



# RESOURCES

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## CONTENTS

**Shifting Gears: New Directions for Cars and Clean Air** 2

Winston Harrington and Margaret A. Walls

**Will Speeding the Retirement of Old Cars Improve Air Quality?** 7

Anna Alberini, David Edelstein, and Virginia D. McConnell

**Inside RFF: News and Publications** 11

**Unpopular Neighbors: Are Dumps and Landfills Sited Equitably?** 16

Vicki Been

**Does Environmental Policy Conflict with Economic Growth?** 19

David Gardiner and Paul R. Portney

## Research at the Ready

Earlier this year, the northeastern states, under pressure to improve urban air quality, moved to adopt California's strict standards for motor vehicle emissions. This action is likely to have far-reaching repercussions for the region and the auto industry—and it's far from clear that California's standards are the most cost-effective way to reduce emissions from cars, trucks, and buses.

For nearly seven years, researchers at RFF have been exploring many different transportation options to improve air quality. Alternatives under scrutiny have included imposing strict emissions standards on all new cars; regularly inspecting on-the-road vehicles; and requiring changes in the types of fuels that cars can use.

In this issue, Winston Harrington and Margaret Walls draw on this research to evaluate the many options for reducing auto emissions and make recommendations about the programs that produce the best results for the least cost. Their conclusions throw into question prevailing legislative and regulatory trends. (The researchers, along with Virginia McConnell, also summarized the findings of the transportation research program at an RFF council meeting in April—see "Inside RFF".)

In a companion piece, Anna Alberini, David Edelstein, and McConnell analyze one specific option for reducing auto emissions: accelerated vehicle-retirement programs. The researchers describe a project they designed and executed in Delaware that bought and scrapped older, often more polluting cars.

Eliminating pollution is a long-standing goal of environmental policy. Now a new concern has surfaced—whether the

effects of environmental pollution fall disproportionately on minorities and the poor. Last fall, RFF invited Vicki Been, a law professor at New York University, to discuss the research she has done on this topic. An article based on her presentation appears inside.

Another question stirring lively discussion these days asks whether there is a fundamental conflict between environmental quality and economic growth. In December, David Gardiner, assistant administrator of EPA's Office of Policy, Planning, and Evaluation, and RFF Vice President Paul Portney discussed this issue before a packed audience at another of RFF's popular weekly seminars. Written versions of their remarks are included in this issue.

"Inside RFF" recounts several recent occasions—including a panel discussion, a forum, and congressional testimony—on which RFF researchers were asked to help policymakers grapple with other difficult issues, such as environmental risk assessment and Superfund reform.

This edition of *Resources* demonstrates well how RFF's research staff often begins research on issues years before those issues become "hot," so we will have information and analysis ready when decisions need to be made. We greatly appreciate the farsightedness of organizations and individuals who understand the importance of impartial research and generously support RFF's programs.

Robert W. Fri, President

## Shifting Gears: New Directions for Cars and Clean Air

Winston Harrington and Margaret A. Walls

As deadlines set by the Clean Air Act Amendments of 1990 loom and pass, state and local officials are scrambling to evaluate policy options and adopt programs that will effectively reduce the motor vehicle emissions that can form ozone. Among the mandated policy options are several command-and-control approaches, some of which call for new developments in emission-control technology. But these approaches may not be as cost-effective as other options that rely on economic incentives. Until these economic incentives have been investigated, decision makers should be cautious about moving ahead with approaches that could have high costs, or uncertain results, or both.

With the Clean Air Act Amendments of 1970, the United States initiated a bold new approach to air pollution problems. For the most part, this approach seems to have worked, as air quality standards set as a result of the 1970 amendments have now been achieved in most locations. But ground-level ozone (smog) still remains a problem in many urban areas.

That is why the Clean Air Act Amendments of 1990 required stricter control of the emission of ozone precursors—mainly oxides of nitrogen (NO<sub>x</sub>) and volatile organic compounds (VOCs)—from stationary sources such as factories and from mobile sources such as cars and buses. But the amendments also set unrealistically short deadlines for action.

State and local officials are now hastily deciding on policies to control motor vehicle emissions and attain ambient

ozone standards. Such decisions could affect the design of cars for decades to come, reshaping the entire car industry (and perhaps the oil industry) and costing motorists billions of dollars each year. Yet, it is not clear that some options for reducing motor vehicle emissions will appreciably affect ambient ozone.

In this article, we explain why many urban areas have not attained ambient ozone standards and how some of the mobile-source provisions of the latest Clean Air Act amendments share many shortcomings of their predecessors. We then present estimates of the cost-effectiveness of various options for reducing motor vehicle emissions and note the reasons to treat these estimates cautiously. We conclude by considering how policymakers could make best use of the various options and offer our views on how policies can be designed to yield the biggest “bang for the buck.”

### Why many urban areas still have ozone problems

One of the major reasons why ozone remains a problem is that ozone formation is complex and not well understood. Ozone is not emitted directly; rather, it is formed from precursor pollutants in a series of complex chemical reactions on hot, sunny days. This makes it difficult to relate reductions in precursors to reductions in ozone. The sources of precursors are extraordinarily numerous and, in the case of VOCs, varied; but the most important source—especially in nonattainment areas where ozone levels exceed the standard—is motor vehicles. In 1989, the Office of Technology Assessment estimated that

cars, trucks, and buses contributed 45 percent of the VOCs and 30–66 percent of the NO<sub>x</sub> emissions in nonattainment areas. Recent studies suggest that these percentages may be even higher.

Rather than directly regulate the driving behavior of millions of motorists, Congress opted to target car manufacturers. In 1970, it began to set increasingly stringent emissions standards (in terms of grams of pollution per mile) for new cars, so that highly polluting

*Even though VOC emissions from new cars today are about 95 percent below what they were in the late 1960s, average emissions rates of the U.S. car fleet have not fallen by nearly this much.*

vehicles would be replaced by less-polluting ones. It is estimated that these standards make the average purchase price of today's car \$500 to nearly \$1,200 higher than it would be in the absence of the standards.

The regulations themselves may have contributed to the persistence of the ozone problem. First, even though VOC emissions from new cars today are about 95 percent below those from cars in the late 1960s, average emissions rates of the U.S. car fleet have not fallen by nearly this much. This is because emissions control systems tend to break down as cars get older, causing emissions to rise. The problem is compounded by the fact that the average age of the U.S. car fleet has increased from 5.1 years in 1969 to 7.7 years in 1990. Second, the regulations have focused only on emissions rates, ignoring vehicle miles traveled (VMTs). Since 1970, VMTs have increased by 69 percent, partially offsetting reductions in emissions per mile brought about by new-

car emissions standards. Third, since the standards were primarily directed at tailpipe emissions, they did not reduce emissions from fuel evaporation, which may account for 10–50 percent of total VOC emissions. Finally, the importance of  $\text{NO}_x$  in ozone formation was overlooked until recently.

—Additional complicating factors include rising roadway congestion over the last two decades and an increase in the average number of trips per household. Congestion increases both evaporative and tailpipe emissions, since VOC emissions rates are higher at low speeds and in stop-and-go traffic. The 22 percent rise between 1969 and 1990 in the number of car trips taken daily by the average household has also increased emissions. Trips increase emissions because a cold vehicle pollutes at a much higher rate than a warm one and because emissions are greatest during cold starts.

### Clean Air Act Amendments of 1990

The Clean Air Act Amendments of 1990 continue the practice of using new-car emissions standards as the primary means for reducing overall car emissions. The amendments significantly tighten emissions rates for new cars beginning with the 1994 model year. They also allow states to adopt California's vehicle emissions standards, which are stricter than federal standards and are scheduled to become even stricter in the future.

Unlike the Clean Air Act Amendments of 1970, the 1990 amendments recognize the importance of evaporative emissions. For example, they force the U.S. Environmental Protection Agency (EPA) to establish regulations to control these emissions and require the use of reformulated gasoline in areas with the worst ozone problems. Other provisions push the frontier of automotive technology by requiring the introduction of alternative-fuel vehicles (for example,

cars that run on methanol or compressed natural gas) in certain commercial and government vehicle fleets in nonattainment areas and by setting up a pilot program in California where such vehicles will be introduced to the general public.

The 1990 amendments also acknowledge the significance of the disparity between new-car and average-car emissions rates, as well as the effect of increasing VMTs on total vehicle emissions. They do this by requiring "enhanced" vehicle inspection and maintenance programs in the areas with the worst ozone problems and by requiring that local transportation plans conform to Clean Air Act goals. Above all, the 1990 amendments recognize that new-car emissions standards are not the only way to reduce motor vehicle emissions, and they leave to local and state governments many decisions about adopting alternative policies.

Despite these improvements in regulating motor vehicle emissions, the 1990 amendments still suffer from three



State and local officials are facing imminent deadlines to find ways of reducing the motor vehicle emissions that can form ozone. RFF Fellow Margaret A. Walls, shown addressing a recent meeting of the RFF council, is one of the RFF researchers studying transportation options to improve air quality.

shortcomings that will make it difficult to attain ambient ozone standards in a cost-effective manner. First, the amendments retain an excessive reliance on emissions standards and technological solutions. Second, they perpetuate EPA's

*Despite improvements in regulating motor vehicle emissions, the 1990 amendments still suffer from shortcomings that will make it difficult to attain ambient ozone standards in a cost-effective manner.*

practice of basing emissions-reduction estimates on its computer models rather than on empirical data, despite the fact that the estimates produced by those models can be grossly inaccurate. Third, they tend to target vehicles with either high emissions per mile or high mileage, instead of vehicles with both.

Because the 1990 amendments set imminent deadlines for attaining ambient ozone standards, they could lead states into hasty and expensive decisions. For example, in February 1994, the Ozone Transport Commission, which coordinates air quality decisions in the northeastern states, requested EPA's permission to adopt California's vehicle emissions standards.

### Cost-effectiveness of various options

The 1990 amendments give local areas flexibility to choose among many ways to reduce vehicle emissions. But which approaches to choose? How can state and local officials avoid costly efforts with uncertain results?

One way of evaluating policy options is to estimate the cost-effectiveness of each policy—that is, the cost in dollars

per ton of pollutant reduced—and then compare the estimates. With such information, states presumably could adopt the low-cost options first. Various groups, including Resources for the Future (RFF), have studied the cost-effectiveness of individual policy options in reducing the emission of VOCs, and our analysis of these studies is summarized here (see table, right). The cost-effectiveness of these approaches varies greatly, from \$1,650 per ton of VOCs reduced for emissions-based vehicle registration fees to \$29,000–\$108,000 for electric vehicles. In general, EPA considers any approach that costs less than \$5,000 per ton of emissions reduced to be highly cost-effective. Options that reduce VOCs for less than \$10,000 per ton are still considered reasonable.

The emissions-reduction options we consider here can be divided into two types. The first type is *command-and-control* approaches that set emissions standards or that specify emission-control technologies. The second type is *economic-incentive* approaches that change prices (such as car purchase prices and gasoline prices) and thereby lead motorists to make decisions that reduce vehicle emissions. For our analysis, we compared options of both types.

Command-and-control approaches include the mandated use of reformulated gasoline, the creation of enhanced inspection and maintenance (I&M) programs, and the replacement of gasoline vehicles by alternative-fuel vehicles. We considered these three approaches, which are required by the 1990 amendments in some nonattainment areas. We also analyzed the group of low-emission vehicles mandated by California.

Reformulated gasoline may be one of the cheaper options for reducing VOCs, according to EPA's estimate of its cost-effectiveness. The overall emissions reductions from reformulated gasoline are small, however.

According to RFF estimates, I&M programs are somewhat more expensive, but they may yield larger emissions reductions. The enhanced I&M program

#### Estimates of the cost-effectiveness of alternative approaches to reducing motor vehicle emissions (in \$ per ton of VOCs reduced)

##### Command-and-Control Approaches

Reformulated gasoline	
Federal	\$1,900–3,900 <sup>a</sup>
California	\$4,100–5,100 <sup>a</sup>
Inspection and maintenance	
EPA enhanced	\$4,500–6,000
Remote sensing	\$2,600–6,000
Hybrid	\$4,000–6,000
Alternative-fuel vehicles	
Methanol	\$30,000–60,000
Compressed natural gas	\$12,000–22,000
Electric	\$29,000–108,000
California vehicles	
Transitional low-emission vehicles	\$3,700–21,000 <sup>b</sup>
Low-emission vehicles	\$2,200–27,000 <sup>b</sup>
Ultra-low-emission vehicles	\$4,200–41,000 <sup>b</sup>

##### Economic-Incentive Approaches

Accelerated vehicle-retirement	\$4,000–6,000
Gasoline-tax increase	\$4,500
Emissions-based vehicle registration fees	\$1,650 <sup>c</sup>

Note: Unless otherwise indicated, estimates are RFF estimates based on RFF studies or other studies. For more details on all estimates, see discussion paper 94-26, "Shifting Gears: New Directions for Cars and Clean Air" by Winston Harrington, Margaret A. Walls, and Virginia D. McConnell.

<sup>a</sup> These EPA estimates are based on reformulation of gasoline according to EPA's recipe (which increases the price per gallon by 3 cents) and according to California's recipe (which increases the price by 8–11 cents per gallon).

<sup>b</sup> These estimates are derived from studies by the California Air Resources Board and the Automotive Consulting Group.

<sup>c</sup> These estimates are based on a draft study by Energy and Environmental Analysis, Inc.

mandated by EPA requires that a new, more accurate, but also more expensive, tailpipe-emissions test be used and that inspections be performed at centralized facilities that only test vehicles, rather than at service stations that both test and repair vehicles. Alternative I&M programs include remote sensing, which uses roadside monitoring and detection devices to measure vehicle emissions, and "hybrid" programs, which employ remote sensing but also subject vehicles to enhanced I&M every two to four years.

Alternative-fuel vehicles, according to RFF estimates, are a very expensive option for reducing VOCs. Policies that require these vehicles are poorly targeted because they ignore emissions from vehicles already on the road. Moreover, such

policies might cause car manufacturers to increase the price of all vehicles so that they can cover the cost of producing alternative-fuel vehicles. If so, motorists might choose to keep their old vehicles rather than purchase new, less-polluting ones. These problems may be compounded if states adopt California's phasedown to "ultra-low-emission vehicles" and "zero-emission vehicles."

One of the problems with command-and-control approaches to regulating motor vehicle emissions is that they are targeted to reduce emissions *rates* instead of total emissions. The variability in vehicle use makes emission-rate regulation less promising than regulations targeted at both emissions rates and mileage. (For example, vehicles driven more than

25,000 miles per year make up only 10 percent of all motor vehicles yet account for 30 percent of the total VMTs.)

Because the command-and-control approaches that we studied rely on emissions standards and technological solutions, they are not, in general, as potentially cost-effective as approaches that are well-targeted and rely on economic incentives. Economic-incentive approaches include accelerated vehicle-retirement (AVR) programs, gasoline taxes, and vehicle registration fees based on emissions rates.

According to RFF estimates, AVR programs and a gas-tax increase of 4.3 cents per gallon reduce VOCs at about the same cost per ton as I&M programs, but both approaches may yield only limited total emissions reductions. AVR programs are not well targeted since the cars they take off the road have at most only a few years of life remaining. AVR programs will not substantially reduce car emissions unless the programs are large scale, in which case their cost-effectiveness decreases (see "Will Speeding the Retirement of Old Cars Improve Air Quality?" on p.7).

Gas-tax increases are poorly targeted as a means to reduce VOC emissions because they discourage the use of all cars, not just the most-polluting ones. Furthermore, a large tax increase could lead consumers to purchase cars with greater fuel efficiency—behavior that could offset emissions reductions in the long run. Gasoline taxes nonetheless would be an incentive for energy conservation and therefore lead to reductions in emissions of carbon dioxide and other "greenhouse" gases.

Vehicle registration fees based on emissions rates appear much more promising. Unlike new-car emissions standards, these fees target emissions from *all* vehicles on the road. They also give motorists the proper incentives to maintain (or scrap) their vehicles, since the fee would be higher for a car that pollutes more. Based on a recent preliminary analysis of such fees, we conclude that they are more cost-effective

than the other options examined here. Again, we note that there are inefficiencies in approaches that reduce emissions rates rather than total emissions. In the context of emissions-based registration fees, cars that have different emissions per mile would be charged different fees even when their mileages are such that their *total* emissions levels are the same.

*In general, EPA considers any approach that costs less than \$5,000 per ton of emissions reduced to be highly cost-effective; options that reduce VOCs for less than \$10,000 per ton are still considered reasonable.*

By the EPA benchmarks of \$5,000 and \$10,000 per ton of VOCs reduced, reformulated gasoline, I&M programs, AVR programs, gas taxes, and, in particular, emissions-based vehicle registration fees all appear to be attractive. In contrast, alternative-fuel vehicles and the low-emission vehicles mandated by California appear to be very unattractive.

### Caveats

Estimates of the cost-effectiveness of all these options should be interpreted cautiously for several reasons. First, the true cost-effectiveness of any particular option depends on previously implemented options. For example, an I&M program might be less cost-effective if it were implemented after the use of reformulated gasoline than if it were implemented beforehand.

Second, policies that cost-effectively reduce VOCs—for example, accelerated vehicle-retirement and reformulated gasoline—are not necessarily effective at

reducing NO<sub>x</sub>. In some areas of the country, NO<sub>x</sub> reduction is essential for ozone improvements.

Third, uncertainty pervades the emissions-reduction estimates on which calculations of cost-effectiveness are based, and often analysts resort to "best case" outcomes. For example, the estimates for EPA's enhanced I&M program assume that cars identified as high emitters are successfully repaired, but repairs have often been ineffective. In one study, more than half of all vehicles that underwent repairs to reduce emissions had *greater* emissions afterwards!

Fourth, some of the cost estimates are also highly uncertain, particularly those for alternative-fuel vehicles and the low-emission vehicles mandated by California. Some observers believe that technological advances could greatly reduce costs; in the case of alternative-fuel vehicles, however, we feel that it is highly unlikely that any such advances are imminent.

### Toward more efficient and effective policy

To ensure that policies to reduce motor vehicle emissions are cost-effective, we must design them with three characteristics in mind. First, we should target policies as precisely as possible to reduce total emissions, rather than emissions per mile, in those places and at those times when ozone creation is at its peak. Second, we must design policies that give motorists incentives consistent with pollution reduction. Third, to the extent possible, we must measure performance on the basis of actual emissions rather than on estimates from computer models.

None of the options considered here is ideal with respect to all three of these characteristics, but each could be improved with relatively minor changes. For example, I&M programs might be more cost-effective if they went after only the very dirtiest vehicles, which tend to be the easiest to detect as well as the most likely to be effectively repaired.

Targeting the very high polluters also might mean that a simpler, less costly emissions test could be used instead of the new emissions test developed and promoted by EPA.

Instead of reducing all VMTs through a gasoline tax, better approaches would include congestion pricing of roadways and downtown parking taxes. Though not targeted at high-polluting vehicles, these options can be targeted to areas with ozone problems, and they have the substantial advantage of reducing traffic congestion.

Emissions-based vehicle registration fees appear to be very cost-effective, and, unlike many of the policies considered here, the potential emissions reductions could be made almost as large as desired simply by raising the fee. This policy could be better targeted and thus even more cost-effective if it were based on a car's estimated total emissions during peak ozone periods. This would require information about the car's average emissions rates and its mileage in particular locations at particular times. Here, remote sensing could be valuable.

*None of the options considered here is ideal, but each could be improved with relatively minor changes.*

Mobile remote-sensing units make it relatively inexpensive to measure car emissions when ground-level ozone is at its peak. A program that uses these units could require motorists to pay high registration fees when their cars' average emissions rates—based on several sensor readings—rise above a certain level. Such a program could target total emissions, not just emissions rates, by setting a high fee for cars that not only have high emissions but also pass by the sensors many times.

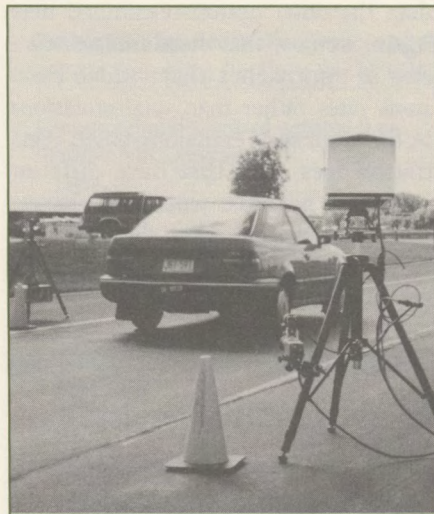


Photo courtesy of Craig S. Rendahl/WI Dept. of Natural Resources

**To reach its full potential, an emissions-based vehicle registration fee should reflect mileage during peak ozone periods as well as emissions rates—information that might require the use of remote sensing devices, such as this one, which can be set up along roadways.**

Remote-sensing devices, however, cannot monitor evaporative emissions, and they are difficult or impossible to use in bad weather. In addition, there may be questions about whether the measured emissions faithfully represent the average performance of cars.

Emissions-based registration fees are promising, but they may encounter the same attitudes that economic instruments for environmental policies always seem to face, including skepticism about their effects on pollution and concern about equity. Nonetheless, the tide in environmental policy has been shifting toward such instruments. Perhaps the time is right for their application to mobile-source emissions control.

### Recommendations

The most economically attractive ways of reducing motor vehicle emissions would be directed at cars already on the road and would require extensive use of economic incentives. Emissions-based registration fees hold much promise. Such a policy could achieve substantial

emissions reductions at relatively low cost even if based only on emissions rates as determined by a conventional emissions test. To reach its full potential, however, an emissions-based registration fee should reflect mileage during peak ozone periods as well as emissions rates. This may require the use of remote sensing. Further investigation of remote sensing to deal with the real—or to lay to rest the perceived—problems associated with that technology is warranted.

Until emissions-based registration fees and other economic-incentive approaches are investigated, it would be a serious mistake for states to commit themselves prematurely to command-and-control approaches, which may prove to be costly, ineffective, and difficult to back away from. Thus, while I&M programs are promising because they target emissions from all cars (not just new cars), we should avoid a nationally mandated, uniform I&M program until we gather data from demonstration programs.

Until some of the other, cheaper alternatives have been investigated, it would be premature for the rest of the country to adopt California's new-car emissions standards. Given great uncertainty and dubious benefits about the costs of new types of low-emission vehicles, it seems wise to let California experiment with these cars by itself. If the costs prove low, then the kinds of economic policies we advocate will bring them to market, thus achieving the emissions-reduction goals of the California vehicle program but without legislative fiat.

*Winston Harrington is a senior fellow in the Quality of the Environment Division and Margaret A. Walls is a fellow in the Energy and Natural Resources Division at Resources for the Future. The issues in this article are detailed in discussion paper 94-26, "Shifting Gears: New Directions for Cars and Clean Air" by Winston Harrington, Margaret A. Walls, and Virginia D. McConnell.*

## Will Speeding the Retirement of Old Cars Improve Air Quality?

Anna Alberini, David Edelstein, and Virginia D. McConnell

Even under increasingly stringent emissions standards, cars are still contributing to urban air pollution. Part of the problem lies with old cars—those manufactured before 1980. Although these cars make up a relatively small percentage of the nation's car fleet, their removal from the road could eliminate a large percentage of some emissions. This is why states, as well as polluting firms that are looking for ways to get emissions-reduction credits, have expressed interest in running accelerated vehicle-retirement (AVR) programs. However, there is much controversy about just how cost-effective AVR programs are likely to be. RFF research suggests that the answer depends on how the cars they enlist differ from the rest of the old-car fleet, as well as on the programs' size, duration, and location.

Despite a substantial decrease in the past twenty-five years, motor-vehicle emissions continue to be a major contributor to air pollution in many urban areas. It is now clear that air quality objectives will never be met simply by setting increasingly stringent emissions standards for vehicles built in the future; something must be done about the emissions of vehicles built in the past.

Given that emissions from newer vehicles have already been drastically cut, policymakers are focusing on emissions from older cars—that is, 1980 and earlier model-year cars. These older cars often do not have advanced emission-control equipment; when they do, it sometimes no longer functions properly. Thus they tend to emit pollutants at

much higher levels, on average, than newer vehicles.

Considering that pre-1980 cars make up only 18 percent of the vehicles in use in the United States and account for only 8 percent of total miles driven, they contribute a surprisingly large share of total motor vehicle emissions. On a typical hot summer day, they emit approximately 40 percent of the hydrocarbon, 40 percent of the carbon monoxide, and 25 percent of the nitrogen oxide emissions of the nation's car fleet.

These statistics suggest that a potentially effective way to reduce hydrocarbon, carbon monoxide, and nitrogen oxide emissions in urban areas is to take older, highly polluting cars off the road. Accelerated vehicle-retirement (AVR) programs offer a new market-based opportunity to do this. These programs buy pre-1980 cars from their owners, usually at a price ranging from \$500 to \$800, and then scrap the cars.

Because AVR programs remove polluting cars from the road, they are one way for private firms and states to fulfill their emissions-reduction obligations. Through AVR programs, firms that are looking for a lower-cost alternative to reducing their own pollution are given a mechanism to earn credits for short-term emissions reductions. AVR programs are also one of many options states are exploring to meet goals for air-pollution control.

At first glance, AVR programs may appear to be an attractive way to tackle urban air problems. However, there are questions about how effective buying and scrapping old cars will be in reducing emissions and how much AVR programs will cost relative to other policies to cut pollution.

In 1992 the President's Commission on Environmental Quality (PCEQ) commissioned us to conduct a study of a small, one-time AVR program run in Delaware by U.S. Generating Company (USGen), an independent electric-power producer. In that study—developed jointly by PCEQ, Resources for the Future, and USGen—we tried to shed light on some of the controversial issues surrounding AVR programs.

### Issues in evaluating AVR programs

Firms and agencies considering whether to operate an AVR program will want to determine the amount of emissions that the program has the potential to reduce. Making this determination is fairly complex, as it means forecasting the outcome of three events that cannot be observed directly: (1) the quantity of pollutants that each car would have emitted had it not been scrapped, (2) the quantity of pollutants emitted by cars bought to replace the scrapped cars, and (3) the number of cars that can be purchased through an AVR program at different prices. An uncertainty that affects the emissions-reduction potential of long-term, large-scale AVR programs is the effect such programs have on the purchase price that owners of old cars are willing to accept.

Many factors determine the amount of emissions that a scrapped car *would* have emitted if it had remained on the road. The car's emissions rate, average annual mileage, and expected remaining life all contribute to what we term the *avoided emissions*. Because these variables are impossible to measure, emissions reductions are usually calculated by imputing to the scrapped cars the emissions rates, annual mileage, and remaining life of "average" cars of the same years as the scrapped cars. However, the resulting estimates of avoided emissions are unlikely to be correct because the cars that enter an AVR program are not representative of cars of a certain age. On the

one hand, the scrapped cars are at the low end of the used-car market and are therefore likely to have a relatively shorter remaining life span than the average vehicle of their age. They also may be driven less. On the other hand, they may have greater per-mile emissions.

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*Because long-term, large-scale AVR programs may increase the demand for old cars, they may reduce emissions at a higher per-ton cost than small-scale programs, which do not affect the market for old cars.*

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Emissions from cars and other modes of transportation that replace scrapped cars are also difficult to predict. Even if we know what cars have been purchased to replace scrapped cars and thus can measure their emissions, it is unlikely that we will also know what cars have been purchased by the people who sold the replacement cars. Nor is it likely we will know what cars the people who sold *those* cars bought to replace the cars *they* sold and so on. Because these chains of transactions are impossible to track, the emissions rates of replacement cars are often assumed to be equal to the average emissions rate of a region's car fleet.

Predicting how vehicle owners will respond to different purchase-price offers presents still more difficulties. Presumably, the higher the offer, the greater the number of cars AVR programs will enlist. But without information about how many cars each different offer will attract, a firm or agency cannot predict what level of emissions reductions can be achieved. This uncertainty makes AVR programs a gamble, because the firms or agencies that run them often will be required to reduce emissions by a specific amount.

When AVR programs are designed to be a large or steady source of emissions-reduction credits for a region, another set of problems arises. Long-term, large-scale AVR programs may create so much demand for old cars that used-car prices will rise. The retirement of a large number of old cars in the region served by the program is likely to increase the value of the remaining old cars in that region. If so, large-scale programs will have to offer increasingly higher prices to obtain a given number of cars; this means that they will reduce emissions at a higher per-ton cost than small-scale programs, which do not affect the market for old cars.

In addition, ongoing AVR programs may create the wrong incentives for car owners. For instance, people might be encouraged to keep their cars longer than they would normally, so as to have an old car to sell. Also, people living in one region might offer their cars to a program operating in a different region. If so, emissions would not be reduced in the geographic area where they were intended to be reduced.

### **Study of the Delaware vehicle-retirement program**

Given these uncertainties, the role AVR programs should play in reducing air pollution is still unclear. However, our analysis of data collected from USGen's AVR program in Delaware in the fall of 1992 provides some insight about the role these programs *could* play.

As noted above, it is difficult for firms and agencies to determine whether AVR programs are worth starting without knowing how many cars they will attract. Before starting its program, USGen estimated that it would have to buy and scrap 125 cars if it wanted to offset an increase in air pollution caused by transporting coal to one of its power plants.

The company predicted that it would recruit this number of cars if it targeted a select group of car owners to partici-

pate in its program. Initially, USGen tried to enlist cars from among the 1,034 cars that had received waivers from Delaware's vehicle inspection and maintenance (I&M) program. These waivers allow cars to be driven after they undergo repairs to reduce tailpipe emissions and fail to pass the I&M program's emissions test a second time. Because cars with waivers are likely to be the most polluting cars on the road, they are the ones AVR programs want to enlist so as to obtain the greatest emissions reductions.

Since USGen enlisted only sixty cars from owners of waived cars, it made offers to about 3,000 owners of cars randomly chosen from the pre-1980 car fleet. From these, it recruited sixty-five additional cars.

The combination of both waived and nonwaived cars gave us the opportunity to test the feasibility and quantify the benefits of an AVR program that targets highly polluting pre-1980 cars, as well as a program that accepts any pre-1980 car.

Half of the 125 cars USGen purchased were given emissions tests. Using the results of the emissions tests, we estimated the average emissions rate of the scrapped cars. We found that, on average, the waived vehicles emitted about 60 percent more hydrocarbons from their tailpipes than the nonwaived vehicles. Using a model developed by the U.S. Environmental Protection Agency, we then predicted the average emissions rate of replacement cars.

We surveyed car owners participating in the program to obtain information on which to base estimates of the annual mileage and the expected remaining life of the 125 cars scrapped. We also surveyed a sample of car owners who were solicited to participate in the AVR program but who declined to do so. By surveying both those who accepted USGen's \$500 purchase-price offer and those who refused it, we were able to determine how the scrapped cars differed from the fleet of pre-1980 cars as a whole.





Photo courtesy of David Edelstein

Accelerated vehicle-retirement programs offer a market-based opportunity to reduce motor vehicle emissions. These programs take older, highly polluting cars off the road by buying pre-1980 cars from their owners and then scrapping the cars.

In the surveys, we asked car owners how often and how many miles they drove their cars, what condition their cars were in, how much longer they planned to keep their cars, whether they expected the cars to need major repairs in the near future, and how much effort it took for them to maintain their cars.

*Among the most polluting cars are those that are given waivers to be driven after repairs fail to reduce their tailpipe emissions; AVR programs want to enlist these waived cars so as to obtain the greatest emissions reductions.*

To gauge how the purchase price affected participation in the program, we asked respondents to give us their *reser-*

*vation price*—that is, the minimum offer they would have accepted for their cars.

To get better estimates of avoided and replacement emissions, we conducted follow-up surveys of both participants and nonparticipants one year later. These surveys examined how participants had replaced their cars—by purchasing new cars or relying on public transportation, for example—and how their driving habits had changed.

### Study results

Using data from the surveys and emissions tests, we were able to estimate the potential for emissions reductions from USGen's AVR program, as well as the program's cost-effectiveness compared with other mechanisms for reducing emissions. We also were able to draw some general conclusions about AVR programs.

Our data analysis focused on the relationship between the value of old cars and the cars' expected remaining life. We found that old cars with low values typically have a short remaining

life. This finding, which is based on the first empirical evidence ever collected about the remaining life of cars sold at different purchase-price offers, confirms what economic theory suggests. AVR programs that offer \$500 will attract cars that would have remained on the road no more than two years on average. This information is essential for evaluating the cost-effectiveness and emissions-reduction potential of AVR programs.

In estimating the cost-effectiveness of the Delaware AVR program and in deriving what economists would call an emissions-supply function (the function that predicts the number of tons of emissions reduced at varying purchase-price offers), we had to make some assumptions about replacement cars' emissions and usage. We based these assumptions on data gathered from the original and follow-up surveys.

Both surveys indicated that the scrapped cars were driven just as many miles (if not more) than the cars not sold and scrapped and that annual mileage was not meaningfully correlated with the age of individual pre-1980 cars. The follow-up surveys showed that, on average, replacement cars were driven no more than scrapped cars had been. We assumed, therefore, that a scrapped car would be replaced by another car with equal annual mileage. The follow-up surveys also showed that the average replacement car was a 1986 model-year car. Because such a car is very similar to the "average" car in the U.S. car fleet, we assumed that the emissions rate of replacement cars was the same as the average emissions rate of the nation's car fleet.

Using these assumptions and the emissions-test and survey data, we estimated a statistical model that correlates the remaining life of a car with the likelihood that its owner will sell it to an AVR program. Based on estimates generated by the model, we determined in two different ways the Delaware AVR program's cost-effectiveness in reducing hydrocarbon emissions. First, we estimated the

**Predicted cost-effectiveness, participation rates, and expected remaining vehicle life in a small-scale accelerated vehicle-retirement program at various purchase-price offers**

Purchase price offer	Average cost per ton of HC reductions	Predicted participation of the pre-1980 fleet	Expected remaining life of a participating vehicle (years)
\$400	\$5,370	1.8 %	1.5
\$500	\$5,946	4.3 %	1.7
\$600	\$6,219	8.0 %	1.9
\$700	\$6,572	12.8 %	2.1
\$800	\$6,904	18.2 %	2.3
\$900	\$7,194	24.0 %	2.4
\$1,000	\$7,509	30.0 %	2.5
\$1,100	\$7,838	36.0 %	2.7
\$1,200	\$8,167	41.7 %	2.8
\$1,300	\$8,477	47.2 %	2.9
\$1,400	\$8,800	52.3 %	3.0
\$1,500	\$9,123	57.0 %	3.1

Note: The program does not target the most highly polluting cars, but rather accepts any pre-1980 car. The shading reflects uncertainty about estimates of cost-effectiveness, participation rates, and expected remaining life at high purchase prices.

cost-effectiveness of the entire program, which included both waived and nonwaived cars. We found that the program reduced hydrocarbon emissions by about fifteen tons at a per-ton cost of about \$5,000. Second, we restricted our analysis to only the waived cars and found that the per-ton cost of emissions reductions was a little more than \$4,000.

Next we estimated the cost of reducing hydrocarbon emissions for a hypothetical AVR program that pays \$500 for any pre-1980 car. We found that the comparatively lower emissions of nonwaived cars in such a program would increase the per-ton cost of reducing hydrocarbon emissions to about \$6,000 (see table, above).

According to these estimates, a program that targets waived cars appears to be more cost-effective than a program that accepts any older car. If we had taken the value of carbon monoxide and nitrogen oxide reductions into account, the cost-effectiveness of each program would have increased.

Emissions reductions depend, of course, on the number of cars recruited,

and participation in AVR programs appears to be very sensitive to the purchase price offered. USGen's offer of \$500 attracted only 4.3 percent of the total population of Delaware's pre-1980 cars, and only 5.9 percent of its subpopulation of waived cars. If the offer price had been increased to \$700, we estimate that the company's program would have attracted approximately 13 percent of the total population and 18 percent of the waived fleet.

Our cost-effectiveness estimates indicate that the expected remaining life of cars purchased by AVR programs is also very sensitive to purchase-price offers. According to our estimates, a car sold to an AVR program for \$500 would otherwise have remained on the road for about 1.7 years, and a car sold for \$700 would have been driven another 2.1 years. In contrast, the average remaining life for the typical pre-1980 car is about 4.2 years. The significant difference between this figure and our estimates shows the danger of relying on average fleetwide estimates of variables, such as expected remaining life, when projecting the benefits of AVR programs.

Another important conjecture is that high purchase-price offers may adversely affect the cost-effectiveness of AVR programs that attract a large percentage of a region's old-car fleet. Removing a large number of cars from the fleet could increase average vehicle prices and thus influence the willingness of potential participants to accept a given offer price. Participation rates would therefore be lower at all offer prices. If this is the case, our estimates of the per-ton cost of removing hydrocarbon emissions would be too low, and our estimates of participation rates would be too high.

Once we established estimates of remaining vehicle life and participation rates, we were able to derive an emissions-supply function that predicts the number of tons of emissions reduced at varying purchase-price offers (see figure, p. 15). The emissions-supply curve is an increasing function of these offers: the higher the offer, the higher the number of cars AVR programs will

*The expected remaining life of cars bought by AVR programs is very sensitive to purchase-price offers. Estimates of the remaining life of these cars tend to be significantly lower than the average fleetwide estimate of the typical pre-1980 car's remaining life: 4.2 years.*

attract and the more emissions savings the programs will realize. The slope of the curve depends on car owners' responsiveness to the offer price, which in turn depends on the number of cars in the targeted fleet that are valued at less than the offer price. Large or ongoing AVR programs would likely make

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# INSIDE RFF NEWS AND PUBLICATIONS

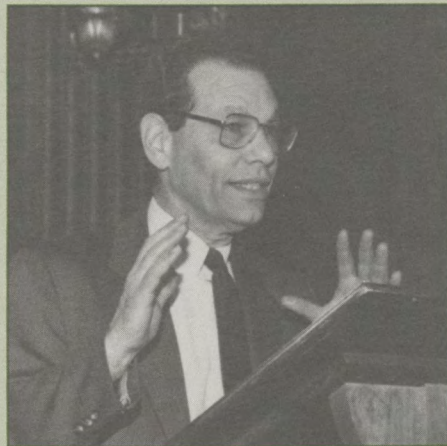
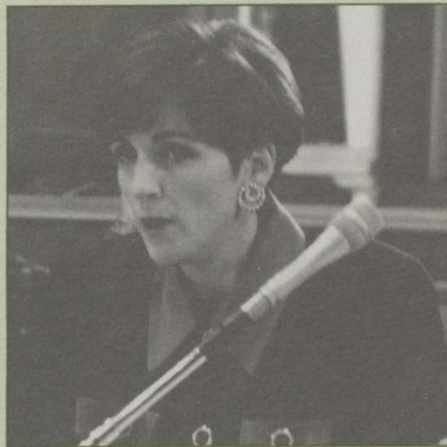
## RFF conducts risk assessment forum in U.S. Senate

Interest in and controversy surrounding the use of quantitative risk assessment in regulation are at an all-time high. Recently, six high-level policymakers sought a forum to discuss these issues and controversies. They turned to RFF's Center for Risk Management as the organizer and sponsor of the event.

The forum was convened at the request of the Senate Environment and Public Works Committee. The participants included Senator Max Baucus (D-Mont.), the committee chair; Representatives John Mica (R-Fla.) and Karen Shepherd (D-Utah); U.S. Environmental Protection Agency (EPA) Administrator Carol Browner; Assistant to the President and Director of the Office of Science and Technology Policy John H. Gibbons; and Sally Katzen, administrator of the Office of Management and Budget's Office of Information and Regulatory Affairs. Terry Davies, director of the Center for Risk Management, served as chair of the meeting.

The policymakers first stated their views on risk assessment and management and then discussed the current state of environmental risk analysis and its future development. Discussion centered on legislation sponsored by Mica that would require EPA to conduct a risk analysis for all regulations it proposed. (A similar requirement had passed the Senate in 1993 by a vote of 95 to 3.) Mica told the panel that his amendment would provide EPA with a management tool to make its regulations more efficient.

Browner opposed Mica's amendment but acknowledged risk assessment to be an "important and reasonable tool" and pointed to its use by EPA in drafting almost a thousand different regulations last year. Requiring EPA by law to use



Representative John Mica and EPA Administrator Carol Browner (top) and RFF's Terry Davies and Senator Max Baucus (bottom) were among the participants at a forum on risk assessment organized by RFF's Center for Risk Management.

risk assessment in every instance, however, is "not reasonable," according to Browner. She contended that "risk assessment has become a code word for those who want to weaken our efforts to pro-

tect public health and the environment" and warned that "when health hangs in the balance, you cannot always put a precise price tag on every single aspect."

*continued on page 12*

## RFF council discusses automobiles and urban air quality

"Automobiles and Urban Air Quality" was the topic of an RFF council meeting held on April 7 as part of the spring 1994 board of directors meeting. The event, held in Fort Myers, Florida, featured participants from federal and state government, the legal profession, and the business and environmental communities, together with members of the

RFF council, board of directors, and research staff. RFF Vice President and Senior Fellow Paul R. Portney moderated the discussion.

Over the past seven years, researchers at RFF have evaluated many of the regulatory approaches designed to reduce mobile-source air pollution. Among

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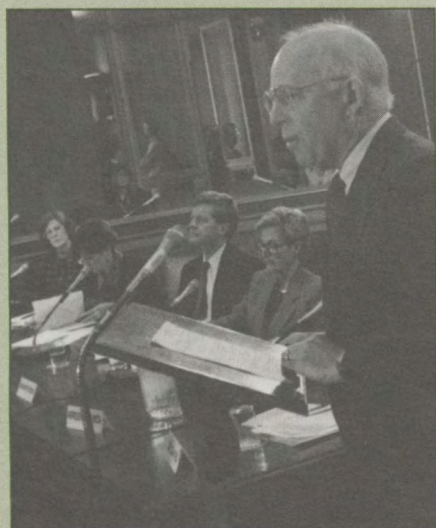
## Risk Assessment Forum

*continued from page 11*

Mica stressed that he was not "anti-environment," but was "appalled by the horror stories related to how EPA does its business" and believed it could do a much better job with limited resources through his amendment.

Baucus said that, while he supports legislation to use risk assessment in specific situations, basing regulation only on risk assessment "is too inflexible and open to scientific question for efficient enactment and enforcement." Furthermore, he noted, Congress is charged with making legislative decisions. If agencies could by law use risk assessment to second guess what the lawmakers have enacted, the result would "take Congress and the public out of the decision-making process."

Despite occasionally sharp differences on how and to what extent quantitative risk assessment and comparative risk analysis should be used in regulation, each panelist acknowledged that they had an important role to play in helping regulators establish priorities. Baucus said at the conclusion of the workshop that he



OMB's Sally Katzen, EPA Administrator Browner, Senator Baucus, and Representative Karen Shepherd listen to John H. Gibbons of the Office of Science and Technology Policy at RFF's forum on risk assessment.

wanted to continue to work with RFF on further dialogues about risk analysis.

RFF President Robert Fri remarked that RFF is "honored to have been asked by Senator Baucus to convene this panel. This forum is part of RFF's mission to improve understanding and communication relevant to important policy issues. It represents one element in the ongoing cooperation between the Center for Risk Management and the federal government to analyze and, when appropriate, apply risk-based concepts to environmental policy."

### Workshop on comparative risk

At the request of the White House Office of Science and Technology Policy (OSTP) and the Office of Management and Budget (OMB), the Center for Risk Management sponsored a workshop on comparative risk assessment on February 16. Among the participants were representatives of government, academia, and industry, including Sally Katzen, administrator of OMB's Office of Information and Regulatory Affairs; Douglas Costle and Lee Thomas, former EPA administrators; and Mark Schaeffer, assistant director of OSTP's environment division. Center Director Terry Davies chaired discussion among the group gathered to assess the process of ranking risks and to assist OSTP and OMB in developing comparative risk guidelines for the federal agencies. Davies also drafted one of six papers presented at the workshop.

Davies noted that comparative risk assessment can help agencies to evaluate their programs. By combining technical data, value judgments, and program information, a comparative risk assessment can assist decision makers in ranking risks systematically. This ranking helps them to allocate scarce resources and to decide which risk-reduction programs should be given priority.

While most risk experts agree on the purpose of comparative risk assessment, there is less consensus on how to go about making that assessment. Davies said it was important to reach consensus

on this issue because comparative risk assessment is becoming increasingly necessary. As the environmental problems become more complex and the resources to alleviate these problems become more scarce, Davies said, we are forced to set priorities more effectively.

### Congressional testimony on risk assessment

Center Fellow Adam M. Finkel presented testimony on February 1 before two subcommittees of the U.S. House of Representatives Committee on Government Operations. Commenting on several legislative proposals to change the way the federal government makes use of risk assessment, Finkel warned about the dangers of focusing too closely on minor or nonexistent problems with risk assessment and management; he also suggested that Congress was avoiding some of the real problems with the technique.

Finkel also presented testimony on March 9 about putting risk assessment to work at EPA. Speaking before the U.S. House of Representatives Committee on Science, Space, and Technology, Subcommittee on Technology, Environment, and Aviation, Finkel offered a supportive view of a proposal to establish a centralized program of risk assessment and management research at EPA.

### Congressional testimony on Superfund

Center Fellow Katherine N. Probst presented testimony on the costs of the Clinton administration's proposed Superfund legislation at a hearing held by Representative Al Swift, chairman of the U.S. House of Representatives Energy and Commerce Committee's Subcommittee on Transportation and Hazardous Materials. Probst presented estimates of needed increases in the Superfund trust fund to implement fully the changes proposed by the Clinton administration, as well as the likely effects of these changes on the magnitude of private-sector transactions costs.



Ed Riddell of the Electric Power Research Institute listens to remarks by EPA official Mary Nichols at the RFF council meeting held in Fort Myers, Florida, in early April.

## RFF council

*continued from page 11*

other topics, they have explored the potential and cost-effectiveness of electric vehicles, alternative fuels (including ethanol, methanol, compressed natural gas, and reformulated gasoline), enhanced inspection and maintenance programs, remote sensing, and accelerated vehicle-retirement programs.

In the morning session, several RFF researchers summarized the general conclusions they have drawn from these studies, identifying implications for such topics as the ozone nonattainment strategy of the U.S. Environmental Protection Agency (EPA), President Clinton's "new car" initiative, and the National Action Plan to stabilize greenhouse gas emissions. Ford Motor Company Vice President John McTague and independent analyst Michael Walsh, an adviser to many national environmental groups, provided commentary and participated in discussion of these presentations, which were made by RFF Senior Fellow Winston Harrington, RFF Visiting Fellow Virginia McConnell, and RFF Fellow Margaret Walls.

A luncheon address was presented by Mary Nichols, assistant administrator for air and radiation at EPA. Nichols,

remarking that "RFF couldn't have picked a more timely topic to be addressing," offered her views on how the United States should deal with air pollution problems associated with mobile sources in years to come.

The afternoon session featured a presentation by Mary Smallwood, an attorney with the firm of Ruden and Barnett, which represents clients involved in the automobile business at the wholesale and retail levels.

This RFF council session provided a valuable forum for RFF research staff to receive feedback on their work from people in government, industry, and the environmental community.

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## Recent contributions from corporations and foundations

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RFF is delighted to acknowledge and thank the following corporations and private foundations for contributions and grants received from December 1, 1993–March 25, 1994.

### Corporations

American Forest and Paper Association  
ARCO Foundation

Ashland Oil Foundation, Inc.  
BankAmerica Corporation  
Bristol-Myers Squibb Company  
CIGNA Corporation  
Dominion Resources, Inc.  
Destec Energy, Inc.  
Duke Power Company  
E.I. du Pont de Nemours and Company  
Enron Corporation  
Ford Motor Company  
GE Foundation, Inc.  
General Public Utilities Corporation  
IBM  
Philip Morris Companies Inc.  
Potlatch Corporation  
Potomac Electric Power Company  
Tokyo Gas Co., Ltd.  
Union Camp Charitable Trust  
Westvaco  
Weyerhaeuser Company Foundation

### Corporate Matching Gifts

The AES Corporation  
PaineWebber Group Inc.  
WMX Technologies Inc.

### Foundations

The Pew Charitable Trusts made a \$100,000 grant to RFF. This represents the final payment of their \$350,000 grant to the Center for Risk Management for research and analysis related to risk.

The G. Unger Vetlesen Foundation provided a \$50,000 grant for continued support of RFF research on climate issues.

The Carnegie Corporation of New York made a \$25,000 grant to the Center for Risk Management toward developing comparative risk assessment guidelines for federal health and safety agencies.

The Esther A. and Joseph Klingenstein Fund provided a \$15,000 grant to RFF in support of a workshop in cooperation with the National Press Foundation to educate journalists on environmental issues. The Klingenstein Fund supported a similar RFF/NPF workshop in 1993.

The Montgomery Street Foundation contributed \$10,000 in unrestricted operating support.

## Especially for RFF donors: Gifts of appreciated securities save taxes twice

As the first in a series of short articles to assist our donors in their estate and charitable gift planning, this article focuses on the benefits of giving appreciated securities to RFF or other charities.

An increasing number of RFF's donors are finding that gifts of appreciated stock allow them to save income taxes twice. In addition to receiving a charitable deduction for the current fair market value of the securities, the donor does not have to pay capital gains tax on the increased value of the stock. To avoid the capital gains tax, it is important that the donor give the securities directly to a nonprofit organization such as RFF, rather than selling the securities first.

For example, when you contribute \$1,000 in cash to RFF, you can take a \$1,000 charitable deduction, reducing your tax bill by \$360. The net result is that your \$1,000 gift "costs" you \$640.

Contributing appreciated securities provides additional tax savings. If you contribute stock that you bought for \$400 that is now worth \$1,000, you can avoid paying capital gains tax of \$168 on the \$600 increase in value. Since RFF does not pay capital gains tax, it receives the benefit of the full \$1,000 rather than the \$832 it would receive if you sold the stock first and contributed the proceeds.

For more information about gifts of appreciated securities, bequests, or other types of planned gifts, please contact RFF Vice President-Finance and Administration Ted Hand at 202-328-5029 or check the appropriate box on the enclosed reply envelope.

## Recent gifts from individuals

The following individuals made gifts of \$100 or more between December 1, 1993 and March 24, 1994 in support of research and education programs at Resources for the Future:

Anonymous (4)  
Marilyn Altobello  
Lee G. Anderson  
Kenneth B. Armitage  
Robert E. Asher  
C. Murray Austin  
Robert Axtell and  
Roxanne Constantino  
James M. Banner  
Olvar Bergland  
John A. Busterud  
Gianni Carbonaro  
Richard E. Cavanagh  
David R. Chittick  
Tiang-Hong Chou  
Ron Cummings  
Robert T. Deacon  
Henry L. Diamond,  
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Weitzman  
Dael Wolfle  
Kenji Yamada  
David Zilberman

The following individuals have made gifts in memory of former RFF President Joseph L. Fisher, after whom RFF has established dissertation awards to support graduate students in the final year of their dissertation research on environmental and natural resource issues:

Anonymous (2)  
Kenneth J. and Selma Arrow  
Berkley Bedell  
Arnold W. Bolle  
Blair T. Bower  
Toby and David Brooks  
Mrs. Erwin D. Canham  
Emery Castle  
Francis T. Christy  
John M. Cornman  
Pierre R. Crosson  
F. Elwood Davis  
Robert K. Davis

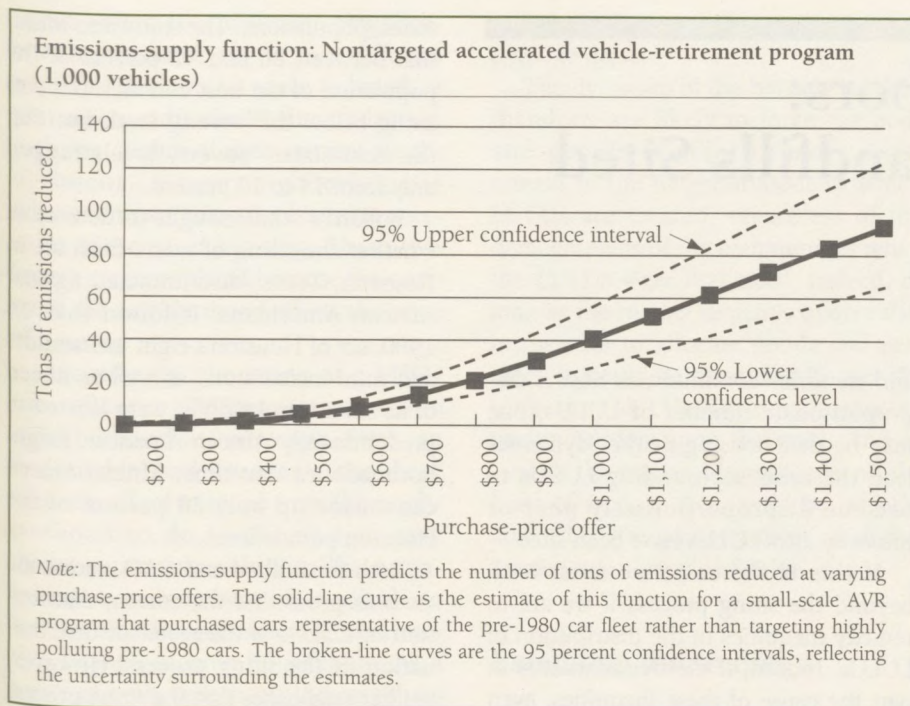
R. K. Dentan  
Joy Dunkerley  
Erik Ferguson  
Betsy Fisher  
Margaret W. Fisher  
Luther H. Foster  
Verne L. Harper  
B. Powell Harrison  
Maynard M. Hufschmidt  
Charles P. Kindleberger  
(also in memory of  
Harold J. Barnett)  
Nathan M. Koffsky  
Bob Krueger

Mary E. McWilliams  
Abner and Zoe Mikva  
Robert R. Nathan  
Harold T. Pinkett  
Reasoner, Davis & Fox  
Stefan H. Robock  
Stanley H. Ruttenberg  
Robert M. Solow  
Harold K. Steen  
Dr. and Mrs. Lee M. Talbot  
Ross Talbot  
The Hon. Russell E. Train  
Dave and Vivian Watts

## About contributions to RFF

Resources for the Future sustains its programs through its endowment and through income from foundations, government agencies, corporations, and individuals. RFF accepts grants on the condition that it is solely responsible for the conduct of its research and the dissemination of its work to the public. RFF does not perform proprietary research.

All contributions to RFF, a publicly funded organization under Section 501(c)(3) of the Internal Revenue Code, are tax deductible.



the curve flatter—especially at high offer prices—because high used-car prices would make most owners less willing to participate in an AVR program.

### The future of AVR programs

Whether AVR programs are cost-effective relative to other means of reducing hydrocarbon emissions will depend on the severity of the air quality problems and the extent of existing pollution controls in the regions they serve. As noted above, the Delaware AVR program, which offered car owners \$500 to scrap their cars, reduced hydrocarbon emissions from waived cars at a per-ton cost of \$4,000. By comparison, the U.S. Environmental Protection Agency estimates that the substitution of reformulated gasoline for regular gasoline would reduce hydrocarbon emissions at a per-ton cost of \$3,900.

A small-scale AVR program that does not target waived cars is less cost-effective. It will reduce hydrocarbon emissions at a per-ton cost ranging from about \$5,000 (at a \$400 purchase-price offer) to about \$7,000 (at a

\$900 purchase-price offer). However, a small-scale AVR program is more cost-effective than a program to replace cars that run on gasoline with cars that run on natural gas or on methanol, which would reduce hydrocarbon emissions at a per-ton cost of \$12,000 and \$30,000, respectively.

We conclude that small-scale, short-term AVR programs can be cost-effective for some regions. Programs that target the most highly polluting old cars may be the most promising. However, only a very large-scale program will generate appreciable emissions reductions. Since such a program is also likely to increase used-car prices, its cost-effectiveness is likely to decrease over time. The cost-effectiveness of ongoing AVR programs may also decrease in the long run because these programs are likely to create adverse incentives and unexpected consequences, especially when combined with efforts to target highly polluting vehicles.

Another area of uncertainty concerns the interaction of AVR programs and states' vehicle inspection and maintenance (I&M) programs. If the I&M programs become more effective in the

future, they may reduce the emissions-reduction potential of AVR programs by identifying and removing from the road many of the most polluting cars. However, there may be many roles for AVR programs in combination with state I&M programs. For instance, joint AVR-I&M programs might allow owners of cars that do not pass emissions tests to choose to either repair or scrap their cars. Our research suggests that the emissions-reduction potential of AVR programs could be maximized if the programs were set up to complement other means of reducing urban air emissions.

*Anna Alberini is a fellow in the Quality of the Environment Division at Resources for the Future, and David Edelstein is a research assistant in the division. Virginia D. McConnell, a professor in the Economics Department at the University of Maryland, is a visiting fellow at RFF. A detailed discussion of the issues in this article can be found in discussion paper 94-27, "Emissions Reduction Credits from Old Cars: The Economics of the Delaware Vehicle Retirement Program," by Anna Alberini, David Edelstein, Winston Harrington, and Virginia D. McConnell.*

RFF discussion papers convey the preliminary findings of research projects for the purpose of critical comment and evaluation. Unedited and unreviewed, they are available at a cost of \$3.00 each to interested members of the research and policy communities. Price includes postage and handling. Prepayment is required.

To get a list of discussion papers, call 202-328-5025. To order discussion papers, please send a written request and a check made out to Resources for the Future to: Discussion Papers, External Affairs, Resources for the Future, 1616 P Street NW, Washington, DC 20036-1400.

## Unpopular Neighbors: Are Dumps and Landfills Sited Equitably?

Vicki Been

Incinerators, landfills, and other "locally undesirable land uses" (LULUs) are not popular neighbors, however essential they may be to the community at large. The fact that many of them are located in poor and minority communities may look at first glance like a clear case of discrimination in siting. A closer look reveals, however, that the problem may not be solely with the siting of LULUs, but also with the housing-market dynamics that come into play *after* a LULU has been established. If so, attempts to achieve a more equitable distribution of LULUs would have to extend beyond changes in the siting process.

Studies show that communities hosting waste management facilities and other locally undesirable land uses (LULUs) have, on average, higher percentages of racial minorities and the poor than other communities. Advocates of environmental justice contend that this is unfair, arguing that environmental risks should be distributed more equitably among races and socioeconomic classes. They assert that the disproportionate burden LULUs impose on poor and minority communities is the result of racism and classism in the siting process. As evidence, they point to studies that reveal a correlation between the racial and class characteristics of communities and the presence of LULUs in those communities.

If the siting process does discriminate against the poor and racial minorities, it should be reformed. However, there may be other reasons why poor

and minority communities host a disproportionate number of LULUs; one may be that housing-market dynamics lead the areas surrounding LULUs to become disproportionately poor or minority *after* LULUs have been sited.

If this is the case, we must look beyond the siting process if we are to remedy inequities in the distribution of LULUs. Indeed, if the free market is in part the cause of these inequities, even a siting system that ensured a perfectly fair initial distribution of LULUs would not result in any long-term benefit to the poor or people of color.

### The GAO and Bullard studies

More than a dozen studies document the fact that poor and minority communities now host a disproportionate number of the nation's LULUs. Two of the most notable studies are "Siting of Hazardous Waste Landfills and Their Correlation with Racial and Economic Status of Surrounding Communities," which was conducted by the General Accounting Office (GAO) in 1983, and "Solid Waste Sites and the Black Houston Community," which was published by Dr. Robert Bullard in the same year.

The GAO study examined the racial and class characteristics of communities surrounding four hazardous waste landfills located in three southeastern states. GAO found that, in 1980, African Americans made up between 52 and 90 percent of the population of three of the four communities where the landfills were sited, but only between 22 and 30 percent of the host

states' populations. The study also found that between 26 and 42 percent of the population of the host communities was living below the poverty level, but that the host states' poverty levels ranged only from 14 to 19 percent.

Bullard's study sought to determine whether the siting of waste facilities in Houston, Texas, discriminated against African Americans. It found that, in 1980, six of Houston's eight incinerators and mini-incinerators, as well as fifteen of its seventeen landfills, were located in predominantly African American neighborhoods. At that time, African Americans made up only 28 percent of the Houston population.

Both the Bullard and GAO studies are cited as proof that the current distribution of LULUs is the result of discrimination in the siting process. However, neither establishes that the siting process caused the disproportionate distribution. Each study considered only the *current* demographics of host and non-host communities, ignoring the demographics of communities at the time siting decisions were made. This failure begs an obvious question—namely, whether host communities were poor and minority communities at the time they were selected as LULU sites or only became so in subsequent years.

If neighborhoods were minority neighborhoods at the time they were selected to host LULUs, the choice of sites may have been racially discriminatory. If so, then the siting decisions would have been unfair. But if the neighborhoods were *not* minority neighborhoods when they became LULU hosts, some factor other than discrimination must account for the fact that they now are disproportionately populated by minorities. That factor may be the dynamics of the housing market.

### The role of housing-market dynamics

Each year, between 17 and 20 percent of the U.S. population moves to a new



home—often to a different neighborhood in the same city or to a different city. The decision to move is based in part upon individuals' dissatisfaction with the quality of their current neighborhoods. A new neighborhood is selected in part because of its characteristics and cost of housing. These two factors are interrelated because the quality of the neighborhood affects the price of housing.

Accordingly, the siting of a LULU can influence the characteristics of a neighborhood in two ways. First, an undesirable land use may cause those who can afford to move from the neighborhood to do so. Second, it may decrease property values in the neighborhood, making housing available to low-income households and unattractive to high-income households. As a result of both influences, the neighborhood is likely to become poorer than it was before it hosted the LULU.

The neighborhood also is likely to become home to an increasing number of people of color, whenever racial discrimination in the sale and rental of housing relegates them to less desirable neighborhoods than are available to whites. Once a neighborhood becomes a

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*The presence of a LULU in a neighborhood can lower the neighborhood's quality and thus its property values, making housing there more available to low-income families.*

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community of color, racial discrimination in the promulgation and enforcement of zoning and environmental protection laws, the provision of municipal services, and the lending practices of banks may cause neighborhood quality to decline further. That further decline will induce those who can leave the neighborhood—namely, the least poor

and those least subject to discrimination—to do so.

The dynamics of the housing market, therefore, are likely to force the poor and people of color to move to or remain in the neighborhoods in which LULUs are located, regardless of the demographics of the communities when the LULUs were first sited. Indeed, as long as the market depends upon existing wealth to allocate goods and services, it would be surprising if, over the long run, LULUs did not impose an undue burden upon the poor. And as long as the market discriminates on the basis of race, it also would be remarkable if LULUs did not impose an undue burden upon people of color.

### Extending the studies

To determine whether the current distribution of LULUs is the result, at least in part, of market dynamics, I extended the GAO and Bullard studies. While those studies documented only the then-current demographics of the communities in question, I documented demographics roughly concurrent with the years in which siting decisions were made. I then traced subsequent demographic changes through 1990.

The GAO study examined the racial and class characteristics of communities surrounding four large hazardous waste landfills in the southeast. Sites for three of these landfills were probably chosen in the early or mid-1970s; the site for the fourth landfill was chosen in the late 1970s. Therefore I examined the 1970 demographic data for the first three sites and the 1980 demographic data for the remaining site.

My analysis of these data reveals that all four host communities studied by the GAO were predominantly African American at the time they were selected as LULU sites. The percentage of African Americans in the host communities' populations at the time the LULUs were sited ranged from 1.6 to 3.3 times that of the host states' populations. In the

GAO's analysis, however, only three of the communities were predominantly African American in 1980.

Accordingly, demographic data from the time of the sitings, rather than from the 1980 census, strengthen the inference that siting choices had a disproportionate impact upon African Americans. This does not necessarily mean, however, that the process was discriminatory. Siting decisions may be based upon land prices, proximity to sources of waste, transportation networks, or other factors unrelated to race or poverty that nevertheless have an incidental, disproportionate effect upon people of color or the poor.

At the same time, the data provide no support for the theory that market dynamics cause host neighborhoods to become increasingly populated by African Americans. In all the communities the GAO studied, the landfill sitings were followed by *decreases* in the percentage of African Americans populating the communities. Between 1970 and 1990, the decreases in two host communities were 32.3 and 35.8 percent, even though the decrease in African Americans making up the total population of South Carolina, where the communities are located, was only 2.3 percent.

Demographic data for the time when the landfills were sited also provide no support for the theory that market dynamics cause host neighborhoods to become increasingly populated by the poor. If this theory were correct, the data should show decreases in relative median family income and relative median housing values, as well as increases in relative poverty subsequent to the sitings. According to my analysis, the relative poverty and relative median family income of the host counties changed only marginally between 1970 and 1990. During the same period, the relative median housing value also changed only slightly, and in two of the four host communities it actually increased.

My extension of the Bullard study offers somewhat different results. As noted above, Bullard examined demo-

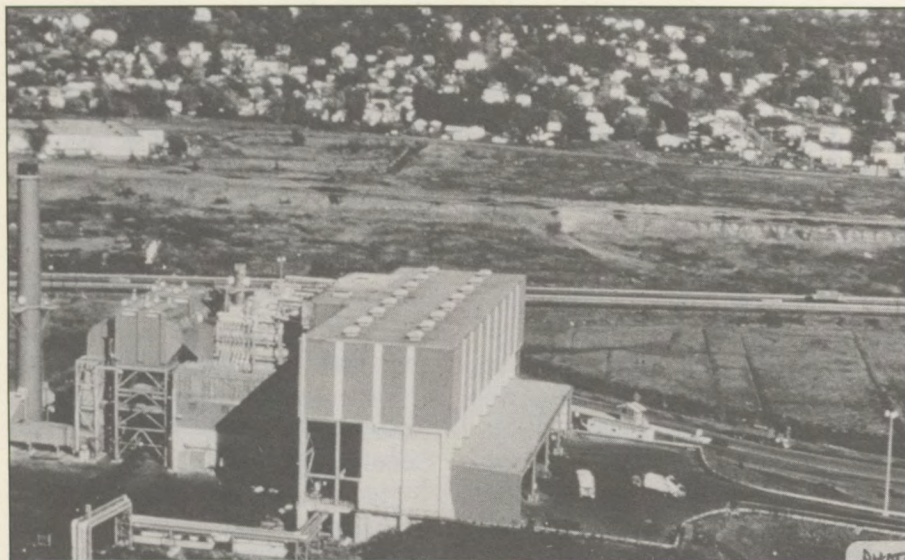


Photo courtesy of Waste Age magazine.

Waste incinerators tend to be located in poor and minority communities. The inequitable distribution of these and other locally undesirable land uses has been blamed on discrimination in the siting process, but may result from housing-market dynamics.

graphic data for Houston communities hosting solid waste management facilities. In redoing his study, I eliminated the community demographics for communities where facilities had ceased to operate by the 1970s, since these sites were selected long ago and meaningful demographic data were not available. Consequently, my analysis was confined to the Houston communities that host the three mini-incinerators and seven landfills cited in the original study. While the original study used "neighborhoods" as its unit of analysis, I examined census tract data. I changed the unit of analysis because I had no information about how Bullard defined neighborhoods and therefore could not replicate his analysis.

In my extension of Bullard's study, then, I examined the 1970 census data for seven communities, because all three of the mini-incinerators and four of the landfills were sited in the early 1970s. For the community hosting the two landfills sited in the early and mid-1950s, I examined both 1950 and 1960 census data. (Because the 1950 census tract containing the landfills was so large, the 1950 data are not particularly meaningful.) The remaining landfill was

sited in 1978, so I examined the 1980 census data for its host community.

My analysis of the census data reveals that three of the seven landfills and two of the three mini-incinerators in question were located in areas where the percentage of African Americans was significantly greater than that of

*Analysis of the Bullard sites shows that the siting process had a disproportionate effect upon African Americans, but it also lends force to the argument that LULUs change a community's demographics by driving down property values.*

Houston as a whole at the time the facilities were sited. Even though about 25 percent of Houston's population was African American, five of the ten facilities were sited in areas where African Americans made up 60 percent of the population. This indicates that the

siting process had a disproportionate effect upon African Americans.

Yet analysis of the host communities' demographics in the decades *after* the LULUs were sited reveals that the siting process was not the sole cause of the undue burden Houston's African Americans now bear. Between 1970 and 1980, the percentage of African Americans in the neighborhoods surrounding the landfills increased by as much as 223 percent, while the percentage of African Americans citywide increased by only 7 percent. And while the number of African Americans as a percentage of the total Houston population changed little in the following decade, the number of African Americans as a percentage of host communities continued to increase in all but one of the communities. By the 1990 census, all of the communities hosting landfills had become home to a disproportionate percentage of African Americans.

Analysis of the host neighborhoods' economic characteristics reveals a similar pattern. Only three of the ten communities studied had poverty rates significantly higher than Harris County, where the communities are located, at the time the facilities were sited. Between 1970 and 1980, the poverty rate of all but two of the host communities (as measured by the percentage of the communities' population with incomes under the poverty level) increased, while that of Harris County dropped. Between 1980 and 1990, most of the communities hosting landfills experienced significantly higher increases in their poverty rates than did Harris County. By the 1990 census, five of these communities and two of the three communities hosting mini-incinerators had become significantly poorer than the county.

Similarly, median family incomes in all but one of the communities hosting landfills decreased relative to those of Harris County between 1970 and 1990. In addition, all but one of the communities in which landfills were sited suffered marked declines in their housing

values relative to Harris County in the decades following the sitings.

According to my analysis of data from the census closest to the date of the siting decisions in question, the siting process had a disproportionate effect upon African Americans. But it also provides considerable support for the theory that market dynamics contribute to the burden LULUs impose upon people of color and the poor. The data I examined lend force to the argument that LULUs change a community's demographics by driving down property values. True to that argument's prediction, the homes surrounding the landfill sites in most of the host communities became less valuable properties relative to homes in other areas of Harris County after the landfills were sited. The host communities then became increasingly populated by African Americans and the poor.

### Implications

Using demographic data from the census nearest in time to siting decisions

(rather than data from the most recent census) and then tracing changes in demographics significantly changes the implications of the GAO and Bullard studies. My analysis of the sites in the GAO study indicates a correlation between neighborhood demographics and siting decisions, but suggests no evidence that market dynamics are forcing the poor or people of color to "come to the nuisance." My analysis of the sites in Bullard's study, on the other hand, indicates that market dynamics may play a significant role in the distribution of the burdens LULUs impose. This finding suggests that even if siting processes can be improved, market forces would be likely to create a pattern in which LULUs become surrounded by people of color or the poor.

My research shows that we can make no easy generalizations about the cause or causes of the current inequity in the distribution of LULUs. More data and analysis are needed to prove either that discrimination in the siting process is the sole cause of this inequity or that both siting decisions and housing-market dynamics—demographic changes

caused by a LULU's effect on property values and by discrimination in the sale and rental of housing—are to blame.

If further study of LULU sitings confirms the findings of my analysis of the sites in Bullard's study, however, the debate about the fairness of the distribution of environmental risks would have to shift gears. It would become a debate, not just about the process of siting LULUs, but also about the free market and poverty and racial segregation in residential areas. Moreover, discussions about remedies would have to extend beyond the siting process, because changes in this process would be unlikely to achieve real, long-term improvement.

*Vicki Been is an associate professor of law at New York University. This article is based on a seminar she gave at Resources for the Future on October 7, 1993. For a complete description of the above-described research, see "Locally Undesirable Land Uses in Minority Neighborhoods: Disproportionate Siting or Market Dynamics?" in The Yale Law Journal, vol. 103 (1994), p. 1383.*

## Does Environmental Policy Conflict with Economic Growth?

David Gardiner and Paul R. Portney

Debates about environmental regulation most often revolve around its economic consequences, particularly its effects on economic growth. Recently, this debate has become sharper. In addition to the "traditional" view that environmental regulation impedes economic growth (most often espoused by those in the business community), an opposing school of thought has developed. According to its proponents, not only can environmental regulation provide health and ecosystem protection, but

it can stimulate the economy and enhance U.S. competitiveness at the same time.

Because this debate has extraordinarily important policy consequences, Resources for the Future sought a way to air—and clarify—the issues bound up in it. Accordingly, RFF Vice President Paul R. Portney and David Gardiner, assistant administrator of the U.S. Environmental Protection Agency's Office of Policy, Planning, and Evaluation, discussed them on December 1, 1993, at one of

RFF's regular Wednesday seminars. The two articles that follow adhere faithfully to their opening remarks.

Although Gardiner is a proponent of the new view, while Portney is more sympathetic to the traditional one, both agree that the relationship between the economy and the environment is a complicated one. Moreover, both agree that the debate so far quite often has been exaggerated and misleading. This presentation is intended to help shed light on a most important subject.

## David Gardiner

Conventional economic wisdom tends to focus on trade-offs as the basis for exploring the relationship between the environment and the economy. It suggests that environmental policy conflicts with economic progress. The U.S. Environmental Protection Agency (EPA) is trying to dispel this false dichotomy by leading discussion away from the somewhat reactive focus on trade-offs and toward a more proactive focus on ways to achieve environmental protection and economic progress at the same time.

### Conventional model of the economy-environment relationship

The conventional approach to exploring the relationship between the environment and the economy is to pit one against the other—as if the real trade-off were between environmental protection and economic progress. By economic progress I mean quantitative and qualitative progress in the context of clean and equitable improvements to socioeconomic systems. Quantitative improvements enable us to meet the essential needs of the present generation without compromising the ability of future generations to meet their own needs. Qualitative improvements reflect our capacity to convert physical resource use into improved services for satisfying human wants.

In general, the conventional approach ignores changes in technology and changes in consumer preferences, and it assumes that everyone out there in the marketplace is fully informed. It also treats expenditures on environmental protection as expenses, rather than investments, and affords no intrinsic or economic value whatsoever to natural resources, such as clean air and clean water.

In reality, none of these assumptions holds true. This is why less-than-optimal

outcomes result for both the economy and the environment when decision makers adopt an either/or model of the economy-environment interaction.

One such outcome resulted when U.S. manufacturers in the automobile coatings segment of the paints and coatings industry failed to anticipate public demand for stronger environmental regulations or opportunities for cost-effective, safe, and clean technological advances. As a result, the manufacture of all water-borne basecoats used in the United States relies substantially on technology developed by European suppliers.

Another example of a less-than-optimal outcome comes from the agriculture sector, where either/or assumptions and market imperfections have left the potential for realizing economic and environmental benefits substantially unmet. A recent cooperative study undertaken by EPA and the University of Missouri indicates that, when compared to conventional systems of farming, cropping systems that incorporate reduced tillage, greater cropping diversity, and more efficient management of commercial pesticides and fertilizers can improve resource conservation, reduce environmental risks, reduce costs of production, and increase short-run profits.

*When decision makers adopt an either/or model of the economy-environment interaction, less-than-optimal outcomes result for both the economy and the environment.*

To obviate the false assumptions that lead to less-than-optimal decision making, we must change the very nature of the debate over the relationship between the economy and the environment. This can be achieved, at least in part, by shift-

ing discussions about that relationship away from the either/or model.

Environmental and economic interdependence is strongly linked to the development and diffusion of technology. As noted above, false assumptions about technology, tastes, and environmental investments form the basis of the view that increased pollution reduction can only be achieved at the expense of economic progress or vice versa, that greater economic activity inevitably hurts the environment. In reality, the myriad relationships between the economy and the environment are continually changing.

### New perspective

The key question, then, is not "Does environmental policy conflict with economic progress?" but rather, "How can we get environmental protection and economic progress at the same time?" Clean technologies and management practices have a particularly important role to play in answering this question, as do price and institutional reforms that encourage reductions in all polluting emissions per unit of industrial output. And because the demand for environmental goods and services, or for a clean environment, increases at a slightly greater rate than income in most cases, we know that the demand for a clean environment is going to increase domestically and internationally.

We want to help give direction to that demand on an international level, so that when the market forms we can meet that demand with U.S. technology. Moreover, we want to provide incentives to industry to target its new capital investments in manufacturing practices and processes that are sustainable over the long term. In this way, we can realize environmental and economic benefits from the ongoing process of technology turnover in all industries.

The development and diffusion of environmentally sound technologies can change the way in which goods and services are produced and also generate

benefits that can increase human welfare. The most promising areas for realizing the gains of environmental technology today relate to energy use and the development of alternative fuels, to biotechnology and the development of agricultural practices that use fewer inputs and harmful pesticides, and to industrial production processes that reduce or prevent pollution.

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*When the market forms for environmental goods and services, we would like to meet that demand with U.S. technology. We want to provide incentives to industry to target its new capital investments in manufacturing practices and processes that are sustainable over the long term.*

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It's worth noting that industry's focus on environmental concerns results not only from the need to comply with environmental regulations; firms are also recognizing new business opportunities and realizing economic gains. Indeed, U.S. industry is racing to capture the world market for new and emerging technologies, which the Organization for Economic Co-operation and Development estimates to be worth \$200–300 billion and forecasts to see sustained growth over the next decade. In addition, "environmentally friendly" has become a powerful marketing tool across all sectors, industries, and services, a tool that recognizes consumer preferences for products that have less harmful impacts on the environment.

Examples abound that let us "brag" about the economic and environmental benefits that result when the interdependence of economic and environ-

mental goals are recognized, understood, and strategically advanced. Inform Inc., a New York-based, non-profit, environmental research organization, reports that in many cases initiatives to reduce pollution at its source have decreased waste streams by 90 percent or more and resulted in significant savings. The savings, tallied for 62 projects, came to \$21 million annually.

In one case cited by Inform, a medium-sized resin and adhesives facility in California made operational changes that slashed by 93 percent its major phenol-laden waste stream, which for years had been discharged first to the local sewer and then to an onsite pond. This reduction has saved the company more than \$150,000 per year in waste disposal and potential legal costs. In another case, a reagent chemicals plant in New Jersey computerized its materials tracking system, identified twenty-one source reduction initiatives, and cut more than 600,000 pounds of waste to achieve annual savings exceeding half a million dollars.

State governments also have documented some good examples. Minnesota estimates that six manufacturers using recyclable materials have created around 1,700 jobs, \$39 million in new wages, and an increase of \$100 million in Gross State Product. Maine reports that recycling added nearly \$300 million in wages, profits, savings, and secondary impacts, as well as more than 2,000 jobs to its economy in 1992. There are many more examples, and we want to continue to add to them.

### **New approaches**

One of EPA's driving principles under Administrator Browner is an uncompromising commitment to environmental goals, while allowing flexibility as to how those goals are met. This combination of uncompromising commitment and flexibility is designed to yield innovation and jobs, as well as better environmental results.

The agency recently announced a major initiative to work closely with industry, states, and environmental groups to explore—on an industry-by-industry basis—coordinated rulemaking, permit streamlining, multi-media compliance and enforcement opportunities, and pollution prevention and environmental technology opportunities that offer "cleaner, cheaper" environmental results. Through initiatives such as these, we can expose the false premises that undermine constructive dialogue on the environment and the economy. Moreover, by demonstrating the interdependence of environmental and economic goals, we can create a new model of thinking that encourages decision makers to leverage the positive relationship between environmental protection and economic progress.

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### **Paul R. Portney**

I welcome this opportunity to react to David Gardiner's views on environmental regulation and its connection to economic growth. Because of the importance of this connection, and the key role that Gardiner's Office of Policy, Planning, and Evaluation plays in EPA's analyses of such issues, his willingness to exchange views is encouraging.

On several key points, I find myself in substantial agreement with him. For instance, the debate over environmental regulation *has* often made it seem that we must choose—in an either/or fashion—between economic growth and environmental quality. In fact, the two can coexist.

For example, between 1970 and 1990, per capita real disposable personal income in the United States (the best measure of what the average person has available to spend) increased by 42 percent. Meanwhile, concentrations of airborne lead, perhaps the most harmful of all the common air pollutants, fell by 90 percent between 1983

and 1990 alone. In addition, the period 1970–1990 saw significant reductions in ambient concentrations of sulfur dioxide, particulate matter, and carbon monoxide in almost every major metropolitan area of the United States, as well as significant—though much less uniform—improvements in water quality. Strictly speaking, then, we do not face an “either/or” choice when thinking about economic growth and environmental quality, and it is wrong to suggest otherwise.

I also agree with Gardiner that new environmental regulations do not inevitably lead to plant closures and unemployment. In fact, as he points out, a substantial number of people are now employed in what might loosely be referred to as the “environmental industry.” (Total U.S. employment in this industry is about one million people.) This positive side of the “jobs” issue is routinely ignored by critics of regulatory programs.

Finally, I agree wholeheartedly with the emphasis Gardiner places on the importance of concocting cheaper ways of meeting the goals of U.S. environmental policy. Twenty years of careful research have demonstrated that we can meet our present environmental goals for a fraction (perhaps as little as 50 percent) of the \$130 billion we now spend each year to comply with federal environmental regulation. Even if the annual savings were as little as 10 percent, or \$13 billion, this would be roughly equivalent to all federal income assistance to poor families and nearly three times the amount of federal assistance to schools for disadvantaged children. We have to take advantage of opportunities like this.

Despite these points of agreement, however, I take issue with some of what Gardiner has to say. And I disagree fundamentally with a message I believe is implicit in his remarks: we can avoid painful choices when setting environmental goals and instead “have it all.” That’s simply not true, and we had better recognize this admittedly

unpleasant reality if we are to fashion wise economic and environmental policies.

### Keeping score with jobs

Gardiner refers several times to favorable job impacts from environmental measures. But we need to keep three things in mind when thinking about jobs and regulation. First, despite much rhetoric from both sides, environmental regulation will never have much of an impact on the aggregate level of employment in the United States. Rather, total employment is determined by much broader

*Given the choice between world dominance in the environmental industry or a comparably strong position in, say, automobile manufacturing, chemical production, or agriculture, we would be foolish not to choose any of the latter.*

forces—such as domestic and international fiscal and monetary policy, attitudes toward saving and investment, and the quality of our labor force. True, regulation can “create” or “destroy” jobs in the short run, but only temporarily; in the long run, the opportunities for productive employment depend on the factors identified above.

Second, the environmental industry is now and probably always will be relatively small in the grand scheme of things. (The one million jobs in the environmental industry represent about eight-tenths of one percent of total civilian employment in the United States.) As economist Richard Schmalensee has pointed out, the year-to-year fluctuation

in total U.S. employment is sometimes only slightly smaller than the whole of the environmental industry. This is emphatically *not* to disparage that industry—indeed, the United States enjoys a favorable balance of trade in environmental goods and services, one I hope grows larger still. But if given the choice between world dominance in the environmental industry or, say, a comparably strong position in automobile manufacturing, chemical production, or agriculture, we would be foolish not to choose any of the latter.

Third, even if environmental regulation could affect the overall level of employment in the long term, counting jobs created or destroyed is simply a poor way to evaluate environmental policies. Consider a regulation that resulted in the closure of a large factory employing hundreds of workers. While surely lamentable, this might be a very good policy from an overall social standpoint if the factory simply could not operate without discharging substances very harmful to human health and the environment. Conversely, one could envision a regulatory program that, in the short term, “created” jobs for hundreds or even thousands of workers. Yet if this program did little or nothing to improve environmental quality, it would be foolish to implement it despite its employment effects—the environmental pork barrel is no more benign than that from which other kinds of make-work projects are often plucked.

### Separating wheat from chaff

How then do we distinguish wise from unwise policy proposals? The answer is at once very simple and very complicated. In my view, desirable regulations are those that promise to produce positive effects (improved human health, ecosystem protection, aesthetic amenities) that, when considered qualitatively yet carefully by our elected and appointed officials, more than offset the negative consequences that will result

(higher prices to consumers, possible plant closures, reduced productivity). In other words, wise regulations are those that pass a kind of commonsense benefit-cost test.

Three quick points are in order. First, and obviously, this type of evaluation is more easily described than done. Determining when the pros swamp the cons is often terribly difficult for any one of us to figure out; throw in the fact that we all have a different system of weights and measures, and you have the makings of environmental policy quagmires and donnybrooks.

Second, note my emphasis on a *qualitative* weighing of benefits and costs. While this may make me persona non grata among my fellow economists, I do not believe that a full-blown benefit-cost analysis—one in which all favorable and unfavorable effects must be expressed in dollar terms—should ever be the basis for a regulatory decision. In my view, uncertainties about valuation, the choice of a discount rate (and sometimes even whether to discount future effects at all), the appropriate handling of distributional concerns, and perhaps other problems as well, will always militate against policymaking by reliance on quantitative benefit-cost alone.

*How do we distinguish wise from unwise policy proposals?*

*The answer is at once very simple and very complicated: Wise regulations pass a kind of commonsense benefit-cost test.*

Third, these first two observations should not—repeat *not*—be taken to suggest that quantitative benefit-cost analysis has no useful role to play in environmental policymaking. Not only can this type of analysis help put on an equal footing many effects that seem incommensurable at first blush, but it

can also reveal starkly the *implicit* values we hold that we often are understandably reluctant to express in dollars and cents. Better to make such trade-offs openly and explicitly, where all can see them, than to fuzz them over by pretending that they do not exist.

Moreover, contrary to some assertions, benefit-cost analysis is perfectly capable of supporting stringent environmental regulation. Among other policies, benefit-cost analyses have supported the Clean Air Act Amendments of 1970, the removal of lead from gasoline, and the phase-out of chlorofluorocarbons (CFCs) because of their role in stratospheric ozone depletion. To be sure, benefit-cost analyses have also cast serious doubt on the wisdom of certain other environmental proposals. Sauce for the goose is sauce for the gander, after all. One thing I think we can be sure of is this: environmental statutes that prohibit even the qualitative weighing of benefits and costs in standard-setting ensure uninformed policymaking.

### Cost-free regulation?

Note my insistence that there *will* be costs to any regulation. Gardiner provides examples that suggest environmental regulation often jogs firms into discovering money-making opportunities about which they were previously ignorant. In these cases, he implies, citizens get the benefits of a cleaner environment while the regulated firm makes out well, too. In such cases, do we not escape the unpleasantness of trade-offs?

I think not. First, while there surely will be cases where complying with a regulation causes a firm to recognize a money-making opportunity it had been overlooking, I think it unlikely that such instances abound or that the associated profits will be very large. While corporations are hardly the paragons of efficiency that economics textbooks sometimes suggest, a kind of Darwinian market discipline does exist that forces

firms to search out and take advantage of profitable opportunities.

More importantly, suppose a firm does realize profits rather than incur out-of-pocket costs when complying with an environmental regulation. In this case, surely, the regulation is costless, right? Wrong. While much more subtle, there is a cost here, too—an opportunity cost that takes the form of the returns the firm would have earned had it invested its expenditures on environmental compliance in other areas—say, on expanding its plant, retraining its work force, or intensifying its research and development efforts. In the same vein, incidentally, there is an opportunity cost associated with a firm's investment in any of the latter activities, even if that investment pays off handsomely. This cost is measured by what the firm could have earned had it put the funds to another use.

While opportunity costs are much less obvious than out-of-pocket expenditures for air or water pollution control equipment, cleaner fuels, or waste cleanup, they are no less real. Moreover, since it will never be possible to spend the same dollars on two things at once, a cost will *always* be associated with each environmental regulatory program. In some cases, it may take the form of out-of-pocket expenditures; but even when regulatory compliance helps a firm make money, we must be sophisticated enough to ask how well the firm would have done if it had put that same money to a different use.

In this regard, then, we can never have our cake and eat it too. Spending money in pursuit of environmental goals has been and can be a *very* wise use of society's scarce resources. But there will always be a cost to environmental regulatory programs, and environmental "paradigms" that promise otherwise are misleading and destined to disappoint.

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