



***The World's Largest Open Access Agricultural & Applied Economics Digital Library***

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search  
<http://ageconsearch.umn.edu>  
[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from AgEcon Search may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

*No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.*

## **The Second-Best Use of Social Cost Estimates**

Dallas Burtraw and Alan J. Krupnick

Discussion Paper 96-29

August 1996

Resources for the Future  
1616 P Street, NW  
Washington, DC 20036  
Telephone 202-328-5000  
Fax 202-939-3460

© 1996 Resources for the Future. All rights reserved.  
No portion of this paper may be reproduced without  
permission of the authors.

Discussion papers are research materials circulated by their  
authors for purposes of information and discussion. They  
have not undergone formal peer review or the editorial  
treatment accorded RFF books and other publications.

## **The Second-Best Use of Social Cost Estimates**

Dallas Burtraw and Alan J. Krupnick

### **Abstract**

A significant literature has developed to estimate the damages to third parties from new electricity generation technologies. This paper focuses on *how* such estimates can be profitably used in the present regulatory environment, and in the potential new environment that may result from restructuring in the electricity industry.

**Key Words:** electricity, environment, social costs, adders, externalities

**JEL Classification No(s):** H23, L94, L98

## **Table of Contents**

I	Introduction .....	1
II.	From Damages to Externalities .....	4
	Liability.....	7
	Compensation .....	10
	Tradable Permits and Fees.....	11
III.	From Externalities to the Second-Best Adder Policy .....	12
IV.	Implementation Issues .....	19
	A. The States and the Electricity Industry .....	20
	B. The Regional and Federal Roles .....	26
V.	Conclusions .....	30
	References .....	34

## **List of Figures and Tables**

Figure 1.	Extending the Damage Function Approach .....	3
Table 1.	A hypothetical comparison of generation technologies and regulatory settings ....	5
Table 2.	Examples of damages that may be internalized through various mechanisms .....	7
Table 3.	Best Estimates of Adjustment Factors for Three Service Territories by Customer Class .....	17



# The Second-Best Use of Social Cost Estimates

Dallas Burtraw and Alan J. Krupnick<sup>1</sup>

## I. INTRODUCTION

A significant literature has developed to estimate the damages to third parties from electricity generation technologies. The usual damage function approach that organizes most of this research traces the pathway from pollution at a source to the monetary cost of its measurable impacts. Relatively little effort has been directed to understanding *how these estimates should be used* to improve electricity resource planning or system operation,<sup>2</sup> either in the context of the present regulatory environment or in a restructured electricity industry. A first-best application of economic theory would counsel the substitution of emissions fees or tradable permits for current regulations over all polluting sectors to efficiently capture the external costs of pollution. Even these prescriptions are subject to a variety of second-best considerations. However, from the state viewpoint, where much of the initiative in social cost research has been evident, the best state regulators can do is to structure their regulations within the context of existing federal, and for the most part, state level environmental regulation.

This paper extends the damage function approach to consider three topics relevant for policy facing state and federal regulators that arise after, or are conditioned upon, attaining

---

<sup>1</sup> Dallas Burtraw is a Fellow, and Alan J. Krupnick a Senior Fellow, at Resources for the Future. The authors acknowledge the contribution of Karen L. Palmer, V. Kerry Smith and two referees, but all responsibility for contents remain their own. Address correspondence to: Resources for the Future, 1616 P Street NW, Washington DC 20036. e-mail: burtraw@rff.org or krupnick@rff.org.

<sup>2</sup> This does not include the debate about whether regulators should be involved in the estimation of damages, or whether such estimation can be done reliably by state agencies.

reliable estimates of environmental damage. Figure 1 displays these topics in relation to the usual illustration of the damage function approach, borrowed from the European Community study (1995),<sup>3</sup> and they are described in turn:

(i) *Damages to Externalities.* From an economic perspective the distinction between observable damages to third parties and externalities is essential because, in many cases observable residual damages are already partially or fully accounted for in the investment (and operating) decisions of firms. For instance, if a firm could credibly be held strictly liable and accountable for unlimited damages from environmental pollution, it would have the incentive to fully anticipate and account for damages *internally* in its investment decisions. In section II of this paper we explore the mapping from damage estimates to externalities, in light of several mechanisms through which damages already may be partially or fully accounted for.

(ii) *Externalities to Policy.* A number of states have adopted "adders" for use in resource planning. Adders are a monetary instrument like an emissions tax, except no revenue is collected. Instead, they serve as a shadow price representing society's opportunity costs that are external to the private financial decisions of the utility but that should be considered by the firm if it is to make socially beneficial investment decisions.

In principle, the adder that would be applied in a policy response is directly related to the estimate of externality. However, the regulatory environment involves a number of pre-existing policies and distortions from market efficiency, such as the divergence between price and marginal cost, the lack of such policies applied to electricity substitutes, and the distortions

---

<sup>3</sup> Executive Summary, Figure 1, p. 3.

**Figure 1.**

Figure is available from the authors sat Resources for the Future.

that accounts for most of the above effects and provides a straight forward approach for calculating the second-best efficient adder.

(iii) *Policy to Implementation.* Even given use of economically efficient second-best adders in utility decisions, there remain broader implementation issues. First is the question about whether the adders should be applied to investment or dispatch and whether consumers should see the price of electricity reflect the external costs. Expanding competition in the utility industry and the opportunity for customers to select among electricity suppliers may make it essential to address environmental issues through dispatch rather than investment planning. Second, important issues of federalism (or regionalism) emerge as long as the primary venue of social costing remains at the state level, while transboundary pollution and relative economic competitiveness among various states remains important. Federal guidance might help rationalize the practice of social costing, even if it continues primarily to be a state-level activity. Ultimately, competition in the industry might require the development of a new institution or perhaps the use of national emissions fees instead of state-level adders or other regulatory policies to internalize externalities. These issues are taken up in Section IV.

## **II. FROM DAMAGES TO EXTERNALITIES**

A first-best instrument would price energy services at their social opportunity cost. However, the application of social costing, as it is currently practiced, can be no more than a second-best instrument because many regulatory and institutional constraints prevent the electricity regulator from implementing such a policy. Instead, social costing has focused on

the choice of energy technology on the basis of least social cost, even if these costs are not fully reflected in prices.

To illustrate the approach of social costing we construct a hypothetical numerical example. Imagine there exists three technologies that can deliver identical energy services, as illustrated in Table 1. First we compare technology A which has a private production cost of 3 cents/kWh and B which has a cost of 9 cents/kWh. Technology A also has environmental effects, and is subject to command and control regulation which imposes an additional abatement cost of 5 cents/kWh. Note in passing that the environmental regulation of A is not economically efficient, since the marginal abatement cost is greater than marginal damage of 2 cent/kWh. The total private cost for A, the sum of production and abatement cost, is 8 cents/kWh, which is less than the private cost for the alternative. On the basis of private cost, technology A would be chosen, but on the basis of social cost, the 2 cents/kWh damage from residual emissions that occur in spite of existing abatement efforts would have to be considered also. The full social cost of A is 10 cents/kWh while the full cost of B is 9 cents/kWh, so on this basis technology B would be chosen.

**Table 1: A hypothetical comparison of generation technologies and regulatory settings**

cents/kWh	Technology A	Technology B	Technology C
<b>Production cost</b>	3	9	5
<b>Abatement cost</b>	5	0	2
<b>Residual environmental damage</b>	2	0	2
<b>Liability for damage</b>	none	none	full
<b>Private cost</b>	8	9	9
<b>Social cost</b>	10	9	9

The fact that existing environmental regulation of technology A is inefficient, in this case A is over-controlled from an efficiency perspective, is largely irrelevant to the social costing exercise at the state level. The state regulator is constrained to take the backdrop of environmental regulations as a given in considering the social costs of the alternative technologies for meeting an increment in electricity demand. However, the potential inefficiency of existing regulations suggests that social cost estimates could have a broader application in the reconciliation of federal and state policies, which we return to in Section IV.

Another alternative illustrated in Table 1 is technology C, which operates under preexisting federal legislation that imposes strict unlimited liability for environmental damage. Imagine that this damage is easy to monitor, and the firm is required to maintain financial certification that it is bonded against any possible damage consequence. In this case, C will have to consider residual environmental damage as a part of its internal financial decisions. One social benefit of its doing so is that it would lead the firm to adopt an efficient level of abatement, e.g., where marginal abatement cost equals marginal environmental damage. However, the internalization of the residual damage places C at a financial disadvantage compared to A when resources are considered only on the basis of private cost.

If the regulator or utility were to make a decision on the comparison of social costs, she would effectively be using an "adder" approach, by imposing a shadow price for environmental damages from each technology into the financial planning problem. This approach reflects efforts by state regulators who have opted to employ quantitative estimates of externalities.

However, the comparison in Table 1 illustrates that the state regulator would not want to apply damage estimates as adders to private cost without considering the regulatory

situations affecting various technologies. The normative criterion for the regulator is the degree to which observed damages constitute technical externalities. Under conventional command and control environmental regulation, observable residual damages to third parties are externalities because the firm is absolved of liability if it conforms with environmental standards. However, in a variety of other cases observed damages to third parties are at least partially reflected in the firm's private costs.

The column headings in Table 2 enumerate three processes that help internalize damages in private costs. The rows in Table 2 illustrate some potentially important categories of damage that, to some degree, are internalized through these processes.

**Table 2: Examples of damages that may be internalized through various mechanisms.**

<b>Damage Categories</b>	<b>Liability</b>	<b>Compensation</b>	<b>Tradable Permits and Fees</b>
Nuclear accidents	Price-Anderson Act		
Oil spills	Oil Pollution Act		
Occupational health and safety concerns	Black Lung Fund; Workers' Compensation	Wages	
Sulfur dioxide effects			Title IV of Clean Air Act of 1990
Damages to roadway surfaces			Road use fees on heavy trucks

### **Liability**

Strict liability can fully internalize the expected value of potential damages if there are no problems of detection, monitoring, enforcement or potential financial insolvency. Damage from accidents at nuclear facilities is one example that meets these criteria in part. The 1988 amendments to the Price-Anderson Act specify the strict and limited legal liability of individual nuclear operators for damages to third parties resulting from an "extraordinary nuclear occurrence" (ENO) associated with the operation of a commercial or government nuclear

facility. However the Act exempts operators from all liability for damages in *excess* of a specified limit. The Act requires that operators carry private insurance for up to \$200 million in damages which implies that the expected value of damages that may occur in the future up to this amount are reflected in the price of electricity produced with the nuclear fuel cycle. A second layer of coverage stems from an industry pooled liability of up to \$7 billion that does not require a financial contribution prior to the occurrence of an ENO. Hence the current price of electricity does not reflect the expected value of damages in this range. Thus, damages above \$200 million are not presently accounted for in the price of electricity.

Hagler Bailly (1995) consider Price-Anderson provisions to be a "no-fault" insurance policy, for which the insurance costs are internalized and hence the externality from nuclear accidents is assumed equal to zero. Lee, et al. (1995) considered the coverage of Price-Anderson to be only partial, in light of some of the problems mentioned above, and attempted to estimate the residual expected damages from an accident that are not internalized through insurance costs. They found an estimate of externality of between zero and 0.062 mills/kWh under alternative scenarios.

Another example of internalization through liability is the Oil Pollution Act (OPA). Again, limits on liability specified under OPA are a potential source of concern, but the resources available through the Oil Spill Liability Trust Fund, which is funded by the oil industry, supplement the liability of individual firms such that virtually all except the largest of possible spills would generate compensation sufficient to cover damages. However, concern about the assessment of damages is warranted with regard to small and intermediate sized spills. It is noteworthy that insurance rates have risen significantly in light of OPA and the

events preceding OPA involving the Exxon Valdez spill in 1989. This suggests that the liability provisions, including rules under OPA, have led to some internalization of expected environmental damages from potential spills.

A third example of the role of liability involves issues in occupational health and safety. Employer financial liability for these damages is explicitly capped through State Workers Compensation Programs, thereby limiting internalization of damages, other things (such as wage rates) equal. The determination of insurance premiums for employers is perhaps the most important component for our purposes, as it is the mechanism for internalizing damages from accidents and it provides incentives for firms to reduce their accident rates. The smallest firms, which constitute 85% of all employers but only 15% of covered employment, have no experience rating and face absolutely no incentive through the premium calculation procedure to reduce the incidence of occupational accidents. However, larger firms are experience-rated, with the premium modified to reflect the firm's own past loss experience.

Employer contribution to special government benefit programs, such as the federal Black Lung Benefits Program, is another manner in which occupational health and safety damages may be internalized. However, the major source of revenue for the program is an excise tax on mined coal sold or used by producers. The tax is imposed on a per ton basis, with no experience rating for the black lung claims previously filed against the operator. Lee, et al. conclude that occupational health and safety damages in mining are probably not internalized fully in coal prices, but that there is insufficient basis upon which to compose a quantitative estimate of the shortfall. They conclude that occupational damages in fuel transportation and electricity generation are probably internalized. Hagler Bailly exclude

damage estimates for occupational damages for acquisition of fuels in their study assuming they are small, or likely to be internalized, with the exception of cancers from operation of nuclear facilities. The E.C. study estimated occupation health damages for the entire fuel cycle, but did not address whether these damages are internalized partially or fully.

## **Compensation**

According to economic theory, the primary mechanism for internalization of occupational health and safety damages should be through increased labor compensation. In a competitive labor market wages and benefits, taken together, will adjust so that at the margin workers are indifferent between more risky jobs and associated higher wages or benefits, and less risky jobs that will have lower wages or benefits (Rosen, 1986; and Moore and Viscusi, 1990). Studies have found that workers in occupations or industries with higher rates of fatalities and injuries do indeed earn risk premiums.<sup>4</sup> Unfortunately, while the empirical literature has been concerned with demonstrating the existence of a positive compensating wage differential, we are concerned with the degree to which wage differentials fail to compensate adequately for damage.<sup>5</sup> In terms of the familiar metaphor of a half full/half empty glass of water, the literature has measured how far the glass is from empty. There are several reasons why labor markets may fall short of the competitive ideal, causing one to view the

---

<sup>4</sup> For example, Viscusi (1979) found that within a sample of blue-collar workers, market-generated compensation for fatality risk averages almost \$1,000.

<sup>5</sup> "It is only fair to note, however, that these results do not prove that risk is allocated efficiently by the labor market. Rather, they indicate that complete market failure does not necessarily exist," (Moore and Viscusi, 1990, p. 15). See also Dillingham (1985) and Dickens (1990) for general critiques.

glass as less than full, including immobility of labor, faulty or incomplete information and risk perceptions, and the monopsony influence of a single high-wage industry in a region.

### **Tradable Permits and Fees**

A third process that serves to internalize damages is incentive-based environmental regulation, such as tradable permit or emission fee programs. Title IV of the 1990 Clean Air Act Amendments (CAAA) instituted a tradable permit program for sulfur dioxide (SO<sub>2</sub>). Since each new source of emissions under the program must receive a permit from an existing source, the net damage is simply the difference in environmental damage from emissions at a new source and an existing source that is the supplier of permits (Freeman et al., 1992; Hobbs, 1992). Net damage for SO<sub>2</sub> trades may be negative for the majority of trades, since allowances are expected to flow from the midwest, where reductions in emissions would be relatively important, to the south, where damage from new emissions might be lower, primarily because prevailing winds push pollution out to sea (NAPAP, 1991). Hagler Bailly and Lee, et al. take similar approaches in characterizing net damages in this fashion.<sup>6</sup>

Emission fees are not common in the U.S. context (the relationship between damages and externalities was not considered in the E.C. study), but other types of fees may be. One example is damage to roadway surfaces from transportation of fuel in heavy trucks. Heavy

---

<sup>6</sup> The Hagler Bailly study acknowledges that, in general, the location of the seller will not be known. Hence, they assume that the region around the location of the seller has an average population density of 38 persons per square kilometer. Therefore, the net effect of the trade is to increase damage if population density in the buyer's location exceeds 38 people/km<sup>2</sup> and to decrease damage if density is less. The Lee, et al. study takes a more targeted approach, estimating population density for states with likely sellers of allowances. The density of areas likely to be supplying allowances is 112 people/ km<sup>2</sup>, or almost three times that used by Hagler Bailly.

trucks impart more than 95% of the damage to roadway surfaces, according to a variety of studies. Potentially offsetting this damage are the use fees that are paid by heavy trucks. Roadway damage that can be attributed to fuel transportation should be adjusted to reflect that portion internalized through fees. Hagler Bailly assume this figure to be ten percent for transportation of coal in New York State. Lee, et al. calculate a range from 10-40% for coal transportation.<sup>7</sup>

### **III. FROM EXTERNALITIES TO THE SECOND-BEST ADDER POLICY**

An important issue in the realm of the second-best is the interaction between regulatory policies and the existing tax system. Any policy that raises price effectively lowers the real wage, and consequently can be thought of as an additional tax added on top of preexisting taxes. The price effect has the potential to induce changes in the supply of labor in the economy, as workers consider a substitution away from labor to leisure. An additional tax of even a small magnitude has the potential to impose significant additional deadweight costs on society if it induces even a small change in labor supply, due to the already sizable difference between the opportunity cost of labor supply and the cost to the firm. Several recent studies have found this issue to have significant effects on the economically efficient level of environmental regulation, leading to the calibration of emission taxes at significantly less than

---

<sup>7</sup> However, Lee, et al. found that in some cases road fees paid for transporting biomass may exceed the damage biomass trucks impose on roadways. Biomass trucks are not as heavy as coal trucks, while damage varies exponentially with weight per axle. Following the logic that road fees internalize some portion of damages, then when fees exceed damages the net effect should count as a benefit. This raises the issue of how to treat tax consequences, in general, when ranking alternative generation technologies according to social costs (see Krupnick and Burtraw in this volume).

Pigouvian (first-best) levels that would be prescribed by usual partial equilibrium analysis.<sup>8</sup>

The use of adders has a trivial effect on prices compared to emission taxes; nonetheless, the tax-interaction effect should remain potent. Heretofore this issue has not been studied in the context of electric utility regulation.

Another second-best issue that has attracted attention concerns the possibility for consumers to alter their consumption behavior in ways that should be anticipated by the regulator. The effect of changes in price have two implications for social costs in this regard. First, customers may seek alternative sources of energy services, which themselves have environmental consequences. This substitution effect could be negative or positive. For example, a higher electricity price may entice a residential customer to heat with wood instead of electricity, which would have adverse environmental effects of its own that are not reflected in the estimates of externality associated with electricity. Alternatively, a large industrial firm may decide to reallocate production away from the service territory of a utility subject to social costing and toward an area with lower electricity prices; or, under future regulatory structures now under consideration, it may opt to contract directly for supply from nonutility generators or utilities located out of state. Second, the regulatory-induced wedge between price and marginal cost may be altered, depending on conditions in the utilities service territory and regulatory behavior.<sup>9</sup>

Freeman et al. (1992) and Burtraw and Krupnick (1992) acknowledged these potential issues, but concluded that a useful rule of thumb from the point of view of a PUC who must

---

<sup>8</sup> See Goulder (1995), Oates (1995) and Parry (1995) for introductions to this literature.

<sup>9</sup> See Tschirhart (1994) for a graphical exposition.

take environmental policy as a given, is to calibrate "adders" equal to estimates of externalities. For example, in Table 1, this would suggest that the adder on Technology A would be set equal to 2 cents/kWh.

Subsequent research has shown that this rule of thumb fails to achieve efficiency in general. With deviations in price from marginal costs of production, and with customer opportunities to bypass the utility system, the second-best efficient adder may differ substantially from the estimate of externality. Burtraw et al. (1995) constructed a normative model to investigate the efficient allocation of electricity production between two technologies in the context of deviation of price from marginal cost and the opportunity for customers to reduce electricity consumption and obtain energy services from unregulated sources, when regulators employ average cost pricing for the regulated industry. The model relates the efficient adder to exogenous estimates of externalities, through a formula that depends solely on information that, in principle, is observable and available to regulators. They find the greater the elasticity of demand and the greater the difference between price and marginal cost, the more the efficient second-best adder will deviate from externality estimates.

The reduced form expression that is obtained from the model provides a functional relationship between the second-best efficient adder and estimates of externality, of the form given in equation (1). The adder  $\alpha^j$  on technology  $j$ , defined as \$/kWh of production, depends linearly on externalities  $e^j$  from  $j$ , also defined as \$/kWh, but is modified by an adjustment factor  $F$  common to each technology reflecting second best aspects of the social welfare problem. The adjustment factor incorporates information about the price of electricity, the difference between price and marginal cost, the quantity of energy services provided by the

regulated and unregulated sources, the externalities associated with an arbitrary reference technology for the regulated sources, the externalities associated with the unregulated source, and the cross-price elasticity between unregulated sources and the regulated price of electricity.<sup>10</sup> As the adjustment factor varies from the number one, the second-best efficient adder will vary from externality estimates.

$$\alpha^j = F \cdot e^j \quad (1)$$

where:

$$F = \frac{\varepsilon^w \left( 1 - \left( \frac{c^y}{p} \right) \right) + 1}{\frac{\varepsilon^w}{p} e^y + \frac{u \varepsilon^{u,p}}{w p} e^u + 1}$$

and:

$\alpha^j$  = second – best optimal adder on technology  $j$

$e^j$  = externalities from technology  $j$

$\varepsilon^w$  = elasticity of demand

$c^y$  = marginal cost of arbitrary reference technology  $y$

$p$  = regulated price of electricity

$e^y$  = externalities from technology  $y$

$u$  = quantity of unregulated energy services consumed

$\varepsilon^{u,p}$  = cross - price elasticity of unregulated supply

$w$  = quantity of regulated electricity consumed

$e^u$  = externalities from unregulated energy services

---

<sup>10</sup> In fact the model has one degree of freedom because it is only the *difference* between adders that matters in the resource planning process. Any one adder can be set arbitrarily, and then the left-hand side of equation (1) becomes the difference between the adder for technology  $j$  and this adder, while the right-hand side involves the difference between the externalities for technology  $j$  and those for the technology with the arbitrarily chosen adder.

The numerator of the adjustment factor reflects the efficiency cost of deviation between the price of electricity and the marginal cost of the reference technology  $y$ . For illustration, if price ( $p$ ) equals marginal cost ( $c^y$ ), the numerator in the expression is one.<sup>11</sup> If the denominator were to equal one, then the adder on  $j$  would be precisely equal to the externality from  $j$ . If the denominator equals one and the price is less than marginal cost, then the term in parenthesis in the numerator is negative. Elasticity of demand is also negative, so their product is positive. Adding this positive product to one causes the adjustment factor to be greater than one, and the adder to be greater than the measure of externality. Hence the adjustment factor accounts for the efficiency cost of the difference between price and marginal cost. The numerator is positive unless demand is very elastic and the marginal cost of  $y$  is less than the price of electricity.

The first term in the denominator includes the elasticity of demand for electricity and the marginal damage of output from the reference technology. The second term in the denominator includes the cross-price elasticity of demand between regulated and unregulated supplies of energy services and the externalities associated with the unregulated supply. This reflects the potential for driving customers away from regulated supplies of electricity. If the cross-price elasticity is large and the externalities from unregulated supplies are large, then this term will be large. This will tend to reduce the adjustment factor and the adder. Under usual conditions, the denominator is positive. Hence, typically the efficient adder for  $j$  moves positively with externality estimates for  $j$ , as intuition would suggest.

---

<sup>11</sup> Assuming a constant emission rate the cost function for technology  $y$  is  $K(y, \sigma^y y)$  so the marginal cost is  $K_y + K_e \sigma^y$ .)

Burtraw, et al. (1996) extend the model by incorporating multiple customer classes, multiple options for customer bypass, and multiple types of environmental costs, and they apply the model to three representative utilities in different regions of the country that face different environmental challenges and technological options, which are reproduced in Table 3. A "neutral" estimate of the adjustment factor would have a value of one, implying the efficient adder is equivalent to the estimate of externality. Table 3 indicates the estimates vary considerably around this value.

**Table 3: Best Estimates of Adjustment Factors for Three Service Territories by Customer Class**

	Residential	Comm./Industrial
<b>Southern Utility</b>	1.152	1.129
<b>Mid-Atlantic Utility</b>	0.886	0.965
<b>Northern New England Utility</b>	1.024	1.791

Adjustment factors in the Southern reference environment are greater than one largely because the use of substitute energy technologies has fewer externalities than those associated with generating electricity using the reference technology. The price of electricity exceeds the marginal cost of delivered electricity generated with the reference technology, which tends to lower the adjustment factor, but this effect is dominated by the externalities of the regulated generation. The adjustment factors in the Mid-Atlantic service territory are less than one because the price of electricity exceeds the marginal cost of generation with the reference technology. In this case, the externalities associated with the utility's own resource option and the consumer's substitution possibilities are approximately equal. The adjustment factors for

the Northern New England Utility are greater than one despite the fact that the alternatives to electricity are relatively dirty. In this example the price of electricity is less than the marginal cost, particularly for commercial and industrial customers, indicating that electricity is underpriced from the viewpoint of economic efficiency. A larger adjustment factor leads the utility to invest in technology that has a higher marginal cost, which indirectly serves to modify the price-marginal cost difference.

The empirical application finds that (a) when price is less than marginal costs the adder should exceed externalities, reflecting the benefits to society of raising prices to better reflect social opportunity costs; (b) if it is easy to substitute away from the electric system and the externalities from unregulated supplies are large, the efficient adder should be less than externalities; and (c) the marginal cost pricing effect dominates the other effects for the utility systems examined and the generally "low" estimates of externalities chosen.<sup>12</sup> The fact that the marginal cost pricing issue imposes a greater influence on this outcome than does bypass is promising because planners are likely to have more confidence about price and marginal cost data (although there is much debate about costs) relative to other parameters in the model. The own price elasticity of demand for electricity also is a critical determinant of the efficient adder. In contrast, information about cross-price elasticities and externalities stemming from bypass options exert relatively little influence on the efficient adder, except when especially large externalities are associated with alternative energy sources (as may be relevant were climate change effects included).

---

<sup>12</sup> The externality estimates are large compared to recent social cost studies, but they exclude global warming.

In general, setting adders equal to externality estimates will fail to achieve economic efficiency from the perspective of second-best policy making. The relative difference between efficient adders and the externality estimates are 10-20% or more in the case studies that were examined. These results illustrate that under current regulatory structures, given the resources that would be required to generate meaningful externality estimates, further efforts to make second-best adjustments to these estimates to account for the marginal cost pricing and bypass issues are likely to yield significant benefits at relatively low cost.

How might these results be affected by restructuring? Greater competition is likely to lead to a convergence of price and marginal cost of electricity. This would seem to lessen the need for an adjustment to externality values. However, Burtraw et al. (1996) find that narrowing the price-marginal cost difference may lead the adjustment factor to diverge further from one, depending on the relative environmental externalities from substitute sources compared to regulated sources of electricity. Further, restructuring is also likely to enhance the menu of options available to consumers, and to result in greater own and cross-price elasticities of electricity demand. In this case sensitivity of the efficient adjustment factor to environmental externalities would be heightened. Coupled with the possibility of large externality estimates from global warming, the adjustment factor could remain significantly different from one even in a restructured electricity industry.

#### **IV. IMPLEMENTATION ISSUES**

Even assuming that second-best adders can be calculated, they still must be implemented through government policy decisions, as private firms would have no incentives

to implement such adders on their own. In this section, we consider options for state and federal policy interventions. Keep in mind, however, that the appropriate character of these interventions is endogenous to the evolution of the electricity industry, in the sense that the interventions depend on as well as shape the form that restructuring will take.

#### **A. The States and the Electricity Industry**

Currently, 16 states require their utilities to use adders or other quantitative methods of accounting for externalities in their planning decisions.<sup>13</sup> In addition, some states have announced their intentions to continue special regulatory authority of polluting activities, conservation efforts and the development of renewable energy irrespective of the type and pace of changes in industry structure. However, with less control over resource planning through the IRP process, new processes or institutions will be needed to accomplish this. For instance, regulators may need to consider incentives and subsidies or renewables rather than central review and control of investment planning.

There is a lively conceptual and simulation literature that has developed on the efficiency consequences of implementation of social costing by the state PUCs under the current structure of the industry (Sheffrin (1992); Andrews (1992); Walther and Jurewitz (1992); Bernow, Biewald and Marron (1991); Wood and Naill (1992); Palmer and Dowlatabadi (1993); Palmer et al. (1995), Dodds and Lesser (1994)). These papers are not

---

<sup>13</sup> Thirty-two states consider environmental issues formally in an IRP process. (National Association of Regulatory Commissioners, 1995.)

irrelevant for a restructured industry, however, because by and large they assume that firms minimize costs, which may better describe firm behavior in the new regime than in the old.

These papers conclude that primary approach to the consideration of social costs by utility regulators -- *least social cost planning* (which restricts the use of adders to the choice of new generation technology) -- suffers from an anti-new source bias and may poorly predict the changes in system-wide emissions after the plant comes on line. Such considerations apply to a restructured industry as well. The anti-new source bias comes about by permitting external costs to modify the ranking of alternative new investment decisions while leaving dispatch decisions to be made with respect to private costs. With this system, new construction is likely to be delayed and a new plant that is chosen is likely to have higher private costs than a "dirtier" plant that otherwise would have been chosen. This latter effect means that the relatively clean new plant may be dispatched less than the dirtier new plant would have been. With existing, perhaps relatively dirty, sources dispatched more than they would have been, emissions from these plants may increase by more than what would be saved by choosing a cleaner new investment option.<sup>14</sup> Thus, social welfare could be lower with this particular form of social costing than without it.

These papers also conclude that by ignoring the environmental effects of a new generation investment on dispatch of the utility system and its imports and exports of power,

---

<sup>14</sup> Palmer and Dowlatabadi (1993) examined this issue with a dispatch model of a hypothetical midwestern utility and found, using illustrative "adders," that the private cost differentials between alternative generation technologies were so large that only very large adders affected investment decisions. They further found that even when investment decisions were affected, the new source bias effect and the perverse effect on emissions was small.

the analysis of external costs can miss capturing the changes in the quantity, timing, and location of emissions in a region when a new plant comes on line. Thus, they advocate what is termed *least social cost dispatch* -- where a utility has to consider the complete social cost of each kWh of electricity generated (Heslin and Hobbs, 1989; Bernow, Biewald, and Marron 1991) but not reflect such costs directly in electricity prices. Indeed, Palmer, et al., 1995 show that the dispatch approach applied to a Maryland utility results in about a two cent/kWh lower social cost (out of a total social cost of 12.1 cents/kWh) than a planning approach in 2008<sup>15</sup>

Implementing least social cost dispatch would put a very high burden on a social costing model to the extent that damages from a marginal unit depend on which inframarginal units are also dispatched. Absent such interdependence, damage estimates by unit and class of meteorological conditions could be calculated "up front." Our companion paper in this volume (Krupnick and Burtraw, 1996) provides a simple approach to calculating damages when interdependencies and nonlinearities can be ignored. However, with severe interdependency (i.e., non-linearity) the dispatcher must solve an interdependent system of equations for the least social cost combination of generating units in every time step.

A third form of social costing, called *least social cost pricing*, would not only dispatch all units according to social costs, but would price the electricity at its social costs. This has the benefit of confronting energy users with the "true" costs of their electricity consumption, thereby discouraging consumption and saving on scarce environmental resources.

---

<sup>15</sup> For instance, the simulations show that the size of the benefits is very sensitive to the size of the adders and the estimation approach does not incorporate the effects of using adders on the overall customer base (although it does account for price induced changes in electricity demand).

Surprisingly, however, as Palmer et al. 1995 shows, the efficiency gains over a least social cost dispatch approach are trivial, only about 2 mills. This small difference is, in part, a function of the much larger price impact of a pricing approach. Had customer flight also been modeled, as would be appropriate for a restructured industry, this difference would have been narrower still or even negative, particularly if pricing were applied only to electricity produced by a single utility and other energy options produced relatively high emissions.

These findings suggest that there is a role for governments in forcing the industry, however it is restructured, into accounting for its environmental externalities at least at the dispatch stage and that it might not be worthwhile to push for social cost pricing, if elements of piecemeal implementation persist. Unfortunately, none of the papers in the literature place social cost implementation in a setting with retail wheeling or other possible features of a competitive electricity market to provide guidance on how this might be accomplished.

We can distinguish two broad models of the future of the industry -- a centralized pool system and bilateral contracting. The pooling model implies that short-term electricity supply (dispatch) will continue to be centrally coordinated, either by an expanded power pooling authority or by a centralized power spot market.<sup>16</sup> Consequently, there will be a regulated entity to administer and enforce a social costing program should it be judged desirable.<sup>17</sup>

---

<sup>16</sup> Under a retail wheeling model, only a portion of the electricity generators within the system would be available for central dispatching thereby limiting the scope for social cost dispatch under such a model.

<sup>17</sup> One reason it might be desirable to do so is the forecast by many observers that competition which accompanies restructuring may lead to greater utilization of relatively older and dirtier coal-fired facilities. Currently 56 percent of the existing electricity capacity in the U.S. burns coal, so the impact could be substantial. Lee and Darani (1995) find that changes in fuel utilization, especially substitution of coal for gas, will have the largest effect on air emissions of any factor resulting from restructuring which they studied.

What would a social cost dispatch system look like under a pooling arrangement?

First, to minimize the piecemeal problem the system should include all generators and electricity users who use transmission resources. Any generator who uses such resources would be subject to the social cost dispatch program even if the bulk of its power is sold through direct retail access contracts. Second, generators offering electricity for sale would report their reservation price (their minimum price to sell power). They also would report their emission rates for power taken from each unit, and other information relevant to estimating damages, such as fuel quality and stack parameters. Third, a computer model would be provided to the dispatcher to calculate, on a time step matching changes in physical/meteorological conditions, the external costs associated with each marginal unit potentially dispatched. This cost would be added to the reservation price which the dispatcher would then use to dispatch electricity in order from the lowest social cost reservation price to the highest until demand is met. As the price of electricity is not adjusted for external costs, some generators may not have their bid accepted even though the spot price exceeds their (private) reservation price. If the industry adopts bilateral contracting, it may be more difficult to structure a workable *dispatch* approach. Thousands of independent contracting agreements to provide power according to various conditions would need to be monitored and enforced, except where power transactions require access to the transmission grid. It may be possible to specify conditions under which adders could be used in such markets. Imagine (i) all bilateral contracts for power were registered with the state PUC, and (ii) sellers were required to report their full private and social costs in their offers, utilizing a methodology sanctioned by

regulatory bodies and subject to review by their competitors. Then sellers would be chosen on the basis of full costs, though payment may be based just on private cost.<sup>18</sup> However, such a scheme could be marred by numerous subtle provisions regarding dispatchability, reliability, etc. that could be used to obfuscate the regulator's intention that the buyer select a supplier on the basis of least social cost. Numerous commentators have observed that proper pricing of access to transmission might involve charging steep access fees to parties relying on the grid only for back-up services, while otherwise relying on bilateral contracts independent of the grid. However, these access fees may not provide a practical mechanism for providing incentives over the *choice* of technologies in the bilateral arrangements that do not make use of the grid or in dispatch decisions.

Another option, one that, from an efficiency perspective, dominates those applied to either the pooling or bilateral contracting models, is the *first-best* instruments for internalizing environmental externalities -- a broad-based set of emissions fees or tradable emission permits that would apply, at a minimum, to all energy sectors.<sup>19</sup> These instruments could be applied by a state, a regional body, or the federal government. More will be said about these instruments below.

---

<sup>18</sup> We are grateful to an anonymous referee for this specific suggestion.

<sup>19</sup> These policies are first-best in the sense they supersede existing environmental regulations. They retain second-best characteristics with respect to other governmental policies including the tax system.

## **B. The Regional and Federal Roles**

Irrespective of the evolution of the structure of the electricity sector, there is a need for a regional and federal role in appropriately addressing environmental and other types of externalities. In addition to developing institutions appropriate to the geographic scale of the problem, the federal role includes coordinating state or regional policies and providing common methodologies for state and regional bodies to use in estimating second-best adders or other methods for capturing externalities.

Some government role is justified by the existence of transboundary effects of pollution. Transboundary effects are a type of piecemeal problem associated with incomplete incorporation of externalities across geographic space. To the extent that air pollution problems dominate, these problems are interstate. Thus, the government authority needs to have interstate jurisdiction. The Ozone Transport Commission, set up by the Clean Air Act of 1990, to address ozone problems in the northeastern U.S., is an example of an organization that presumably could design and implement social cost dispatch policies.

The states, for their part, can obviate the need for higher level governments to get involved by taking a cooperative approach or they can hasten intervention by taking a self-interested position. That is, they can count only damages to the residents of the state or count damages to neighboring states, to the entire U. S., or even to the world. Fortunately, to date states have generally acted altruistically in the social costing arena, but historically they have appeared less altruistic concerning issues such as transboundary sulfur deposition and economic development.

These behaviors highlight another role for regional institutions or federal involvement--reducing pernicious interstate competition for economic development. Treating all transboundary effects as costs may have unfortunate consequences related to economic development. Not only may ratepayers as a whole pay more than the benefits that accrue to the state from the consideration of all costs, but this approach may exacerbate the problems of bypass or industrial flight. If a noncaptive customer decides to bypass the utility's system it may have the opportunity to capture the environmental benefits of the utility's benevolent policies and avoid the cost, even achieving a cost advantage compared to its competitors. The model introduced in Section III offers a way to quantify and incorporate these issues in the decisions of state regulators acting individually. However, the point of this discussion is that regulators acting individually are the source of particular strategic and coordination problems. Consequently, from an economic perspective one can complain legitimately that the states are an inappropriate forum for addressing transboundary issues such as global warming and even regional impacts, absent some mechanism for coordinating state policies.

The federal government or new regional institutions might help to coordinate the policies between state regulators, i.e., to develop reciprocal agreements to consider spill-over of environmental and potentially nonenvironmental externalities. Such coordination is clearly needed. In some cases the affected states in such transactions have proposed the application of vastly different values for associated damages. The most controversial of such proposals was the California PUC's suggestion that social cost adders developed for damages caused by power generated within California be applied to all transactions that import power from out of state; use of such damage estimates where they obviously do not apply (i.e., Nevada) is unlikely

to be efficient. A serious problem of popular perception about California or other populated areas "exporting their pollution" seems to preclude regulatory policy from using differentiated values, even though the analytical foundation for damage values differentiated by geographic and demographic characteristics is amply illustrated in other papers in this volume.

There is also a role for information provision to improve and help standardize methods for estimating damages and externalities. Note that we do not advocate, in general, Federal efforts to estimate these costs for the States themselves. Agreement on a common set of values for emissions occurring in different locations is not appropriate.

A final option for a federal or regional role involves scraping the social costing approaches entirely in favor of an emissions fee or tradable permit system. From the perspective of the social costing debate, a benefit of emissions fees (or tradable permits) at the federal level is that they represent a mechanism for overcoming many of the piecemeal problems posed by social costing that would be exacerbated by increased competition. If the umbrella of emissions fees were broad enough it could cover most of the possible pollution that could result from substitutions by consumers between alternative forms of energy. The piecemeal problem would not be entirely solved, however, unless the possibility for substitution between energy and other factors of production was also covered under this rubric.

A full consideration of the relevant issues suggests it would be a major challenge to create an appropriate system of fees or tradable permits. In theory, such a system should, at a minimum, cover the major pollutants in all media and from all major sources including area, mobile, and point sources. The interdependence of sources on one another might suggest that

a general equilibrium model with spatial and temporal characteristics would be needed to drive any damage estimation model.

However, in practice it may be possible to obtain most of the benefits from such a ideal system through a considerably less complex approach. First, one can imagine creating one or more "model" sites that are "average sites" at a national or regional level. For this approach to be credible, damage functions would need to be linear, or approximately so. Greater geographic resolution could be achieved by constructing less aggregated model sites. Approaches such as these are implicit in the SO<sub>2</sub> emission allowance trading program and in the RECLAIM program in Southern California.

If linearity is not an acceptable assumption, then locational differences cannot be averaged because marginal damages are different depending on baseline conditions. In this case one might characterize "representative" sites, not necessarily in the same geographic location, that share common features critical to the analysis. The geographic information system (GIS) may provide a means to obtain the requisite baseline information needed to estimate local or regional damages. The least tractable option is to explicitly estimate the damages and benefits at *all* sites. One can imagine making simplifying assumptions to make this analysis possible, such as assuming that a particular policy will affect the output of all firms in the same way, without regard to their current location.

The greater the number of sites and technology options, the more challenging the informational and analytical requirements of the analysis. The *first* major challenge is compiling data on the technologies and fuel cycle activities; on the population and ecosystems at risk; and on other site-specific data such as meteorological information and the background

concentrations of pollutants. As demonstrated by the social costing studies reported on in this volume, the challenge is surmountable but resource-intensive, especially as the number of alternative sites increases. As implementation of the damage function approach becomes more common, its data needs will be addressed more efficiently.

## **V. CONCLUSIONS**

Social costing, as it has taken shape in federal and state venues over the last few years, has served as a thorough and path-breaking accounting exercise, resulting in the collection of scientific and economic information about the various impacts on third parties that may not be properly reflected in utility decisions, from the perspective of economic efficiency.

This paper addresses *how* such estimates can be used to improve resource allocation in the utility industry, with attention to special issues raised by a restructured industry. Our point of departure is the observation that state regulators can not hope to implement a first-best application of these social cost estimates through Pigouvian pricing, for example, due to a variety of preexisting institutional constraints. Consequently state regulatory policy, and to some extent the possible federal policies that we explore, are firmly rooted in the realm of second-best policy making.

The second-best issues we explore all stem from the exercise of choice by economic agents who are expected, according to economic theory, to adjust their behavior in response to changes in policies and prices by substituting toward options that impose less cost on themselves. Firms are expected to minimize costs by substituting among technologies in

response to the internalization of environmental effects.<sup>20</sup> Consumers are expected to substitute among electricity and other forms of energy services, including unregulated supplies, in order to minimize their costs. Further, as we enter an era of open transmission access and industry deregulation, retail utilities, large firms and ultimately perhaps individual households will be able to select among generators of electricity according to features important to them, including price. This paper extends the usual damage function approach through consideration of this general opportunity for substitution, which affects not only the implementation of policy, but also the measurement of impacts and damages. The paper provides guidance for how to make the most of social cost estimates within this second-best setting.

First, we illustrate that damages to third parties are not necessarily externalities. A variety of regulatory backdrops sometimes provide mechanisms -- such as strict liability and incentive based environmental regulation -- serve to internalize the costs of damages in private financial decisions of firms. Further, in the important category of occupational health and safety damages, if the labor market functions according to the theoretical ideal, compensating wages and benefits serve to internalize damages in firms' decisions. Our main point is that these mechanisms work to some degree in these settings, but usually they do not work flawlessly or completely. Nonetheless damage estimates should be amended to reflect the role of these institutions where they apply. In the majority of cases involving environmental issues, however, the relevant environmental laws are command and control in nature, exonerating

---

<sup>20</sup> In principle, affected parties also have the opportunity to substitute through averting behavior away from activities that expose them to impacts, thereby lessening the measure of damage (Mohring and Boyd, 1971; Oates, 1983). We have not incorporated this aspect explicitly because for the most part such opportunities are expected to have been exercised.

firms from liability for residual emissions that occur. Hence, at least a portion of the estimated damages are externalities.

Second, given that externalities are properly estimated, state social costing policies can produce important unintended consequences stemming principally from the narrow application of social costing to just the electricity industry. If social cost policies alter the resource mix, they will affect prices and the difference between price and marginal cost for regulated firms, and thereby consumer demand for other sources of energy services which have their own environmental impacts. These potential unintended consequences are consistent with basic theory which suggests that any thing *may* happen when implementing policies in a second-best setting. However, regulators can go a long way toward controlling what *will* happen by anticipating and accounting for these possibilities. We summarize an estimable model that can be used to calibrate adjusted shadow prices, or "adders," on the basis of externality estimates while taking into account some of the most important second-best considerations.

Finally, we argue that implementation of social costing policies should move swiftly toward an approach aimed at dispatch or operation of generation resources, rather than a more narrow focus on planning, both for theoretical reasons, i.e. new source bias, and practical ones. For the latter, regulators may be unable to regulate investment planning, and may have to focus efforts on the dispatch of facilities and regulation of access to the grid. Recent social cost studies provide some encouragement that externality estimates for individual facilities can be derived that capture the lion's share of external costs without being critically dependent on interdependencies and the order of dispatch among facilities, but this remains uncertain and should be a high priority area of research.

With any eventuality regarding the possible evolution of the industry, there remain problems in the implementation of social costing policies at the state level. Issues of transboundary pollution, strategic competition for industrial customers, and dissimilarity of approaches to estimating costs suggest a fruitful role for federal coordination of state efforts. Ultimately, however, we are led to return to the familiar recommendations from economics: successful social cost policy should encompass the broader economy beyond just electricity generation and the unit of government that matches the geographical scope of the problem (be it state, regional, or national); and employ incentive based approaches such as tradable permits or emission fees. Federal leadership would seem essential to achieving this, and to do so would move significantly out of the thicket of second-best policies in the direction of first-best theory. The development of the social costing literature over the last few years is a necessary condition to making these approaches attainable in the future.

## REFERENCES

- Andrews, Clinton J. 1992. "The Marginality of Regulating Marginal Investments: Why We Need a Systematic Perspective on Environmental Externality Adders," *Energy Policy*, vol. 20, no. 5, pp. 450-463.
- Bernow, Stephen, Bruce Biewald and Donald Marron. 1991. "Full-Cost Dispatch: Incorporating Environmental Externalities in Electric System Operation," *The Electricity Journal*, March 1991, pp. 20-34.
- Burtraw, Dallas, Winston Harrington, A. Myrick Freeman III, and Alan J. Krupnick. 1995. "Efficiency 'Adders' for Environmental Damage by Public Utilities," *Journal of Environmental Economics and Management*, vol. 29, no. 3, (November), pp. S1-S19.
- Burtraw, Dallas, Karen Palmer, and Alan J. Krupnick. 1996. "Second-Best' Adjustments to Externality Estimates in Electricity Planning with Competition," Discussion Paper 96-04, Resources for the Future, Washington, D.C.
- Dickens, William T. 1990. "Assuming the Can Opener: Hedonic Wage Estimates and the Value of Life," Working Paper No. 3446, National Bureau of Economic Research, Cambridge, Mass. (September).
- Dillingham, Alan E. 1985. "The Influence of Risk Variable Definition on Value of Life Estimates," *Economic Inquiry*, 24, pp. 277-294.
- Dodds, Daniel E., and Jonathan A. Lesser. 1994. "Can Utility Commissions Improve on Environmental Regulations?" *Land Economics*, vol. 70, no. 1, 63-76.
- European Commission. 1995. *Externalities of Energy: ExternE Project. For the Directorate General XII*. Prepared by Metroeconomica, CEPN, IER, Eyre Energy-Environment, ETSU, Ecole des Mines.

- Freeman, A. Myrick III, Dallas Burtraw, Winston Harrington, and Alan J. Krupnick. 1992. "Externalities—How to Do It Right," *The Electricity Journal*, vol. 5, no. 7 (August/September), pp. 18-25.
- Goulder, Lawrence H. 1995. "Environmental Taxation and the 'Double Dividend': A Reader's Guide," *International Tax and Public Finance*, vol. 2, no. 2, pp. 157-183.
- Hagler Bailly Consulting, Inc. 1995. *The New York State Externalities Cost Study* (Dobbs Ferry, N.Y., Oceana Publications).
- Heslin, James S., and Benjamin F. Hobbs. 1989. "A Multiobjective Production Costing Model for Analyzing Emissions Dispatching and Fuel Switching," *IEEE Transactions on Power Systems*, vol. 4, no. 3 (August), pp. 836-842.
- Hobbs, Benjamin F. 1992. "SO<sub>2</sub> Trading and Adders: Do They Mix?," *The Electricity Journal*, vol. 5, no. 7 (August/September), pp. 26-34.
- Krupnick, Alan J., and Dallas Burtraw. 1996. "The Social Costs of Electricity: Do the Numbers Add Up?", Resources for the Future, mimeo.
- Lee, Henry, and Negeen Darani. 1995. *Electricity Restructuring and the Environment*, Harvard University (November 22).
- Lee, R., A. J. Krupnick, D. Burtraw, et al. 1995. *Estimating Externalities of Electric Fuel Cycles: Analytical Methods and Issues*, *Estimating Externalities of Coal Fuel Cycles*, and additional volumes for other fuel cycles (Washington, D.C., McGraw-Hill/Utility Data Institute).
- Mohring, Herbert, and J. Hayden Boyd. 1971. "Analysing 'Externalities': 'Direct Interaction' vs 'Asset Utilization' Frameworks," *Economica*, vol. 38 (November), pp. 347-361.
- Moore, Michael J., and W. Kip Viscusi. 1990. *Compensation Mechanisms for Job Risks: Wages, Workers' Compensation, and Product Liability* (Princeton, N.J., Princeton University Press).

- National Acid Precipitation Program (NAPAP). 1991. *1990 Integrated Assessment Report*.
- National Association of Regulatory Commissioners. 1995. *Utility Regulation in the U.S. and Canada, Compilation*.
- Oates, Wallace E. 1983. "The Regulation of Externalities: Efficient Behavior by Sources and Victims," *Public Finance*, vol. 38, no. 3, pp. 362-375.
- Oates, Wallace E. 1995. "Green Taxes: Can We Protect the Environment and Improve the Tax system at the Same Time?" *Southern Economic Journal*, vol. 61, no. 4, pp. 914-922.
- Palmer, Karen, and Hadi Dowlatbadi. 1993. "Implementing Social Costing in the Electric Utility Industry," *Energy and Environment*, 4, pp. 197-200.
- Palmer, Karen, Alan Krupnick, Hadi Dowlatbadi, and Stuart Siegel. 1995. "Social Costing of Electricity in Maryland: Effects on Pollution, Investment and Prices," *The Energy Journal*, 16, pp. 1-26.
- Parry, Ian W. H. 1995. "Pollution Taxes and Revenue Recycling," *Journal of Environmental Economics and Management*, 29, pp. S64-S77.
- Rosen, Sherwin. 1986. "The Theory of Equalizing Differences," in O. Ashenfelter and R. Layard, eds., *Handbook of Labor Economics* (Elsevier Science Publishers BV).
- Sheffrin, Anjali. 1992. "Pricing of Residual Emissions in Theory and Practice: A Case Study in Electric Utility Resource Decisions," paper presented at the Advanced Workshop in Regulation and Public Utility Economics Fifth Annual Western Conference, San Diego, CA, July 8-10, 1992.
- Tschirhart, John. 1994. "On the Use of 'Adders' by Public Utility Commissions," *The Energy Journal*, vol. 15, no. 1 (October), pp. 121-128.
- Viscusi, W. Kip. 1979. *Employment Hazards: An Investigation of Market Performance* (Cambridge, Mass., Harvard University Press).

Walther, Robin Jane, and John L. Jurewitz. 1992. "Including Environmental Externalities and Market-Based Mechanisms in Utility Resource Planning: Some Thoughts and Some Experience," paper presented at the Advanced Workshop in Regulation and Public Utility Economics Fifth Annual Western Conference, San Diego, CA, July 8 - 10, 1992.

Wood, Frances, and Roger Naill. 1992. "Using Externalities in Utility Planning: What Will It Cost?" *The Electricity Journal*, vol. 5, pp. 35-43.