Environmentally Responsible Energy Pricing

by

W. Kip Viscusi,*

Wesley A. Magat,**

Alan Carlin,***

and

Mark Dreyfus****

May 12, 1993

*George G. Allen Professor of Economics, Dept. of Economics, Duke University, Durham, North Carolina 27706, phone 919-660-1833, fax 919-684-8974, and member of EPA Sciences Advisory Board on the Clean Air Act.

*Professor of Business Administration and Senior Associate Dean, Fuqua School of Business, Duke University, Durham, North Carolina 27706, phone 919-660-7728.

**Senior economist, Office of Policy Planning and Evaluation, U.S. EPA, PM-221, 401 M Street S.W., Waterside Mall, Room 3220K, Washington, D.C. 20460, phone (202)260-5499.

****Doctoral candidate in economics, Duke University.

This research was supported by EPA Cooperative Agreement #817478-1. The supporting analysis underlying this article is detailed in W. Kip Viscusi and Wesley A. Magat, 'lEnvironmentally Responsible Energy Pricing," Report to U.S. EPA, 1992. The views expressed here do not necessarily represent the views of EPA.

DISCLAIMER

Although prepared under EPA Cooperative Agreement No. CR814388-02., this report has neither been reviewed nor approved by the U.S. Environmental Protection Agency for publication as an EPA report. The contents do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Abstract

This paper assesses the value of the non-global warming externalities associated with energy use. The estimates of the full social cost energy prices based on this **"no regrets"** approach imply environmental costs that often greatly exceed current tax amounts. The midpoint estimates suggest that the price of coal is most out of line with its efficient level. Natural gas is currently overtaxed, and gasoline is appropriately taxed. There is also a substantial range of uncertainty embodied in the no regrets estimates.

Introduction

In 1993 the Clinton administration began active consideration of a variety of different energy taxes. Although energy taxes share with other forms of taxes the attractive property of raising funds for the government, they have an additional feature as well. In the usual tax situation, one views the distortions in economic decisions generated by the tax as being associated with the loss of economic efficiency. However, in the case of energy taxes, these higher tax values may serve a constructive function by promoting energy conservation and possibly shifting the types of energy that are used.

One potential use of these taxes is to incorporate some recognition of the adverse externalities generated by energy use in the price that energy consumers pay. Conventional pollution damages, such as the visibility loss associated with air pollution, is among the types of damages that could be reduced through tax incentives. In addition, imposition of an energy tax will also discourage the generation of gases that lead to possible adverse long-term consequences for the global environment. The emphasis of this paper will be on assessing the energy taxes that are appropriate from the standpoint of addressing the costs associated with conventional forms of pollution. This tax can be viewed as a first step toward addressing the broader environmental damages associated with greenhouse warming.

The main reason for abstracting from the role of climate change is that the character and associated consequences are

highly uncertain.' At the most extreme, some scientists suggest that prospective climate changes may, on balance, be beneficial. Many observers have consequently recommended a more cautious policy approach, at least as an initial step. Until the pertinent uncertainties are resolved, they suggest that we should follow the minimal course of action dictated by our current knowledge. The stringency of policies consequently should reflect the non-global warming damages and costs associated with emissions of greenhouse gases. This policy prescription has come to be known as the "no regrets" approach since even the most favorable informational developments regarding the risks of global warming will not undermine the desirability of taking these minimal actions.[2] In 1992 there was increased prominence given to the "no regrets approach," as environmental advocates viewed it as a politically feasible alternative to a full scale global warming policy.[3]

In other words, a "no regrets" approach is to adjust current prices to reflect all non-global warming damages associated with the emission of greenhouse gases.[4] To ensure that society adopts the most efficient mode of energy use, which is the most important source of greenhouse gases, and that the economically efficient amount of energy will be used, the prices of these energy sources should reflect their total social costs. On the basis of this principle, the 1991 National Academy of Sciences greenhouse warming panel recommended:

> Study in detail the "full social cost pricing" of energy, with a goal of gradually introducing such a

> system. ..On the basis of the principle that the polluter should pay, pricing of energy production and use should reflect the full costs of the associated environmental problems. The concept of full social cost pricing is a goal toward which to strive. Including all social, environmental, and other costs in energy prices would provide consumers and producers with the appropriate information to decide about fuel mix, new investments, and research and developments

The results reported in this article seem to establish a major component of the value of the full social cost prices. The environmental damages from fossil fuel use represent only a major component of the full social costs because they exclude the non-environmental social costs of fossil fuel use. Other possible cost components include: national security costs associated with ensuring uninterrupted oil imports and inefficiencies resulting from failure of electric utilities to use marginal cost pricing.[6] Although we know of no systematic study of these non-environmental social costs, the magnitude of these costs may also be very large. The results reported here, however, pertain only to the environmental damages of fossil fuel use.[7]

Our assessment of the full social cost prices of energy suggests that even a "no regrets" policy involves enormous dollar stakes. Shifting our focus from climate change to more conventional environmental effects does not eliminate the prospect of considerable economic costs. Policies based on the estimated environmental impacts would necessitate substantial expenditures, possibly hundreds of billions of dollars annually. Moreover, there is also considerable uncertainty with respect to environmental damages from energy uses other than greenhouse

warming, although less so than with the valuation of global warming damages.

Even if full social cost energy pricing is never implemented, examination of these prices is a useful mechanism for identifying the divergence between private and social costs. Should our policy emphasis, for example, be on improving fuel efficiency of automobiles, or should we direct greater attention to decreasing pollution from coal? In terms of eliminating the underlying uncertainties, should analysts focus their attention on resolving the complexities of acid rain, or do the mortality risks associated with sulfur oxides represent an area in which there is much more to be learned? Examining full social cost energy prices highlights the salient open research questions as well as the broad outlines of what is currently known about appropriate pricing of energy. These issues are pertinent not only to climate change policy, but also to the debate over our national energy strategy.

Economic Foundations

Ideally a society interested in the welfare of its citizens wants to promote efficient utilization of all resources, including energy resources. This concern is particularly great since energy consumption has been linked to a number of environmental costs, principally relating to air pollution. Because energy users do not compensate those who bear these costs as part of a market transaction, they represent a classic case of environmental externalities.

In any market context, it is economically efficient for participants to bear the full consequences of their actions so that their behavior will incorporate the social effects as well as the private benefits. Consumers of energy are not paying these costs since they are permitted to use an environmental resource (i.e., atmospheric waste disposal) without paying any explicit fee.

The economic objective is twofold. First, energy producers should supply the appropriate amount of each form of energy given these social costs. Second, consumers should consume the amount of each energy source that reflects a balancing of the benefits to them of the energy and the social costs of their actions. To achieve this efficient energy usage objective, the incentives for energy production and utilization must be correct.

This article estimates user fees that lead energy users to incorporate the environmental costs of energy in their energy choices.[8] This objective is obviously quite ambitious. Obtaining a definitive assessment could ultimately require a much more extensive research effort. Because of resource constraints, the scope of this study will necessarily be more limited, and substantial reliance will be placed on previous government analyses of energy-related pollution.[9]

The incorporation of the environmental externality costs of energy will be undertaken by relying largely upon benefit assessments that have served as the basis for EPA standards. Perhaps more than any other available documents, these

assessments represent an official governmental view of the environmental damages from energy use. This is not to say that these assessments should be accepted uncritically, as they have frequently been challenged by other government agencies, academics, and **industry.**[10] Our approach provides an approximation of these environmental costs.

The estimates reflect only a subset of the adverse environmental externalities created by energy use. The most notable exception is the omission of the global warming externalities from the analysis. The reason for this omission is not that these externalities are unimportant. Rather, the magnitude and even the direction of the greenhouse effect impacts remain under strenuous debate. The intent of the "no regrets" policy assessment is to determine whether many of the objectives of those advocating policies to address the risks of climate change can be achieved through a more limited approach that recognizes only those externalities other than climate change."

Before being implemented, the the full social cost pricing approach must be refined. Ideally, the tax should be on pollution, not on energy. The most obvious distinction that must be made is between anthracite and bituminous coal. However, generally there will be a need to reorganize differences in pollution associated with a particular energy source. One of the main purposes of an energy pollution-free system is to encourage innovation to reduce pollution, such as by introducing control equipment that will decrease pollution from a particular form of

energy. Firms will have no such incentive if they are penalized based on the type of energy they use rather than on the damage that it generates. The ultimate objective is to establish fees for pollution, not for energy use. The calculations in this paper present what such a fee structure would look like overall, but should not be regarded as providing a rationale for ignoring the level of damage associated with each energy source.

Energy Sources and Pollutants

Existing evidence on the costs associated with energy are most developed for various forms of petroleum (gasoline, diesel aircraft fuel, heating oil, and natural gas), wood, and coal.[12] Excluded from this listing are three energy sources for which the environmental damages may be negligible. Wind and solar power generate virtually no adverse environmental effects, and the water pollution and air pollution damages associated with geothermal power are believed to be minimal.

Another energy source that we will not examine is nuclear power. Unfortunately, there is no comparable governmental study of nuclear hazards that enables us to include the associated nuclear risks in our analysis. Emissions levels are observable, and with the aid of health benefit assessments, it is possible to make judgments pertaining to the likely impacts of pollution from coal, wood, and petroleum-based fuels.

Assessment of the costs of nuclear power is a quite different enterprise.[13] Major reactor failures are a rare event. How, for example, should we incorporate the Chernobyl

experience in risk assessments for the U.S. nuclear industry? We observe signals of likely hazards -- faulty safety practices, minor mishaps, and near disasters -- but ultimately the risk assessment for nuclear power hinges on subjective assessments of human and engineering failures. Some observers claim that the risks have been overblown, whereas others view nuclear power as a serious threat. We do not view these uncertainties as insurmountable, but to date there have been no definitive assessments of the risks of nuclear power. In the absence of governmental risk assessment for nuclear power or a comparable definitive analysis, nuclear power will be excluded from consideration.

The social cost results below should not provide a relative subsidy to nuclear power simply by default. Before any environmental cost fee system is implemented, there should be a comparably vigorous assessment of the expected externality costs associated with nuclear energy.

Each of the columns in Table 1 list the different energy sources that will be the subject of the assessment. For each energy source, seven different components of external costs were considered. The importance of these categories differs by energy source. For gasoline, the most detrimental externalities are for particulate, in large part because EPA regulations have already greatly reduced the role of lead pollution from motor vehicles. Particulate are also an important category of pollution for diesel, aircraft fuel, and wood. For coal and heating oil,

sulfur oxide mortality is of greatest import. Ozone is the most damaging pollutant linked to natural gas.

The externality costs associated with each pollutant are given both in terms of a contribution per unit of the fuel as well as a percentage of the 1986 retail price.[14] The year 1986 was selected to ensure the availability of the key data components. The estimates in Table 1 are based on the midpoints of the estimated EPA pollution benefit ranges. The degree of uncertainty in these estimates is explored below. These estimates also pertain to average benefit values over the entire range of remaining benefits. As a consequence, these estimates may understate the marginal unit benefits of pollution reduction.

The role of the different pollutants varies by energy source. The remaining lead in gasoline imposes external costs on society that constitute roughly 1 percent of the retail price.[15] Particulate emissions are pertinent to all the energy sources listed in Table 1. With the exception of natural gas, every energy source generates substantial particulate emissions. Both motor fuels as well as stationary source fuel combustion are involved.[16] Particulate emissions impose costs on society equal to 9 percent of the price of gasoline, 23 percent of the price of diesel, 11 percent of the price of aircraft fuel, 6 percent of the price of heating oils, under 1 percent of the price of natural gas, 147 percent of the price of wood, and 25 of the price of coal.

The next two categories of externalities in Table 1 pertain

to sulfur oxides. Emissions of sulfur dioxide and resulting sulfate particles from motor fuels and stationary source fuel combustion impose losses that can be best distinguished in terms of those that affect mortality and those that do not.[17] Although significant sulfur oxide costs are associated with both diesel and heating oils, by far the greatest relative cost of sulfur oxide externalities are those associated with coal. Sulfide damages excluding mortality constitute 13 percent of the price of coal, and the mortality effects constitute 464 percent of the price of coal. Put somewhat differently, the midpoint estimates of the sulfur oxide mortality effects of coal are almost 5 times larger than the market price of coal. As will be indicated below, the level of these costs is also very uncertain.

The next category of externalities are those associated with reducing ambient ozone concentrations resulting from motor fuels and stationary source fuel combustion.[18] The costs of ozone pollution constitute 2 percent of the price for gasoline and diesel, under 1 percent of the price for aircraft fuel, heating oils, and natural gas, and 3 percent of the price for wood and coal. The visibility externalities are largely associated with reducing sulfur oxide emissions from coal-fired power plants.[19] These visibility costs constitute 23 percent of the price of coal.

The final environmental cost component in Table 1 consists of the quantities of potential cancer cases related to non-lead emissions from motor vehicles.[20] These air toxic effects

constitute 2 percent of the price of gasoline and 14 percent of the price of diesel.

Externalities and Net Taxes

Ideally, the prices of these various energy sources should reflect the social costs they impose. To adjust for these costs one can impose an additional charge on the use of these energy sources. One might view these charges as being a user fee for the environmental resource that is not properly recognized in market transactions. To the extent that there are existing taxes imposed on energy sources, these would correct at least in part for the disparity between the private price and the social price of the energy source.

Table 2 summarizes the current net taxes paid by various energy sources as well as the external costs that are generated. In situations in which the taxes equal the external costs, no additional charges on the energy source are appropriate.

Current taxes on gasoline are 17 percent of the price, roughly the same as the externality cost. In the case of diesel fuel, the current net tax per gallon is 13 percent, whereas the externality cost per gallon is 50 percent. In the case of aircraft fuel, the current net tax per gallon is 16 percent of the price, and the externality cost is 13 percent. Existing tax levels are below the amount of the appropriate user fee in the case of diesel fuel, but there is no such discrepancy for gasoline and aircraft fuel.[21]

Heating oils represent a case similar to that of diesel

fuel. The current tax level is 15 percent, whereas the environmental cost is 64 percent. Natural gas currently has taxes of 6 percent, whereas the environmental cost is 1 percent. Somewhat strikingly, the current tax levels for natural gas are in fact above the user fee level based on this analysis. Moreover, the environmental costs are very low in percentage terms.

Wood currently is not taxed, whereas the appropriate user fee for each short ton of wood is 152 percent of the price. Heat provided by wood stoves clearly is not a totally environmentally responsible solution to the energy ***crisis.***

The case of coal is most dramatic. The current tax per ton of coal is 36 percent of the price, whereas the environmental costs are 529 percent of the price.

These taxes can be also put in different terms more closely linked to the current greenhouse debate. Advocates of policies to address greenhouse warming frequently propose that a carbon tax be **implemented.**[22] The externalities considered here can also be incorporated within the context of a carbon tax, but the level of the base carbon tax to account for the externalities other than greenhouse warming will not be uniform. The final column in Table 2 indicates how high the relative carbon tax on each fuel should be, where the level of the carbon tax has been normalized by setting the tax on natural gas equal to 1. The relative carbon tax for those gasoline sources for which estimates are available is much greater than it would be on

natural gas, which is a comparatively clean energy source. The relative carbon tax levels range from 1 for natural gas to 28 for gasoline to 105 for coal. A uniform carbon tax is not an appropriate vehicle for addressing environmental damages other than global warming. One of the major advantages of our approach is that it adjusts for the substantial heterogeneity in environmental costs rather than relying on a simple carbon tax.

Irrespective of whether the tax is levied through a carbon tax or some other mechanism, the total price tag for the externalities will be quite high. Table 3 summarizes the total environmental costs associated with each energy source, assuming that there is no change in the quantity of energy used. There would, of course, be a substantial shifting away from energy sources whose relative price increased. The total tax amount is $208 billion, which is about two-thirds of the $281 billion projected budget deficit for fiscal year 1992.[23] Over two-thirds of the estimated energy tax amount is attributable to coal. Gasoline, heating oils, and wood would be taxed in the $10-$20 billion range, and coal would be $149 billion.

Imposing externality charges of this magnitude is certainly a daunting prospect. A major source of the relative popularity of regulatory standards as compared with taxes is that firms do not currently have to pay for these costs. In effect, the imposition of regulatory standards allows firms to have a level of pollution up to the standard for free.[24] Standards can be effective in promoting the efficient degree of pollution control

for any particular energy source, but they will not provide the correct incentives for the modal choice among alternative sources of energy.

Suppose, for example, that there are two possible sources of energy. Source A is a highly polluting energy source for which it is very difficult to reduce pollution levels. Source B is a very clean energy source for which it is possible to virtually eliminate the pollution level at little cost. Setting efficient regulatory standards, which is to say those that equate the marginal benefits to society of additional pollution reduction with the marginal costs of controls, will lead to very minimal pollution reduction for energy Source A, but may lead to the elimination of pollution for Source B. In each case efficient controls would have been imposed for the energy source, but what remains is an immense uncompensated environmental cost imposed on society for energy Source A. Notwithstanding these externalities, society perhaps should continue to use Source A. However, unless the price that consumers pay for this energy source reflects the remaining environmental costs that are generated, the price mechanism will not provide consumers with the appropriate incentive for making the appropriate energy choice.

Alternative Tax Approaches

The focus thus far has been on two forms of taxes that are linked to the externalities. The first type of tax that we considered was a consumption tax set based on the level of the

externality associated with consumption of each particular energy type. The implications of the consumption tax for product prices appear in the first column of Table 4. A tax of, for example, 28 cents per gallon on gasoline would be warranted.

The second approach is to levy the tax in terms of a tax on carbon content. The information in the second column of Table 4 indicates how high the carbon tax level would need to be for each particular energy source in order to generate the same revenue as would the consumption tax. Because of the absence of data on the carbon content of aircraft fuel and wood, the total tax revenue raised for these calculations will be for all of the energy sources for which data are available. As the results in the second column of Table 4 indicate, the carbon tax levels will be quite different than that implied by the consumption tax in many cases. For example, diesel fuel will be much more heavily taxed under a carbon tax approach than a consumption tax approach. In addition, coal will be substantially undertaxed under a carbon tax approach, although it will still be heavily taxed. The tax implied for gasoline is roughly similar either under a carbon tax or a consumption tax system.

Both the consumption tax, which is based on conventional pollution externalities, and the carbon tax, for which the rationale can be traced to greenhouse warming concerns, are much more explicitly linked to models of environmental damages than the tax policies that played a prominent role in the Clinton administration policy debate. The most prominent policy option

was a BTU tax linked to the BTU content of each fuel type. Another possibility that was considered was an ad **valorem** energy tax, which would impose a uniform tax on energy use. As before, let the objective be to raise the same amount of revenue as would be raised using a consumption tax. Although the actual revenue objectives of the Clinton administration's proposals are more modest, maintaining symmetry in terms of the revenue raised facilitates comparison across the different tax types.

The ad **valorem** tax has a disproportionate impact on several energy sources that are considerably overtaxed relative to the externalities they generate. Chief among these are natural gas, gasoline, and aircraft fuel. In contrast, coal is taxed at **one-**seventh of the rate that would be appropriate from the standpoint of conventional externalities and less than one-fourth of the amount that would be taxed under a carbon tax approach. Although the ad **valorem** tax may offer an advantage of administrative simplicity, it is not particularly well-linked to the economic rationales for imposition of a tax.

The BTU tax, which is summarized in the final column of Table 4, comes much closer to an optimal tax than does the ad **valorem** tax. Coal is taxed three times as heavily under a BTU tax as it would be under an ad **valorem** tax, and fuel sources such as gasoline and diesel fuel are taxed less heavily. Unfortunately, the relatively clean energy source -- natural gas -- is taxed even a bit more stringently under the BTU tax than under an ad **valorem** tax. Moreover, all of these taxes on

natural gas are considerably out of line with what is appropriate given the externalities generated by this gas source.

Although there appears to be a substantial misallocation in terms of the distribution of the tax burden, much of this difficulty arises from the substantial estimates of the damages associated with coal. Moreover, as was indicated above in the discussion of Table 1, the costs associated with coal are largely due to sulfur oxide mortality. The degree to which one could confidently move forward with a particular energy tax structure depends in large part on the firmness of this evidence, which we will now explore in some detail.

The Range of Uncertainty[25]

One reason for caution with respect to implementing such externality charges is that there remains considerable uncertainty in the ranges of the cost estimates. The pollution effect estimates are disputed by private industry officials as well as by many independent analysts. Moreover, there remains a substantial range of uncertainty implied by the governmental studies on which this analysis has been based. Most of those analyses served as the economic framework underlying the justification of government regulations and, as a consequence, were the result of substantial research effort. The range of uncertainty that remains reflects, at least in part, the current imprecision of our scientific knowledge that may be costly to reduce.

Instead of focusing on environmental costs based on the

midpoints of government analyses, Figure 1 indicates the current tax amounts, and the lower and upper bounds on the appropriate environmental cost surcharge. Gasoline has a modest range of uncertainty -- from 2.5 percent to 31.0 percent of its price. In contrast, the lower bound estimate for coal externalities is 21.0 percent, and the upper bound is 1,035.0 percent.

It is instructive to consider some of the sources of these uncertainties. In the case of gasoline, the principal uncertainty is the societal cost of particulate emissions, for which the estimates range from 0.5-17.4 percent of the price. Particulate costs are also the major uncertainty for diesel (l.2-44.7 percent of the price), aircraft fuel (0.5-20.6 percent of the price), and wood (7.5-287.4 percent of the price). The sulfur oxide mortality effect range is the greatest for two energy sources -- heating oils (0.0-106.2 percent of the price) and coal (0.0-928.0 percent of the price) . Although one can make judgments regarding the appropriate estimate within these ranges, such as our reliance on the midpoints, the range of uncertainty signals the potential benefits of improving the informational base underlying full social cost energy pricing. The extent of uncertainty, our ability to resolve the uncertainty, the cost of resolving the uncertainty, and the benefits to the design of the energy pricing system all affect the desirability of acquiring this information.

Unless there is no potential for information acquisition, these results **imply** that adopting the **"no regrets"** social cost

pricing approach may also involve substantial regret as well. The presence of uncertainty need not paralyze policy development since taking no action may be costly as well. It does suggest, however, that policies of information acquisition and refinement of these environmental damage estimates should be a high priority for additional research.

Conclusion

Reverting to an environmental strategy of "no regrets" that abstracts from the risks of global warming does not completely simplify the policy task. The remaining uncertainties involved are currently substantial, though they can potentially be reduced through additional scientific and economic research. There is a particular need for further knowledge of the nature of the relationship between the external costs on society and additional reductions in pollution. In addition, some of the most uncertain high stakes externality components, such as sulfur oxide mortality, merit detailed scrutiny so as to narrow the range of uncertainty.

Shifting the focus from greenhouse warming to more short-term air pollution problems also does not eliminate the need for bearing enormous economic costs. The levels of the environmental damages involved are substantial -- possibly on the order of hundreds of billions of dollars annually. Non-environmental costs may be significant as well.

The financial pressures to reduce the budget deficit may make economists' discussion of the role of energy taxes more than

hypothetical. However, there has not yet been an explicit attempt to link these taxes to the damages caused by use. One difficulty is that there is no explicit market transaction that makes clear the implicit price for energy pollution that society is now paying. Adverse health effects, such as mortality, are diffuse. Many of these impacts occur with a long time lag, and their incidence cannot easily be linked to particular energy sources. As a result, their magnitude is widely debated.

Even if society does not adopt a full social cost pricing system for energy, analyzing what the prices should be from an efficiency standpoint provides an illuminating framework for analysis and for ranking alternative tax approaches. Chief among the conclusions of this study is that the prices of the energy sources that seem most out of line with their environmental damage are coal and wood. Natural gas is a comparatively clean energy source that is currently taxed more than is warranted given the costs that its use imposes on society. Moreover, the almost exclusive obsession of the popular press and much government regulation with private motor vehicles appears to be misplaced. Gasoline pays its own way in the sense that the current gasoline tax equals the environmental damage imposed. Perhaps because of these efforts, the gap between the environmental costs resulting from gasoline and the taxes already imposed is much less than for energy sources such as diesel fuel and heating oils. Moreover, all of those adverse effects are dwarfed by the enormous, but highly uncertain environmental costs

associated with coal.

Pursuit of a “no regrets” policy of full social cost energy pricing raises the same class of concerns as do proposals to address climate change, but to a lesser degree. The stakes are immense, the uncertainties are considerable, and the possibility of regret over controlling pollution by more than will prove to have been warranted is quite real. These parallels suggest that this entire policy area involves intrinsic uncertainties. Ultimately, decisions will have to be made without clear-cut guarantees regarding their effects. At the same time, these uncertainties suggest that the value to society of scientific and economic research that improves the environmental information base may be considerable.

Figure 1

Taxes and Air Pollution Externalities as a Percent of Fuel Price

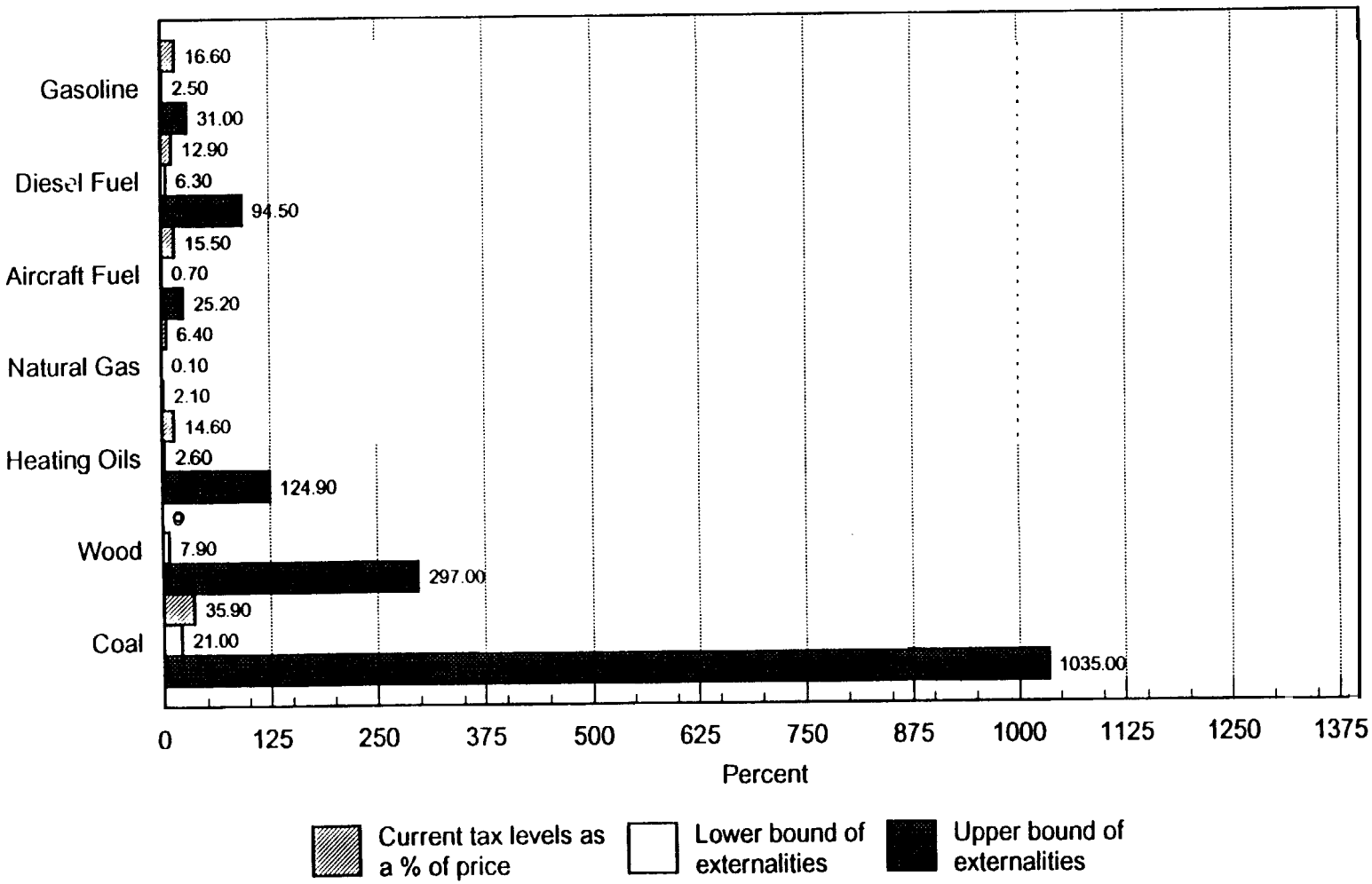

Table 1

Unit Value of Benefits of Emission Reduction to Zero Following Compliance with Current Standards*

Pollution Category	Gasoline $ per gal (% of price)	Diesel $ per gal (% of price)	Aircraft Fuel $ per gal (% of price)	Heating Oils $ per gal (% of price)	Natural Gas $ per 1,000 ft^3 (% of price)	Wood $ per short ton (% of price)	Coal $ per short ton (% of price)
Lead in Gasoline	0.0108 (1.16)						
	0.0831 (8.92)	0.2156 (22.94)	0.0679 (10.55)	0.0432 (6.23)	0.0181 (0.46)	91.0788 (147.43)	8.4069 (25.25)
	0.0005 (0.05)	0.0029 (0.31)	0.0003 (0.04)	0.0102 (1.48)	0.0001 (0.00)	0.1166 (0.04)	4.3005 (12.92)
Sulfur Oxides SO_4 Mortalit	0.0169 (1.82)	0.1044 (11.10)	0.0091 (1.42)	0.3653 (53.09)	0.0026 (0.07)	0.9108 (1.48)	154.51 (464.00)
Ozone	0.0214 (2.30)	0.0176 (1.87)	0.0055 (0.86)	0.0021 (0.29)	0.0228 (0.58)	2.1076 (3.41)	1.0579 (3.18)
Visibility	0.0008 (0.09)	0.0051 (0.55)	0.0005 (0.07)	0.0178 (2.60)	0.0001 (0.00)	0.0425 (0.07)	7.54 (22.66)
Air Toxics from Motor Vehicles	0.0223 (2.40)	0.1281 (13.63)					

*These estimates are based on midpoints of the estimated range of values.

Table 2

Summary of Energy Externalities and Taxes

Assuming Compliance with Existing Environmental

	Current Tax per Unit 1986[a]	Current Tax as a Percent of Price (1 986)	Externality Cost Estimate as a Percent of Price (1 986)[b]	Relative Carbon Tax
Gasoline (gal)	0.15	16.60	16.74	27.89
Diesel Fuel (gal)	0.12	12.90	50.40	52.88
Aircraft Fuel (gal)	0.10	15.50	12.94	NA
Natural Gas (1000 cu. ft.)	0.25	6.40	1.11	1,00
Heating oils (gal)	0.10	14.60	63.69	47.99
Wood (tons)	0.00	0.00	152.43	0.00
Coal (tons)	11.95	35.90	528.01	104.87

a. Excludes taxes designated for Federal Highway Trust Fund, Superfund Tax, and Black Lung Tax.

b. Based on midpoint environmental damage estimates in Table 1.

c. Based upon carbon emissions per unit fuel. Relative carbon tax values are normalized with natural gas equal to 1.

Table 3

Total Tax Revenue for Each Fuel Type*

Fuel Type	Total Tax Revenues ($ billions)	Net Tax Revenues ($ billions)
Gasoline	26.87	17.98
Diesel Fuel	5.00	2.38
Aircraft Fuel	1.71	1.71
Heating Oils	4.72	4.70
Natural Gas	4.11	4.11
wood	NA	NA
Coal	10.17	9.61
TOTAL TAX	52.58	40.49

*Based on most recent estimated consumption volumes. 1989 in most cases except wood, 1987. All figures in 1986 dollars.

Table 4

Alternative Tax Structures

	Consumption Tax	Carbon Tax	Ad Valorem Tax	BTU Tax
Description of Tax	Tax assessed at retail level for all fuel types.	Tax assessed at retail level for al 1 fuel types. Tax amount determined by carbon content of each fuel.	A uniform tax at a rate of 1.02% of retail price.	Tax assessed based on BTU content of each fuel type.
Level of Tax				
Gasolina	$ 0.28/gal	$ 0.25/gal[2]	0.953/gal	O.54/gal
Diesel	0.61/gal	2.81/gal	0.962/gal	O. 59/gal
Aircraft	0.12/gal	NA	0.658/gal	0.52/gal
Coal	232.71/ton	142.30/ton	34.094/ton	92.03/ton
Heating Oils	O.58/gal	1 .43/gal	0.704/gal	0.62/gal
Natural Gas	0.06/1000 cu. ft.	0.06/1000 cu. ft.	4.054/1000 cu. ft.	4.42/1000 cu. ft.
Wood	134.11/ton	NA	63.253/ton	
Petroleum				
Electricity				
Total Tax Revenue for 1989 estimsted consumption volumes (in billions $)'	284.99	259.383	281.72	267.80
Range of Tax Revenue: lower and upper bounds (in billions $)	21.41 - 548.36	21.51 - 497.53	22.22 - 541.04	21.80 - 513.59

[1]Sum over all fuel types of optimal tax (midpoint estimate) for each fuel multiplied by most recent estimate of consumption of that fuel.
[2]Tax constraint calculated as sum of optimal tax on gasoline, diesel fuel, coal, heating oils, and natural gas multiplied by 1986 consumption volumes for each fuel. Aircraft fuel and wood fuel were deleted due to insufficient carbon content data.
[3]Excludes carbon taxes on aircraft fuels and wood fuel.

Notes

1. There remains a debate regarding the implications of climate change for greenhouse warming. Some areas may be affected differently by climate change. In addition, some researchers hypothesize that there may be global cooling. The emphasis of this paper will be on greenhouse warming, recognizing that there are diverse scientific views. See the National Academy of Sciences, Policy Implications of Greenhouse Warming (Washington: National Academy of Sciences, 1991) . Some states share these concerns. See the New York State Energy Office, Draft New York State Energy Plan, Executive Summary, July 1991.

2. Others have labeled this the "bootstrap" approach. See Stephen H. Schneider, Global Warming: Are We Entering the Greenhouse Century? (San Francisco: Sierra Club Books, 1989).

3. The "no regrets" approach has been characterized as follows: "Reducing pollution now makes sense whether or not global warming occurs. And at the end of the decade, with the benefit of more information and new technologies, the U.S. could decide whether more aggressive actions were warranted." New York Times, May 25, 1992, p. A16.

"The Administration's approach, reasonable in principle, is to adopt multi-purpose measures that enhance the environment or energy security while also reducing greenhouse emissions. That way there will be 'no regrets' even if global warming proves a false alarm.

But in practice the Administration is doing far less than is should. . . Its failure to propose a 'no regrets' carbon tax, the strongest weapon available, shows more commitment to rhetoric than results." New York Times, May 24, 1992, p. E10.

4. Our analysis of this "no regrets" approach does not imply an endorsement of it. If the effects of current actions are irreversible, waiting for uncertainties to be resolved may impose considerable costs. More generally, see Schmalensee, "Comparing Greenhouse Gases for Policy Purposes," The Energy Journal, Vol. 14, No. 1 (1993), pp. 245-255, for a recent perspective on these issues.

5. National Academy of Sciences, Policy Implications of Greenhouse Warming (Washington: National Academy Press, 1991) , p. 73.

6. Some other omitted cost categories are those related to the following: urban vehicle congestion due to non-pricing of road use during peak hours; overbuilding (from an economic perspective) of housing (and hence overuse of heating and cooling) due to the home mortgage deduction; possible overuse of energy due to the inclusion of costs for energy-using utilities in the rents charged for many apartments; possible overuse of highways to haul freight in heavy trucks that may not pay the full cost of the damages they cause to the highways; and possible adverse effects of dependency on foreign oil on U.S. trade policy. An issue arises as to what extent some of these externalities should be attributed to the general activity or the

energy source. The analysis also excludes total life cycle environmental costs and only examines costs associated with energy use. Total costs for the fuel cycle also are likely to be greatest for coal.

7. The main building blocks for our assessment are past U.S. Environmental Protection Agency (EPA) studies of the economic damages from environmental pollutants resulting from fossil fuel use that the agency prepares as part of its major regulatory initiatives. Although these estimates can clearly be debated and possibly refined, they have received substantial internal and public review since they provide the analytical foundation for U.S. regulatory policies.

8. It should be noted that the user fees should be regarded as only an initial approximation to such optimal fee levels. The theoretically correct user fee amount is based on a complex set of economic influences beyond the degree of refinement possible with available data. See Dennis Carlton and Glenn Loury, "The Limitation of Pigouvian Taxes as a Long-Run Remedy for Externalities," Quarterly Journal of Economics, 1980, pp. 559-566.

9. These studies in turn have sometimes relied on the academic literature, such as Lester B. Lave and Eugene P. Seskin, Air Pollution and Human Health (Baltimore: Johns Hopkins Press for Resources for the Future, 1978).

10. See A.L. Nichols, and R.J. Zeckhauser, "The Perils of Prudence," Regulation Vol. 10 (1986), pp. 13-24; Lester B. Lave,

cd. , Quantitative Risk Assessment in Regulation (Washington: Brookings Institution, 1982) ; and R.J. Zeckhauser and W.K. Viscusi, "Risk Within Reason, " Science Vol. 248, No. 4955 (1990), pp« 559-563.

11. This assessment of the social costs of energy embodies several simplifying assumptions. Most fundamental is that the focus of the study is on the total social costs of pollution, which will generally be lower than the social cost that firms must pay for the right to pollute. These environmental costs do take into account the role of compliance with existing regulations, but do not incorporate charges that firms now pay or will pay under EPA policies being implemented. Under the acid rain trading system, new firms in areas that have not attained their air quality standards are required to purchase permits for their pollution from firms that have reduced pollution by a comparable amount. These permit costs in effect will serve as a price that should be counted toward the firm's payment of its full social costs.

Even when there are no permit changes, there generally are EPA regulations that frequently impose requirements that are more stringent than would be dictated on economic efficiency grounds. The difficulty is that even stringent standards do not solve all of the economic problems. Firms will still be given pollution levels up to the standard for free. Indeed, all of the estimates in this study are based on an assumption of compliance with regulations. The focus is, however, on existing regulations, not

on all regulations that will emerge as a consequence of the new Clean Air Act. As a result, the incentive of firms to enter the industry will be too great. The appropriate economic solution to achieve an efficient outcome requires the use of some kind of system to augment regulations. The level of these fees will, however, be influenced by the stringency of current regulations -- a complication not incorporated in the analysis.

12. Darwin Hall, '"Social and Private Costs of Alternative Energy Technologies," Contemporary Policy Issues, 1990; Thomas C. Schelling, "Climatic Change: Implications for Welfare and Policy," Changing Climate, Report of the Carbon Dioxide Assessment Committee (Washington: National Academy Press, 1983); and Thomas C. Schelling, "Economic Responses to Global Warming: Prospects for Cooperative Approaches," in R. Dornbusch and J.M. Poterba, eds., Global Warming: Economic Policy Responses (Cambridge: MIT Press, 1991), pp. 197-221.

13. See Hall, op. cit. for a review of the literature on these effects.

14. These calculations also assume that compliance with existing EPA standards will achieve a 25 percent reduction in current pollution levels. The sensitivity of the results to this assumption is discussed in W. Kip Viscusi and Wesley A. Magat, "Interim Draft Report on Efficient Energy Pricing," Report to U.S. EPA, September 1991. To ensure comparability, the analysis uses 1986 as the reference year.

15. These estimates were based on information from the U.S. EPA, Office of Policy Analysis, Costs and Benefits of Reducing Lead in Gasoline, Final RIA, February 1985.

16. The underlying externality estimates are based on information from the U.S. EPA, Strategies and Air Standards Division, Regulatory Impact Analysis of the NAAQS for PM, Second Addendum, December 1986.

17. The basis for these estimates is the U.S. EPA, Office of Air and Radiation, Regulatory Impact Analysis of the NAAQS for Sulphur Oxides (Sulphur Dioxide), Draft Report, March 1988.

18. Resources for the Future, "The Health and Agricultural Benefits of Reduction in Ambient Ozone in the United States," December 1988.

19. National Acid Precipitation Program, Integrated Assessment question One Economics, June 11, 1990.

20. U.S. EPA, Office of Mobile Sources, Air Toxics Emissions From Motor Vehicles, September 1987.

21. This tax would be even larger if we knew the externalities for NO_x.

22. See William D. Nordhaus and Gary W. Yohe, "Future Carbon Dioxide Emissions from Fossil Fuels," Changing Climate, Report of the Carbon Dioxide Assessment Committee (Washington: National Academy Press, 1983); James M. Poterba, "Tax Policy to Combat Global Warming: On Designing a Carbon Tax," in R. Dornbusch and J.M. Poterba, eds., Global Warming: Economic Policy Responses (Cambridge: MIT Press, 1991), pp. 71-97; and William D. Nordhaus,

"Economic Approaches to Greenhouse Warming," in R. Dornbusch and J.M. Poterba, eds., Global Warming: Economic Policy Responses (Cambridge: MIT Press, 1991), pp. 33-66.

23. Council of Economic Advisors, Economic Report of the President, 1991, p. 375.

24. Robert Crandall, Controlling Industrial Pollution: The Economics and Politics of Clean Air (Washington: Brookings Institution, 1983).

25. Uncertainty is an inherent component in other risk regulation contexts as well. See Richard Wilson and E.A.C. Crouch, "Risk Assessment and Comparisons: An Introduction," Science, Vol. 236 (1987), and A.J. Krupnick and P.R. Portney, "Controlling Urban Air Pollution: A Benefit-Cost Assessment," Science, Vol. 252 (1991), pp. 522-528.