized projects among themselves, taking into account comparative advantages such as geography, scientific bases, and special interests.

For example, an important challenge to environmental science and technology is to understand the environmental impacts of biomass energy—that is, the conversion of crops and trees to fuels and electricity. Biomass offers an attractive renewable-energy strategy for developing countries because the up-front investment is relatively low. Although badly conceived projects or overexploitation will cause severe environmental damage, well- designed projects involving new technology can provide multiple benefits involving energy, agriculture, water, habitat, and other resources. Each of several industrialized and developing countries should undertake responsibility for pilot projects or test facilities related to particular biomass-based technologies. Parallel projects should be assigned to two or more countries, both to take into account regional variability and to encourage some degree of competition. The thirteen International Agricultural Research Centers, each specializing in particular crops, represent an important precedent for what we are proposing.

A useful concept in the design of international arrangements for research and development is "technological leapfrogging," in which the deployment of new technologies occurs *first* in developing countries. Indeed, one of the great stimuli to innovation will come from confronting the problems of the developing South as new problems. Some of the solutions proposed will take the form of new technologies that will apply in the industrialized North. Other solutions that do not apply will still be welcomed by the North for alleviating stress on the common global environment. If the R&D is conducted so as to strengthen independent capabilities in developing countries, the process of technological innovation can become self-sustaining, thereby assisting national development processes while improving the environment.

New technologies are not panaceas, but they can provide improvements in both industrial productivity and environmental quality. And they can restructure political or institutional arrangements and accelerate the pace of progress. Designing policies to elicit new technology is a task that should bring together the leaders of government, business, and environmental organizations. Modern society, which has been ill served by the lack of cooperation among these communities, will greatly benefit.

Recommended reading

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