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The Road to Reduced Carbon Emissions

If prevention of global warming is the goal, a mix of regulatory and market-based federal policies will be necessary.

Scientists cannot yet predict the magnitude of the impact that gases contributing to the greenhouse effect will have on Earth's climate. But it's clear that decisions to limit emissions of these gases can't await the time when all impacts are evident. Whatever the damaging effects of the gases that have already been emitted might be, they won't be fully expressed for decades or centuries. The time needed to reverse the damage is also on that order. Even if we take serious steps to limit emissions today, the planet has been set on a course of atmospheric change that will run well into the twenty-first century or beyond.

Alarmed by the potential consequences of global warming, many industrialized countries, principally in Europe, have called for either a freeze or a 20 percent reduction in carbon dioxide emissions by the developed world by the year 2000 or shortly thereafter; several have pledged to freeze or reduce emissions whether or not the rest of the world participates. In the United States, Congress asked its Office of Technology Assessment (OTA) to evaluate the potential for reductions in carbon dioxide emissions in the United States, which is responsible for about 20 percent of the global total

As a starting point, OTA determined that if the United States takes no new action, carbon dioxide emissions will likely rise by 50 percent over the next 25 years. In evaluating the possible technical and policy measures the United States could adopt to reduce carbon emissions, OTA grouped them into two scenarios. The "moderate" scenario entails a package of relatively low-cost, low-pain measures that would result in 2015 in emissions that would be 15 percent higher than in 1987. Under the "tough" scenario, emissions in 2015 would be as much as 35 percent lower than they were in 1987.

We estimate that annualized capital and operating costs under the tough scenario will be between $350 billion and $520 billion per year. Fuel savings will be about $370 billion per year, if the fuel prices we assumed for 2015 are correct. The net result is that the program could save the United States as much as $20

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"carrot and stick" approach—can be particularly effective.

Demand-side management. This refers to electric utility programs designed to encourage customers to modify their patterns of energy use. Energy conservation is allowed to compete with construction of new power plants as an investment option for utilities trying to balance energy supply and demand. Utilities can then fund efforts to improve building shells or the equipment inside buildings. In some cases, utilities pay for rebate programs, give out high-efficiency light bulbs, or otherwise stimulate end-use efficiency improvements, and in so doing save energy at a fraction of the cost of new power supplies. There is already considerable support for demand-side management by many state energy offices, state legislatures, and public utility commissions. The key to success is for state public service commissions to allow utilities to profit from demand-side investments.

Further, the federal government could mandate that environmental consequences be considered when public utility commissions evaluate new sources of electricity. For example, New York State includes an estimate of the costs of environmental damage that would accrue from a new coal-fired power plant when it calculates the total cost of that supply option. Congress has already mandated, in the 1980 Pacific Northwest Electric Power Planning and Conservation Act (Public Law 96–501), that the Northwest Power Planning Council adopt rate structures that give conservation measures a cost break over other more traditional supply-side measures.

Technology-specific regulations. Congress can mandate improvements in efficiency through measures such as appliance standards and energy codes for buildings. The National Appliance Energy Conservation Act, which sets minimum efficiency standards for appliances such as refrigerators, home air conditioners, furnaces, and water heaters, is expected to lower residential energy use by as much as 10 percent by the year 2000. However, even stricter standards are possible using currently available technologies. Congress could also consider extending standards to other equipment such as commercial heating, ventilation, and air-conditioning equipment; lighting; and building components such as windows.

Energy-related building codes serve a function analogous to that of appliance standards by preventing the construction of very inefficient buildings. However, building codes have traditionally been under the jurisdiction of states and localities. In 1976, Congress enacted legislation that required the development of the Building Energy Performance Standards, a mandatory national code. In 1983, the law was modified to be mandatory only for federal buildings. Although a mandatory national building code could reduce carbon emissions significantly, it currently lacks the necessary political support from states and the construction industry.

Consumer information and marketing programs. Uncertainty and lack of information have been identified as key barriers to greater investment in energy conservation in the building sector. The large number of highly cost-effective investments in energy efficiency that are not chosen by consumers indicates that price alone doesn't stimulate optimal investment decisions. Requiring utilities to offer energy audits or requiring home energy ratings as a condition of federally financed mortgages are two ways to improve consumer knowledge of energy use.

Transportation

In the transportation sector, the moderate package promises a 4 percent reduction in U.S. carbon emissions from the current total by 2015; with the tough package the reduction could be 15 percent. The biggest reductions come from fuel efficiency improvements in cars and trucks and getting more people into vans, buses, or mass transit. If consumers maintain their current preference for mid-size cars with powerful engines, an aggressive pursuit by manufacturers of technical improvements could yield new-car efficiencies of 39 miles per gallon (mpg) by 2000 and 55 mpg by 2010. If the majority of consumers can be convinced to buy smaller cars, new-car fleet-average efficiencies of 42 mpg by 2000 and 58 mpg by 2010 might be achievable. Congress has three policy options that will promote new-car efficiency.

A gasoline tax. This would create incentives for increased efficiency and reduced travel. Taxes would induce consumers to use less fuel while leaving them free to choose how they adjust their behavior. In concert with increasing fuel economy standards (see below), taxes could have a long-term impact on the efficiency of this country's vehicle fleet.

Although the effectiveness of taxes is hard to predict from studies of the responses of consumers to price changes in the past, our midrange estimate is that a 50 percent increase in price could reduce consumption 5 to 20 percent over the near term and even more over the long term. About half of consumers' long-term adjustment to high price is expected to take the form of driving less and the other half to take the form of choosing more efficient vehicles.

Fuel economy standards. These influence the tradeoffs among cost, performance, size, and efficiency that underlie manufacturers' decisions to develop and introduce new models. The current fuel economy standards for cars, in place since 1978, have helped to increase auto fuel economy. More stringent standards can lower carbon dioxide emissions as well as reduce our dependence on imported oil. Redesigned standards based on vehicle volume—allowing larger vehicles to meet a size-adjusted standard—can help minimize the burden on U.S. manufacturers that offer a wide range of car sizes.

Vehicle taxes and rebates. Taxes on inefficient vehicles can create incentives for consumers to

Other approaches

OTA isn't the only agency to have considered what the government's response to global warming might be. A panel convened by the Committee on Science, Engineering, and Public Policy (COSEPUP) of the National Academies of Sciences and Engineering and the Institute of Medicine looked at the question too in its recent report, Policy Implications of Greenhouse Warming. And the Department of Energy (DOE) has recommended a National Energy Strategy. All three documents conclude that the United States can significantly slow the growth of carbon dioxide emissions over the next 25 years by adopting a series of low-cost measures. The proposals emphasized by COSEPUP yield a reduction close to the one promised by OTA's moderate package: 10 percent more emissions in 2015 than in 1990. The DOE's strategy allows emissions to grow by about 25 percent.

OTA, COSEPUP, and DOE all examine a variety of technical measures to inhibit the growth of greenhouse gas emissions, but the three studies differ in important ways. For example, the National Energy Strategy appears to derive over half of its reductions from supply-side changes—primarily increased reliance on nuclear power and biomass-derived transportation fuels. OTA and COSEPUP achieve the bulk of their reductions by means of efforts to cut demand, using technologies that, for the most part, exist today. According to our estimates, reductions in emissions from low-cost measures of energy conservation are two to three times greater in the OTA and COSEPUP studies than in the DOE strategy. (Both OTA and COSEPUP conclude that the building sector is the largest potential source of cost-effective reductions in emissions, followed by industry.)

These analyses differ not only in the weight they give to supply-side versus demand-side technical strategies but also in the policies they propose to see technical changes through to fruition. The OTA and COSEPUP reports discuss a mix of federal initiatives including regulations (such as auto efficiency standards and building codes), financial measures (such as taxes), federal research, development, and demonstration programs, and public information programs. In fact, the OTA study assumes that the use of a variety of policy measures will be crucial to the success of any program to reduce emissions of greenhouse gases. The National Energy Strategy relies extensively on the success of research and development and on public information programs, to be conducted by the states with federal help. The only financial measures the DOE includes are incentives for the production of energy from less carbon-rich sources. Regulatory programs that would force utilities to encourage efficient energy use by consumers are left to the states.

-R.B. & R.M.F.

R&D programs are vital if we hope to keep emissions on a downward trend past 2015.

choose better fuel economy and forego large size and extra power. Such a program would be most effective if accompanied by rebates for highly efficient cars. In a "feebate" program, the money taken in from the taxes would be redistributed through the rebates, and thus the program would be revenue-neutral. Because new-car buyers are thought to be more sensitive to initial purchase price than to lifetime fuel costs, this alternative may be particularly effective.

The federal "gas guzzler" tax already applies to cars with fuel efficiencies below stipulated minimums. An expanded program of auto purchase taxes and rebates could either complement fuel economy standards or be substituted for them. Like fuel economy standards, feebates could also pose trade difficulties as long as the high-efficiency end of the auto market is dominated by imports.

Transportation control measures. These tactics to reduce the number of vehicle miles traveled include promotion of carpools, higher parking fees at the workplace, employer subsidies to employees who use mass transit or vanpools, and mass transit improvements such as expanded bus service and schedules and lower fares. Although experience with transportation controls as a means of limiting air pollution suggests that they hold only modest promise for reducing car travel nationwide, in some congested cities the results could be significant.

Long-term reductions in emissions can be achieved by changing patterns of settlement to minimize the need for travel. This can be accomplished by planning for high densities, or by mixing uses so that residences, jobs, and services are roughly balanced. When more destinations are close to home, more trips can be made by foot; when densities are higher, public transit can serve more people effectively. Restrictions on suburban development—sometimes only on commercial and industrial development, and sometimes on residential development as well—have been attempted in a few regions of the United States. Resistance to such measures is likely to be high, and it is not an area where national policymakers can have significant influence.

For large cuts in carbon emissions to be achieved in the transportation sector, the most effective approach will be an integrated portfolio of policy measures that concurrently influence the fuel efficiency of new vehicles through standards or feebates, discourage automobile use through gasoline taxes or other measures, and provide alternatives to single-passenger automobile travel through carpooling, mass transit, and/or strategies to increase the density of urban and suburban settlements.

Manufacturing

In this sector three technical improvements hold the greatest promise. The first is "process changes"—for example, using electric arc rather than oxygen furnaces to make steel. The top four consumers of energy in manufacturing—paper, chemicals, petroleum, and primary metals—account for more than 75 percent of energy consumption in this sector. Together, by means of process changes, these industries improved their energy efficiency by between 2.3 and 4.3 percent per year between 1980 and 1985. If this pace can be maintained, as we assume in our tough set of options for Congress, total carbon emissions in the U.S. could drop by about 8 percent of the current total by the year 2015.

Cogenerating electricity and steam for industrial processes is another promising strategy. If electricity were generated at industrial sites where the heat could be used to drive engines and fire furnaces, the efficiency of fossil fuels would rise dramatically. Widespread use of cogeneration technologies could contribute about a 4 percent drop in U.S. carbon emissions from the current total by 2015. More efficient motors are a third technical improvement that can bring substantial improvements, yielding reductions of about 4 percent by 2015.

A variety of promising policy options can encourage these technical measures:

A carbon tax would levy economic penalties against factories with the highest emissions of carbon. Given such an approach, the tax would be highest on plants burning coal, low for those burning natural gas,

and zero for those depending on noncarbon sources such as wind, solar, geothermal, or nuclear power. For industries in which the cost of energy is a particularly important variable, carbon taxes should encourage energy efficiency, fuel switching, and cogeneration.

Using several econometric models, the Congressional Budget Office has estimated that a carbon tax of $100 per ton would have the effect of lowering industrial carbon dioxide emissions by between 10 and 35 percent by the year 2000. The higher estimate assumes a 70 percent shift away from coal.

Marketable permits would be an alternative to a carbon tax similar to the current program for regulating sulfur dioxide emissions to control acid rain. Manufacturers could be issued permits based, for example, on some percentage of their 1990 emissions. They might make reductions by installing energy-efficient technologies and switching to less carbon-rich fuels. Manufacturers might also be allowed to offset excess emissions at factories by planting trees. If permits were required for carbon emissions by electric utilities as well, cogeneration would also be a source of reductions. It would be up to the manufacturer to choose the most cost-effective strategy. Marketable permits would allow firms to trade their unused carbon rights to firms that were exceeding their limits.

Demand-side management programs by electric utilities, which we considered in our discussion of the building sector, can help lower electricity consumption—and therefore carbon emissions—in the industrial sector, too. The most promising programs are low-interest loans to customers for the purchase of more efficient equipment, installation of such equipment at the utility's cost, and rebates to customers following installation of the equipment.

Efficiency standards for common energy-using equipment would be similar to those that already exist for automobiles and some appliances. Motors, as a category, would be the most likely candidate.

If market-based approaches to lowering emissions—carbon taxes or marketable permits—will work in any sector, they are most likely to be effective for manufacturing (and electric utilities—see below). Demand-side management programs can substitute for market-based emission controls but are more effective as a complement to such controls. Designing standards that make sense for the widely divergent uses of energy-consuming equipment in manufacturing is much more difficult than for the building or transportation sector. Such standards should be possible, however, for at least some of the more common types of technologies in these sectors.

Electrical utilities

About a third of U.S. carbon emissions occur in the generation of electricity; by 2015, if we do nothing, that share may be as large as 45 percent. We discussed in previous sections steps that utilities could take to lower their customers' need for electricity. Taking steps to lower the rate at which carbon is emitted for each kilowatt-hour of electricity generated can yield substantial reductions as well.

OTA's moderate package of supply-side measures for utilities can lower emissions by about 7 percent of the current U.S. total. The two ideas with the greatest potential are increasing the efficiency of fossil-fuel-fired plants (by about 5 percent) through improved maintenance, and operating existing nuclear power plants 70 percent of the time (similar to practices in western Europe and Japan) and extending their useful life to 45 years. At present, U.S. plants operate about 60 percent of the time and are licensed for about 35 to 40 years.

By shifting a large share of the demand for energy away from coal, our tough measures (combined with the moderate measures listed above) would reduce emissions by about 14 percent of the current total by 2015. Plants generating power from renewable energy sources, nuclear plants with improved designs that may be available after 2005, and high-efficiency gas turbines are the only new facilities allowed to be built in our tough scenario. However, if all the tough demand-side measures in the building and industrial sectors are implemented, growth in demand for electricity will be so low that very few new plants will be needed through 2015. Thus, the tough scenario also requires existing fossil-fuel-fired plants to be retired after 40 years of operation (rather than the typical 60 years) and replaced by plants using renewable or nuclear energy or natural gas. In addition, existing coal plants must burn half coal, half natural gas. Again, a mix of policy measures is necessary to achieve the potential emissions reductions.

Carbon taxes or marketable permits would influence utilities in much the same way as they would influence industries. Either approach would en-

courage fuel switching and improvements in efficiency and motivate the utilities to develop more noncarbon energy sources.

Emissions limits and efficiency standards. For example, a limit on the rate of carbon emission by older utility plants might be set equal to the rate of the most efficient new coal-burning technologies. Such a limit would require a typical midwestern plant burning Illinois coal to burn between about 10 and 30 percent gas, depending on the plant's efficiency.

Two somewhat different strategies could be pursued to set carbon dioxide emission limits for new plants. If the intent is to force development of ultra-efficient coal technologies, then a standard could be set about equal to the lowest rate of emission anticipated from technologies in the laboratory stage of development today. If the intent is to limit new fossil-fuel-fired generation to the cleanest sources only, then an even lower performance standard could be set—recognizing, however, that this might foreclose the option of using coal. To speed up replacement of old plants with new, less polluting ones, Congress could require the retirement of existing fossil-fuel-fired plants earlier than their expected lifetime of 60 years.

Federal funding for research, development, and demonstration projects in the areas of renewable energy, conservation, and nuclear fission has fallen sharply over the past decade. In 1990, the combined budget for work in these three areas was 80 percent lower in constant dollars than it was in 1980. Bringing current spending up to the 1980 mark would cost about $2.6 billion. By doing so, the federal government could hasten the development and demonstration of supply technologies that would reduce greenhouse gas emissions. Although such programs may take several decades to bear fruit, they're vital if we hope to keep emissions on a downward trend past 2015.

The most promising technologies are commercial fuel cells, storage technologies for solar electricity, biomass-driven turbines, variable-speed wind turbines, and better designs for nuclear power plants. Many experts estimate that these technologies could be commercial in 20 or 30 years.

The government could also play a role in reducing the perceived risks of new technologies and in integrating renewable energy sources into existing energy systems by conducting demonstration projects or, perhaps, by providing government-backed loans. To encourage new nuclear energy sources, for example, a two-track process appears best: The Department of Energy could help fund full-scale demonstrations, both of new "evolutionary" light-water reactors and of such "revolutionary" design innovations as a modular high-temperature gas reactor.

In the utility sector, either market-based approaches (carbon taxes or marketable permits) or more traditional supply-side regulations (limits on allowable emissions and energy-efficiency standards) could achieve large reductions. Regardless of which tactic is emphasized, however, continued progress will be helped by an aggressive research and development program.

Forestry

A complete discussion of the role of forests in efforts to cope with global warming is beyond the scope of this article, but a few points are worth noting in passing. Living trees hold carbon and keep it out of the atmosphere. Thus, expansion of forests can offset carbon emissions. Forest-related measures with the greatest potential include increasing the productivity of forested areas through genetic selection of superior strains, planting trees in new areas, and growing tree crops for biomass energy. OTA estimates that these measures would offset about 7 percent of current U.S. carbon emissions by 2015. (In comparison, President George Bush's proposed "America the Beautiful" program to plant a billion trees a year would offset less than 1 percent of carbon dioxide emissions over the same period.) It's important to recognize, however, that forests are an imperfect solution to the problem of global warming, because their capacity to offset carbon emissions is short-term. Once a tree dies, it releases its stored carbon back to the atmosphere.

Beyond the horizon

Even if all the actions recommended under the tough scenario are implemented, carbon dioxide emissions will begin rising after 2015 unless nonfossil energy sources such as solar and nuclear power are viable alternatives by that time. For this to happen, research, development, and demonstration (RD&D) programs must be strengthened now.

Government can speed the process of testing and commercializing many energy-supply and end-use

technologies. We've noted, however, that recent federal energy RD&D budgets have been less than half what they were in 1980. Moreover, only about 5 percent of the $3.7 billion national budget for energy technology RD&D in 1991 was devoted to renewable energy and conservation projects. We also note that any effort to increase these budgets will have to contend, at least, with the constraints imposed by the schedule Congress has set for itself to reduce the deficit and by the funding needs of other federal programs, current and future.

Although a 35 percent reduction in carbon dioxide emissions is a very ambitious goal, even this will not, by itself, stop global warming. The Intergovernmental Panel on Climate Change (convened in 1988 by the World Meteorological Organization and the United Nations Environmental Programme) and the U.S. Environmental Protection Agency have each suggested that stabilizing the concentration of greenhouse gases in the atmosphere will require a 50 to 80 percent reduction in carbon dioxide emissions worldwide, as well as significant reductions in the other greenhouse gases. To achieve this goal, a more far-reaching global effort will be necessary.

Recommended reading

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