Is Environmental Technology a Key to a Healthy Economy?

Surrounded by palms and tropical plants, President Clinton met with reporters in the U.S. Botanical Garden on Earth Day (21 April) to give a big boost to "green" technologies—technologies meant to save the environment as well as produce profits. Among the showiest pieces of greenery in his speech were his plans for cleaner cars. He said he was signing executive orders that would have federal agencies stock their fleets with thousands of vehicles powered by fuels other than gasoline.

BETTMANN

Green thoughts in a green shade. President Clinton announces environmental initiatives on Earth Day.

Clinton's enthusiasm is backed up by some behind-the-scenes maneuvering, in which the White House science staff has been doing its part to create what it calls a "new generation of automobiles." Since February, presidential science adviser John Gibbons has been trying to sign up the big three automakers for a "clean car initiative"—a government-industry collaboration to develop vehicles powered by fuel cells or other nonpolluting engines. The goal, according to a Clinton policy paper, is not just to improve air quality, but to take "a bold and dramatic step toward a more profitable and more environmentally sound future for one of America's most important industries."

This enthusiasm for the clean car reflects the Administration's belief that environmentally safe technologies are not just good for the environment but good for business. Administration leaders believe that U.S. companies profit in several ways from stringent standards: by selling more cleanup equipment, by becoming more efficient, and by gaining an edge on competitors through advances in technology. For the auto industry, Gibbons has said, the object is to create a new industrial revolution that will remove "the automobile from the list of national environmental problems" and restore the "technological preeminence" of U.S. auto manufacturers.

But the auto industry isn't convinced—not by a long shot. At this writing, according to Donald Zinger of the Environmental Protection Agency's (EPA) air quality office, "There's a fair distance between government views and auto industry views." The White House hopes to announce a joint R&D agreement for the clean car soon, but the terms have been hard to nail down—in part, observers say, because industry folk are nervous about the size of the commitment they're being asked to make. So far, industry's only public plans for making clean cars are modest—such as those announced for a General Motors electric car called the Impact. Kenneth Baker, GM's electric vehicles manager, spoke last winter about the company's plans to build 50 of these cars, describing it as a "high-risk" venture designed to test public interest in the machines and gain production experience. Chrysler and Ford are also building electric vehicles this year because a California law requires the companies to sell a certain number of "zero emission" cars by 1998. For the carmakers, local regulations, not global competition, are the impetus.

The situation in the automobile industry reflects the Alice-in-Wonderland world of green technology. Companies, government agencies, and pressure groups all seem to be embracing something "green"—but what they think they are embracing, and their reasons for doing so, are often wildly different. Members of Congress, like the Administration, are speaking of a "green race" in which the United States is in danger of falling behind Japan and Europe. Some corporate groups are praising clean-by-design manufacturing processes as ways to save money and meet environmental regulations more cheaply. And environmental groups are hailing it all as proof that environmental regulations can be good for the economy. As Jonathan Lash, president of the World Resources Institute (WRI), put it in recent testimony to the Senate, the United States must make environmental regulation "an engine of technological change" in order to "stay abreast of Germany and Japan." Indeed, he says, the governments of those countries have "recognized that market demand is for products and practices which are environmentally superior have already escalated throughout the world."

But for all the concern about keeping up with the competition, there is strikingly little experience to support many of the hopes for green technologies. Even statistics on the past sales of water and air treatment equipment are sketchy, for example. Some economists say the annual trade amounts to $200 billion worldwide, while others say it is far less. Economists are also divided on the broader question of whether tough environmental standards help domestic industries by goading them to become more efficient and technologically sophisticated or simply cost them money (see sidebar on p. 1888).

Becoming a "Green Giant." Despite the obstacles and doubts, green technologists in the White House and Congress are working feverishly to provide new incentives for clean and efficient products and processes. The government has attempted to do this in the past, notably during the oil shortage scares of the 1970s (see sidebar on p. 1887). But in the radically different political climate of the 1990s, when the Democrats are presenting themselves as a pro-business party, the government appears to be taking a different approach—one that touts potential benefits to industry.

This vision of a green future is summed up in a paper, "The Clean Air Marketplace," issued by the EPA in March. EPA claims that environmental laws are "not only creating entirely new job opportunities" for companies that sell pollution control equipment, but are providing new missions for "defense contractors and aerospace firms" scrambling to survive. Strong regulations encourage everyone to be more efficient: Even "nonenvironmental companies can become tougher international competitors as they become 'smarter' in response to Clean Air Act requirements," says EPA.

To promote these green technologies, says Henry Kelly, a former staffer at the congressional office of technology assessment now working for Gibbons, the Administration is trying, first of all, to get its own house in order. In its technology policy statement released on 22 February, the White House calls for federal agencies to install better lighting, heating, and cooling systems in their own buildings; to subsidize the same conversions in public housing; and to favor green products in purchase contracts. The Clinton Administration is also calling on high-tech agencies—Defense, Energy, and Commerce—to focus R&D on areas that need dramatic improvement. For example, the National Institute of Standards and Technology is joining with the Electric Power Research Institute to develop clean substitutes for the chlorofluorocarbon (CFC) refrigerant called R22.

Congress is pushing hard in the same direction. In the Senate, Barbara Mikulski (D–MD) made a pitch last fall to create a

new National Environmental Technologies Agency to subsidize environmental designs, saying the United States needed stronger government leadership to become the "green giant" of the world. The bill died, but Mikulski has joined with Senators Max Baucus (D–MT) and Joseph Lieberman (D–CT) to introduce new legislation this year calling for the creation of a National Environmental Technologies Institute to sponsor green projects. Meanwhile House Space, Science, and Technology Committee chairman George Brown (D–CA) is introducing a similar green technology bill. All these efforts are motivated by the feeling that U.S. companies need to "catch up" with the perceived front-runners in green technology—Germany and Japan—which spend at least $470 million and $1 billion a year, respectively, on R&D for "environmentally critical technologies," according to WRI.

Additional enthusiasm for green thinking is coming from members of Congress who have an interest in developing a new role for the national labs. Senator Pete Domenici, a Republican from New Mexico, home of the Los Alamos and Sandia National Laboratories, is proposing that the national labs be designated centers of green research. The idea is popular, because Congress would like to see the huge expenditures already planned for lab cleanup go to projects that might benefit U.S. industry. Already, Department of Energy labs have joint projects with companies to develop a low-cost fiber-optic sensor to monitor toxic chemicals in soil and mobile labs to test for radioactive waste.

Industry: willing, but wary. Industry, for the most part, isn't sold on the new philosophy. Some industry executives—particularly in chemicals and electronics manufacturing—have embraced the green revolution. But even these leaders tend to describe the virtues of green technology cautiously, as a means of anticipating future government regulations or curbing wasteful processes rather than a method of promoting exports. To engineers and executives who cope with the technical details, the green-equals-competitive equation doesn't always hold up.

At a 23 February hearing before the Senate Environment Committee, for example, Frank Popoff, chairman of Dow Chemical, said that environmental controls should be adopted on their merits, "not as a way to improve the competitiveness of U.S.-based production." He told the committee that his company saved $750,000 by installing equipment to recover waste in an agricultural chemical process in California, and $770,000

A Fair Wind Blows for One Green Technology

The current rage in Washington for environmentally benign technologies (see main text) isn't the first time the U.S. government has begun to see green. In fact, some of the monuments to its earlier enthusiasm—a response to oil shocks of the 1970s and the fledgling environmental movement—are still standing, recalling how government sponsorship of environmental technologies has waxed and waned. One such monument is Mod 5B, a giant windmill built as a demonstration project by the Boeing Company for the Department of Energy and later erected at a windfarm on Oahu Island, Hawaii.

PETER MENZEL

New generation. Smaller, sturdier windmills, like these in California, have replaced earlier behemoths.

Though Mod 5B was completed in 1987, it is the legacy of a 1970s initiative in which federal agencies were more directly involved in the design of windmills than they have been since. The agencies hired aerospace companies such as Boeing to develop gargantuan wind energy machines. The project reflected the reigning theory of its day—that bigger windmills would be more efficient. And the contrast between Mod 5B and its successors suggests that government can have a positive effect on the development of green technology, but not necessarily by becoming involved in the technology's design.

Standing more than 200 feet tall, Mod 5B was the last of the Boeing Company's big machines and the heaviest the company ever built, weighing more than a fully loaded 747 jet. A special crane had to be brought in from the mainland to put it up. With blades as big as airplane wings, it could generate a whopping 3.2 megawatts of power when running. The problem is that this behemoth didn't always run, according to Scott Shirai, spokesman for the former owner, Hawaiian Electric Industries. Mod 5B and 15 smaller (600 kilowatt) windmills built by Westinghouse on government contracts were out of commission "a lot more than we expected," says Shirai, mainly because they contained so many custom-made parts. A few months ago, Hawaiian Electric sold its windfarm, claiming it could no longer sustain the economic losses.

A second generation of smaller machines sprang up during the 1980s—mainly in California. A combination of federal and state tax credits encouraged their construction, but the government involvement was less direct, because the agencies didn't step in and commission specific designs. Most of these are still generating power, though they, too, suffered some technical bugs. According to Edgar DeMeo of the Electric Power Research Institute, they have now been surpassed by a third, even more reliable generation.

The newest machines are small and robust, typically capable of generating 50 to 500 kilowatts each. Sales have been helped along, both in Europe and the United States, by laws requiring utility companies to offer fixed purchase-price contracts to suppliers of wind electricity. Another boost comes from the National Energy Policy Act, signed into law last fall by George Bush. It permits a 1.5 cent per kilowatt-hour tax credit for generators of electricity from renewable sources. Emphasizing energy production is "a much smarter approach" than just rewarding construction of new windmills, says Alexander Ellis, an executive at Kenetech/U.S. Windpower, because it encourages companies to deliver durable products.

Today, the wind energy business seems to be booming, bearing out the Administration's faith that environmental technologies can open new markets. There are now more than 16,000 wind turbines installed in the United States, according to DeMeo, most of them still in California. Europe is also moving ahead. Although European countries have installed fewer machines to date, DeMeo says, the European Community has ambitious plans, calling for double the current U.S. wind energy capacity by the end of the decade. About 10 major manufacturers in the United States and abroad are vying for this business. Ellis of Kenetech says, "Europe is a very exciting market for us," adding that his company has already built "the largest windfarm in Europe"—a group of 150 machines producing 100 kilowatts each near Gibraltar, Spain. It took some fine-tuning, but government incentives to nurture this green technology seem to be working.

–E.M.

Green Profits: Believers and Doubters

The Clinton Administration has embraced the idea that inducing firms to adopt "green" technologies, designed with the environment in mind, can bolster their bottom line (see main text). But these officials aren't the first to be intrigued by the notion. Last year, during William Reilly's tenure as Environmental Protection Agency (EPA) chief, agency economists decided to look closely into a green-is-profitable theory proposed by Harvard University business professor Michael Porter. The closer they looked, however, the less concrete evidence they found.

The EPA researchers analyzed an assertion published by Porter in the April 1991 *Scientific American*. In a claim still quoted approvingly by environmentalists and officials, Porter wrote that "strict environmental regulations do not inevitably hinder competitive advantage against foreign rivals." Indeed, he said, "they often enhance it." Porter claimed that tough standards "trigger innovation and upgrading" of technology, making companies more efficient. In the 1980s, he said, foreign firms had moved ahead of U.S. companies in environmental sensitivity, and that as a result, "U.S. trade...suffered." It was a surprising conclusion, in part because it clashed with a study by Joseph Kalt, another Harvard economist, who had found that environmental regulation "appears to have a negative effect on industries' trade performance."

To sort out these conflicting signals, EPA hired economist Albert Nichols of the National Economic Research Associates in Cambridge, Massachusetts, to review the literature. Nichols says his first step was to translate Porter's essay into a form that could be tested by economic analysis and secure Porter's blessing of the new wording. Then, Nichols says, it became clear that the new formula was so hedged with qualifiers that it simply couldn't be tested. No one would be surprised to learn, Nichols wrote last year in a memo to EPA, "that in some cases environmental regulations actually lower costs" by introducing more efficient processes. But he could find no basis for Porter's claim that "firms systematically miss opportunities to make significant savings" by developing cleaner, greener processes and products.

Porter isn't backing away from his hypothesis, although he now agrees that, as expressed in the *Scientific American* essay, it wasn't testable. The reason, he says, is that data on trade in clean products and processes just aren't "fine-grained" enough to permit the kind of analysis that may be required to convince skeptics. He thinks Kalt's negative conclusion is flawed for the same reason.

The picture may sharpen, however, with some new studies on the benefits of environmental regulation. Porter says a Swiss colleague, Claas van de Linde, is tackling the subject in some detail and will report later this year. Porter himself plans to have an in-depth analysis out by the end of the summer. Critics at Resources for the Future (RFF)—who say it's hard to understand why companies would look for more efficient production methods only if challenged to do so by regulations—have also begun a careful review of the Porter hypothesis. Meanwhile, economist Dennis Anderson at the World Bank lends his support to it, based on his own historical analysis of the benefits to industrial development brought about by improvements in environmental and public health. For now, though, says Paul Portney of RFF, the green-to-greenbacks debate is largely a battle of "conjecture versus conjecture."

–E.M.

by reducing landfill shipments at a latex plant in Michigan. But Popoff warned that some other greener, more efficient processes resulted in a net loss for Dow.

When the goal is to cope with environmental regulations, however, Popoff and other leaders of both the chemical and electronics industries are finding that manufacturing strategies that avoid waste and pollution are often cheaper than cleaning up afterward. Called "industrial ecology," this new strategy calls on engineers to consider the environmental impacts of each component of a new design or process before it is added to the production line. Whenever possible, the designer chooses the least polluting alternative.

The chemical industry got the earliest start on this planned approach to handling pollutants, goaded into action by regulation and by catastrophes such as the mass poisoning in Bhopal, India. This effort, called "responsible care," began in the 1980s (*Science*, 19 March, p. 1538). Electronics firms have now joined in. They, too, have been spurred by government actions. In the United States, they have been trying to cope with rules designed to protect the ozone layer against depletion by CFCs.

Makers of circuit boards, for example, had to eliminate CFC-based solvents used in cleaning off wastes from soldering. Some companies took a short-sighted approach, says Braden Allenby, environmental attorney at AT&T, shifting from CFCs to other volatile, chlorine-based scrubbing compounds. Others took a longer view, completely restructuring their processes either to eliminate cleaning or use new water-based or semi-aqueous methods wherever possible, and relying on chlorinated compounds only as a last resort. This radical approach proved more economical in the end, says Allenby, because those who opted for the short-cut eventually had to redesign their processes a second time as air quality rules tightened further.

Although most of industry is in a decidedly cautious mode, a few companies are looking beyond U.S. regulations and beginning to accept the Administration's equation of green strategies with global competitiveness. For the most part, the impetus is another set of environmental regulations—those their products face overseas. For example, the Microelectronics and Computer Technology Corp. (MCC), a consortium in Austin, Texas, has become concerned about a new green law in Germany. In its first phase, it requires manufacturers to "take back" all packaging materials used to ship electronic products.

The next phase, now pending government approval, would require companies to take back and recycle defunct electronic components. In a major study issued this spring, an MCC panel wrote: "Given the increasing costs of managing pollution, environmentally benign production is now both a business and a technological issue, not just a mission for the environmental movement." It warned that the future of the computer industry hangs on its ability to adapt to new environmental standards worldwide.

And that's not just true for computer chip makers, the MCC panel noted. The German takeback law may soon apply to automobiles, and MCC environmental program manager Greg Pitts says this has become a "hot button" for U.S. companies. They worry that the idea may catch on throughout Europe, and possibly jump across the ocean to America. Some members of the MCC panel claimed that European and Japanese firms are "ahead" of their U.S. competitors in preparing for the new green standards. The MCC panel couldn't settle the question, but it noted that foreign governments are "working cooperatively" with industry on environmental issues and urged the United States to do the same.

That sounds like the Clinton Administration itself. And while Allenby concedes that "nobody has really institutionalized [green design] yet," it's only a matter of time, he predicts. By then, perhaps, industry and the government will be wearing the same shade of green.

–Eliot Marshall