EXTERNALITY VALUATION VERSUS SYSTEMWIDE ANALYSIS: IDENTIFYING COST AND EMISSIONS REDUCTION STRATEGIES FOR ELECTRIC SERVICE

by

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Abstract

In an effort to require electric utilities to assess the environmental impacts of their activities, public utilities commissions nationwide have been turning to the use of environmental externality valuation as a tool in integrated resource planning. To date, policy discussions have focused predominantly upon the correct value and calculation of externality adders, rather than their use and applicability as a planning tool. This paper discusses the use and utility of externality valuation for identifying low-cost, low-emissions electric service strategies. Using data obtained from a broad based examination of New England's electric service options, this paper compares the externality valuation concepts with the information generally obtained from electric power system simulation and production-costing analyses. While a valid economic concept, the application of externality values is of little use in identifying which strategies are both low-cost and low-emissions, or the specific policy options required to ensure their implementation. Externality valuation should therefore be used only as a last step, to select from among low-cost, low-emissions strategies once the aggregate cost and emissions impacts of those strategies have been identified.

Introduction

Across the nation, state regulatory agencies are employing the economic principle of externalities in an effort to ensure that decisions, made in electric utility resource acquisitions, reflect the true or social cost of electric service. Social cost refers to all the costs associated with the production and delivery of a good or service. By including the uncosted components of electric service in the resource planning and acquisition processes, it is hoped that an electric power system which is "least cost to society" will be identified and implemented. To date, the uncosted components of greatest interest have been those associated with environmental damages.

A recent report by the Electric Power Research Institute (EPRI), entitled Environmental Externalities: An Overview of Theory and Practice, provides a good overview of the recent initiatives regarding externalities, their evaluation, and use in planning. (EPRI 1991) The theory of social cost evaluation, and the use of externalities as a policy option in that process, are discussed by Connors in a recent report. (Connors 1991c) As the EPRI report discusses, one of the environmental externality valuation techniques focuses on quantifying, or finding some reasonable proxy for the actual damage costs associated with pollutant emissions. This "monetization" of environmental externalities had been implemented in several states such as Massachusetts, California, and Nevada.

Monetization of environmental externalities has generally been achieved by multiplying the emissions associated with a resource by an environmental adder ($/ton-pollutant). This cost is then added to the cost of the resources prior to overall resource evaluation and selection. Table One provides some examples of monetized externality values recently selected by several states (hereafter called just externality values, or externalities).

Table One: Monetized Externality Values for Three States

Pollutant Emission	Mass. DPU	California PUC	Nevada PSC	% Range in Values
Sulfur Dioxide	$1,500	$12,960	$1,560	88.4
Nitrogen Oxides	$6,500	$13,060	$6,800	50.2
Carbon Dioxide	$22	$8	$22	63.6
Suspended Particulates	$4,000	$8,780	$4,180	54.4
	(1989$/ton)	(1990$/ton)	(1990$/ton)	(%)

(California 1991; Massachusetts 1990; Nevada 1991)

While externality values have been selected, and justified based upon the estimation of damage costs, or past expenditures to reduce emissions, how effective are they as a tool to identify strategies that are "least cost to society?" This paper will explore this question three ways. First, an overview of the types of information communicated by externalities and systemwide analysis, and what they add to the evaluation of resources and resource portfolios in a least-social-cost framework. Second, for one region's electric power system, New England, how do externality values, selected using costs from specific projects, compare with the cost of reducing emissions that can estimated using industry-standard production-costing models (systemwide analysis). Finally, how effective are externality values, when used within systemwide analysis, at identifying "least social cost" strategies.

Externality Values and Systemwide Evaluation

The externality value, as a tool in evaluating whether resources or strategies are of least social cost, is an odd numeraire. First, its units ($/unit-emission) are those of a rate, and therefore do not communicate the overall external costs, or emission involved in the evaluation. An externality's derivation requires a rather complete understanding of the environmental impacts of pollutant emissions, and their resulting costs–in dollars–to society. In many instances this information is absent, or very difficult to assess in a reliable fashion. The range of values in Table One attests to this. In the derivation of their externality values, the Massachusetts Department of Public Utilities (Mass. DPU) recognized this quantitative uncertainty, and set standards for the selection of externality values as follows:

> (1) where feasible, comprehensive damage costs provide the most appropriate values for decision making purposes;
> (2) where marginal cost of damage is not available, cost of control is the best available proxy until the cost of damage can be assessed more accurately;
> (3) where available, the marginal cost of control incurred to meet emission limits mandated by society should be used to determine the value of pollutants or pollution abatement.
> (Massachusetts 1991, pp. 42-43)

This approach (3) has been referred to as the "implied valuation method." It equates the cost of meeting new or existing environmental regulations with society's value, or willingness-to-pay to avoid that emission. (Chernick and Caverhill 1991) While this *may* be true, within a least-social-cost framework what society is willing-to-pay is not the issue; what is the-least-that-must-be-paid is. Setting the price of a service equal to the recipients' value is the logic applied to free and open markets. In a regulated environment, particularly one where there is an obligation to serve, the price of the service has traditionally been based upon a supplier's costs rather than a customer's value for that service. Shouldn't this be the case when evaluating social costs as well? This long-standing approach of basing the price of electric service upon its cost, rather than its value, has been used to guard consumers against the possible misuse of monopoly power. The transformation of utility resource planning from least-cost to least-societal-cost should maintain this consumer safeguard.

The question remains however; how do we assess the external, social costs of pollutant emissions if the damage costs are unknown or highly uncertain? Clearly, knowing how much, or little, we would have to pay to reduce emissions provides a better position to judge our willingness-to-pay than what we *had* to pay to meet highly constrained–with respect to implementation–regulatory emissions limits. Furthermore, under the least-social-cost framework we should exhaust all opportunities to reduce costs *and* emissions before entertaining the question of how much we are willing-to-pay for further emission reductions.

One way to approach this issue is to examine the type of information required to assess the cost and emissions reduction opportunities available. Figure One displays a stylized tradeoff graph showing a variety of strategies with varying costs and emissions (in this example, Nitrogen Oxides–NO_x). Each point on the graph represents a mix of new and existing resources, which when used to provide electric service over a certain time period yields a cost (internal), shown on the y-axis, and a level of emissions (NO_x), shown on the x-axis.

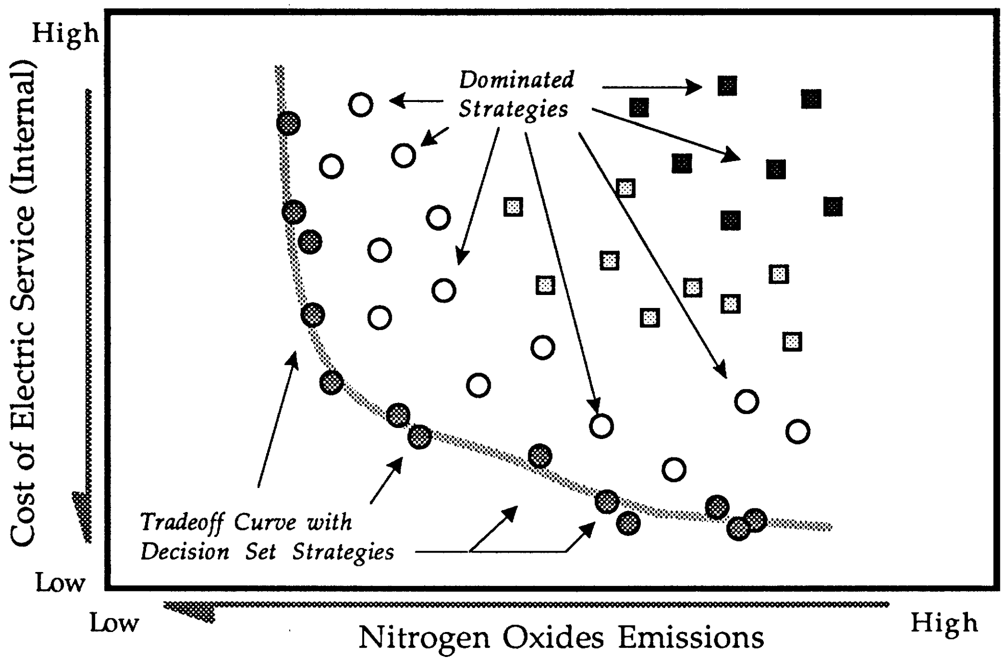
What is clear, even without the use of social costs and externalities, is that, for any two strategies, if one has lower costs *and* emissions (holding all else constant) it is superior, and in the nomenclature of multiple-attribute analysis, dominates the more expensive, higher polluting strategy. By successive pairwise comparisons we can eliminate from consideration all strategies that have higher costs and emissions than any other. What remains is a collection of strategies called the "Decision Set" which, when connected by a line, form a "tradeoff curve."

Each strategy along the tradeoff curve represents a collection of resources which in combination result in a least-cost and emissions strategy. Moving along the tradeoff curve from right to left describes the most cost-effective ways to reduce emissions[1]. By comparing strategies along the tradeoff curve we can calculate

1 For the collection of options, and sequence of future events evaluated.

the cost incurred (internalized) by requiring, or desiring, lower emissions. The shape of the tradeoff curve informs us as to way costs increase as emissions are reduced.

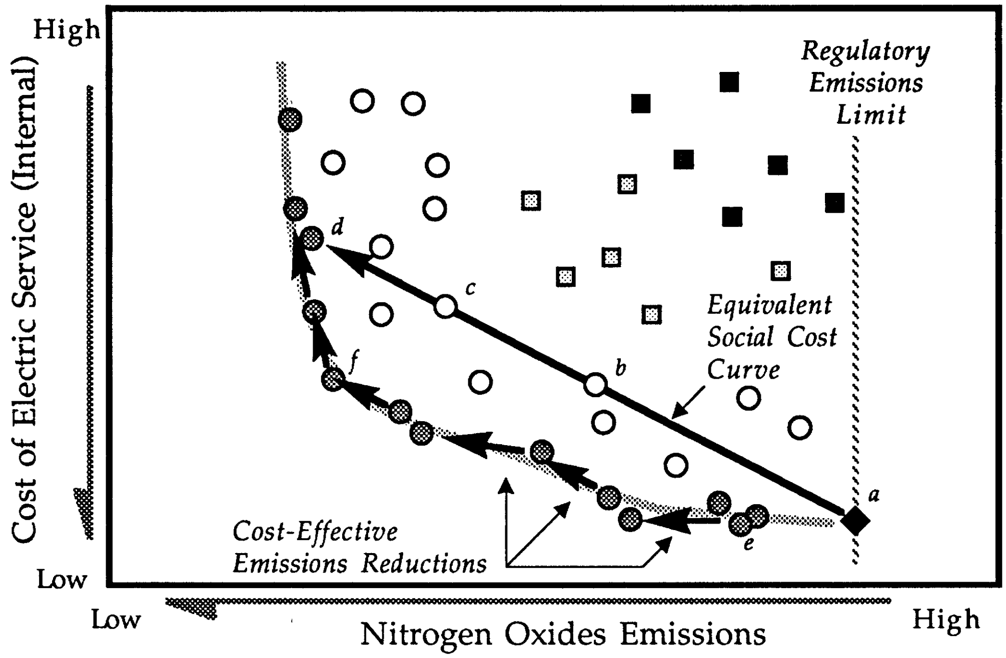
Figure One: The Evaluation of Strategies using Systemwide Analysis Alone



We can superimpose upon Figure One the effects of externality valuation. Using the logic of the Massachusetts decision, society is willing to pay an additional $6500 per ton of avoided NO_x emissions. Therefore, any strategy which has higher direct, or internal, cost of electric service–at a rate of $6500 per ton of NO_x avoided–is of equivalent social cost. Beginning with any strategy on the tradeoff graph, we can draw a line rising up and to the left with a slope equal to the externality value. All strategies on this curve are, by definition, of equal social cost.

Figure Two shows such a line, referred to here as an equivalent social cost curve. To draw this curve we have had to make some assumptions. The selection of an externality value does not tell us from where to begin our comparisons. Therefore, we have to assume a starting point. In Figure Two, the equivalent social cost curve originates at 'a', the minimum level of emissions to be in compliance with environmental regulations, at a cost equal to the least-cost strategy along the tradeoff curve ('e'). This starting point was selected to be in line regulatory requirements–prior to the application of social cost theory–such that costs are minimized while meeting environmental standards.

Figure Two: *Externality Valuation in the Context of Systemwide Analysis*



Since strategies 'a', 'b', 'c', and 'd' all lie upon the equivalent social cost curve, they all have the same social cost. Implicit in the use of externality values is the assumption that any strategy of equivalent social cost, and lower emissions, will be the one selected in resource acquisition process. The internalization of the cost difference between strategies 'a' and 'd', independent of its magnitude, is justified since it reflects a more equitable distribution of social costs, collecting them from the beneficiaries of the service, rather than those who would otherwise bear the brunt of the environmental damage.

Two important aspects in the use of externalities relate to when and what they are applied, during the course of analysis. If the valuation of externalities is performed upon specific options, rather than the overall performance of the system, then resources may be selected without knowing whether the system will end up at 'b', 'c' or 'd'. Notice that employing externality values pushes decisions towards the upper-left corner of the tradeoff graph, when "least-social-cost" resides in the lower-left corner.

Unlike the equivalent social cost curve, the tradeoff curve describes the most cost-effective ways to reduce emissions. It is based solely upon the evaluation of the power system's performance for a range of feasible options. A "cost-effective emissions reduction rate" can be calculated between any two points on the tradeoff curve (in $/pollutant-emission-avoided). In calculating this rate, the actual cost increase (internal), and emission reduction for that pollutant are known. Furthermore, the costs internalized can be considered a maximum, since the entire cost difference between the two strategies may not be attributable exclusively to the reduction of that emission.

Comparing Cost-Effective Emissions Reductions with Externality Valuation

How well do externality values compare to the cost-effective emission reduction rates derived from systemwide analysis? As part of their ongoing work with THE NEW ENGLAND PROJECT: Analyzing Regional Electricity Alternatives[2], (NEPOOL 1991) the Analysis Group for Regional Electricity Alternatives (AGREA) at the M.I.T. Energy Laboratory has evaluated the performance of New England's electric power system for a broad range of strategies.

Using information obtained from individual New England utilities, NEPOOL, EPRI and other sources, and using EPRI's EGEAS production costing model, the NEPOOL Load Forecasting Model, as well as a capacity planning module AGREA developed themselves, the M.I.T. research team has simulated the operation of New England's electric power system for a broad range of strategies. In all, 288 individual strategies were evaluated across fifteen combinations of load growth and fuel prices (for a total of 4320 simulations). For each simulation, data was recorded that tracked the costs, emissions, fuel consumption, reliability, and load and capacity growth for a twenty year period (1990-2009). By comparing the performance of these strategies, least-cost, least-

[2] THE NEW ENGLAND PROJECT: Analyzing Regional Electricity Alternatives is research project at the M.I.T. Energy Laboratory which brings together utility executives, regulators, consumer and environmental interest groups, and other stakeholders in New England's electric power industry to discuss the issues facing, and long-term strategies available to, the region. It is funded by a consortium of New England's electric utilities.

emissions strategies can be identified, and cost-effective emissions reduction rates calculated.

Each strategy is a combination of five separate components;

1) a choice of new generation technologies (technology mix),
2) a choice of the level and relative contribution of conservation and peak load management (DSM),
3) the persistence of existing capacity in the system, and how–if applicable–it is replaced (existing capacity treatment),
4) the choice of fuel in existing residual oil-fired units (boiler fuel switching), and
5) the desired level of extra capacity to have available (reserve margin).

Table Two shows the options available within each component. Exhaustively combining all the components' options yields 288 separate strategies. In the analysis, no effort is made beforehand to determine which strategies perform better than others. Simulation results themselves communicate which strategies were less expensive and had lower emissions. Examination of these strategies in detail can inform decisionmakers as to which options to stress or discourage in actual resource procurement.

Table Two: *Strategy Components and Options*

Number of Strategies	288		
New Technology Mix	**4**	**Existing Capacity Treatment**	**3**
Gas/Oil Dependent		Life Extension	
Gas/Oil & Clean Coal		Scheduled Retirement	
Clean Coal Dependent		Repower Existing	
Gas/Oil & Nuclear			
		Boiler Fuel Choice–Residual	**2**
Demand-Side Management	**6**	1990 Fuel Choice	
1990 Utility DSM Programs		0.5% Sulfur Oil 6	
Double 1990 Programs			
Triple Conservation		**Target Reserve Margin**	**2**
Triple Peak Management		Default 23%	
No Utility Demand-Side Mgt.		Higher 30%	
Technical Potential			

Figure Three shows the performance of a selection strategies for the measures of direct cost and cumulative sulfur dioxide (SO_2) emissions, for a future with a pessimistic economy/low load forecast, and medium oil and natural gas prices (the "PM" future)[3]. Direct costs are defined as the total cost stream associated with the provision of electric service in New England, discounted at the rate of inflation to 1989 dollars[4]. (NEPLAN 1989) Direct costs include customer as well as utility expenditures for conservation measures. The external, societal costs of emissions *are not* included in the direct cost calculation.

Figure Three shows results from two of the six levels of Demand-Side Management; the Double 1990 Programs, and the Triple Conservation levels of DSM. These two classes of strategies have been selected because they consistently had lower direct costs than the other levels of DSM[5]. The difference in costs and range of SO_2 emissions among the strategies of like DSM is due to the other four strategy components described in Table Two. The broad range of SO_2 emissions exhibited for each level of DSM emphasizes the need to develop integrated strategies.

We can compare the environmental externality values selected by the Mass. DPU with the cost-effective emission reduction rates, described by the tradeoff curve, by superimposing equivalent social cost curves (with slopes of $1500/ton SO_2) upon the tradeoff graph. A tradeoff, and equivalent social cost curve has been drawn for each of the two DSM levels since the feasibility at the assumed costs of these two levels of DSM is unknown. The equivalent social cost curves originate at seven million tons of SO_2. This twenty-year, New England-wide SO_2 emissions cap (total emissions allowable 1990-2009) was estimated by applying federal and state sulfur dioxide regulations to historical New England utility fossil fuel consumption.

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3 The PM future has been selected for discussion because, of the fifteen futures used in the simulations, it most closely matches the long-term load growth trend contained in the 1991 NEPOOL CELT Report. (NEPOOL, 1991)

4 Many of the assumptions regarding technology characteristics, and cost escalation factors were taken from the December 1989 NEPOOL Generation Task Force Report. (NEPLAN, 1989)

5 It is important to note that while it is possible to simulate a given level of demand-side management, such as Triple Conservation, whether such an option can be implemented, at the assumed costs, is not known.

For both these levels of demand-side management, there are cost-effective emissions reduction rates below the Mass. DPU rate of \$1500/ton SO_2. The first pair of strategies for the Double 1990 Programs level has an emissions reduction rate of \$1325/ton. Similarly, the cost-effective emissions reduction rates between the first two strategies (\$667/ton), and the first and third strategies (\$1281/ton) on the Triple Conservation tradeoff curve are also lower than the Mass. DPU number.[6] (EIA 1991)

Evaluating the relative performance of strategies in this manner provides a set of information usually not available when attempting to develop externality values directly via technology or market based assessments. Using this approach, the absolute changes in direct costs and emissions obtained when one strategy or portfolio is chosen over another becomes known. Table Three summarizes the changes in direct costs, sulfur dioxide emissions, and emissions reduction rates for sulfur dioxide, for strategies along the Triple Conservation tradeoff curve. Comparisons are made between each strategy and the strategy at the rightmost (lowest cost) end of the tradeoff curve ("A"), and then again from the emissions cap ("Cap"), identified in Figure Three.

As can be seen, cost increases along the tradeoff curve are modest (on a percentage basis) for this set of scenarios. The direct cost increase between strategies "A" and "B" for the entire twenty year period is only 0.5%, or 0.02% per year for twenty years. In absolute terms however these are large cost increases, over one billion dollars total, or fifty-one million dollars per year (for the New England region's entire system). There are, however, sizable SO_2 emission reductions. By choosing strategy "B" instead of "A", an additional 3.6 million tons of SO_2 emissions are avoided. This is an additional 30% reduction, lowering total SO_2 emissions to below half the seven million ton emissions cap estimated for the 1990 Clean Air Act. Note that all except one of the cost-effective emissions reduction rates calculated in Table Three fall below the Department's \$1500/ton SO_2 externality value.

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6 Although we can superimpose an equivalent social cost curve onto a tradeoff graph, we cannot move with the use of externality values, or any other methodology, between any two strategies on the graph. To arrive at point "B" instead of "A" requires adding resources to the existing system, over a twenty year period, consistent with "B's" strategy.

Figure Three: Cost-Effective Emissions Reductions vs. Equivalent Social Costs for SO_2 Emissions (Emissions Cap Comparison)

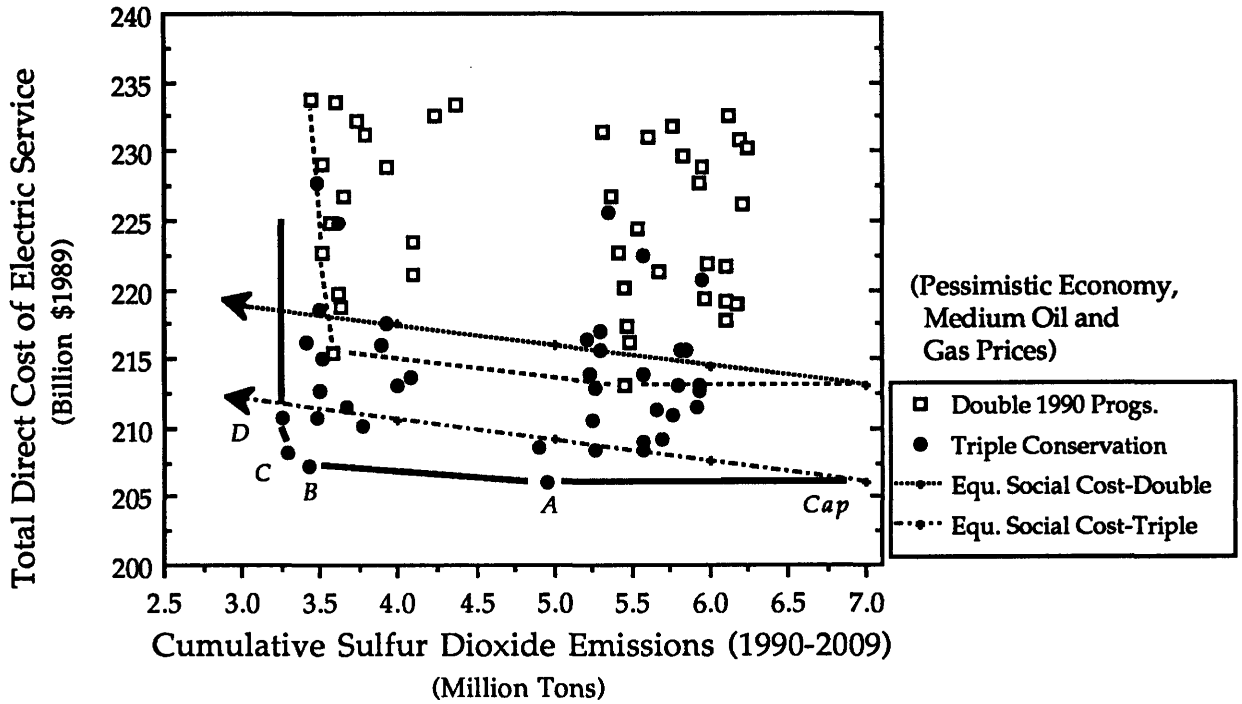

Table Three: Cost and Sulfur Dioxide Emissions Comparison – Triple Conservation Decision Set

Decision Set Strategy	Total Direct Costs	Cumulative Sulfur Dioxide Emissions	Change in Direct Costs vs. A: Delta Direct Costs	Change in Direct Costs vs. A: % Total Direct Costs	Change in Direct Costs vs. A: % Change Annual Average
Cap	*206.12*	*7.00*	—	—	—
A	206.12	4.95	—	—	—
B	207.14	3.42	1.02	0.49	0.02
C	208.24	3.29	2.12	1.03	0.05
D	210.78	3.26	4.66	2.26	0.11
	(B$'89)	(Million Tons)	(B$'89)	(%-20 yr.)	(%-1 yr.)

Decision Set Strategy	Change in Sulfur Dioxide Emissions vs. Cap: Delta Emissions	vs. Cap: % Change Emissions	vs. A: Delta Emissions	vs. A: % Change Emissions	Cost-Effective Emissions Reduction Rates vs. Cap	Cost-Effective Emissions Reduction Rates vs. A
Cap	—	—	—	—	—	—
A	2.05	-29.33	—	—	**$0**	—
B	3.58	-51.19	1.53	-30.93	**$285**	**$667**
C	3.71	-52.98	1.66	-33.46	**$572**	**$1,281**
D	3.74	-53.44	1.69	-34.12	**$1,246**	**$2,761**
	(Million Tons)	(%-20 yr.)	(Million Tons)	(%-20 yr.)	($'89/ton)	

The emission reduction rates in Table Three assume that all the increases in direct costs were used to reduce sulfur dioxide emissions. Similar calculations can be done for nitrogen oxides (NO_x), carbon dioxide (CO_2), and other emissions. Figures Four and Five compare the tradeoff curves for direct costs and NO_x and CO_2 emissions, with the equivalent social cost curves based on externality values of $6500/ton NO_x, and $22/ton CO_2. The starting points for the equivalent social cost curves are positioned at what NO_x and CO_2 emissions would be if New England-wide emissions from the electric sector were held constant at 1989 levels[7]. The accompanying changes in costs, emissions and cost-effective emissions reduction rates are presented in Tables Four and Five.

As can be seen, there are cost-effective emissions reduction strategies which fall well below the equivalent social cost lines for NO_x and CO_2 offering substantial reductions in these emissions as well. The lowest-cost, highest-emissions strategy on the NO_x Triple Conservation tradeoff curve ("I") has emissions 22% lower than constant New England-wide NO_x emissions limit. The amount of NO_x reductions that the 1990 Clean Air Act will require from the New England electric power sector has not yet been decided. Reductions in (as yet unregulated) carbon dioxide reach 16% before direct costs begin to climb sharply. In both cases, the cost-effective emissions reduction rates between the twenty-year 1989 limit for NO_x and CO_2 emissions, and the first three strategies along each tradeoff curve, fall below the Mass DPU values of $6500/ton NO_x and $22/ton CO_2.

Developing cost-effective emissions reduction functions from the data obtained through systemwide analysis allows us to inform ourselves, and society, about our options for reducing emissions. Figure Six compares the direct cost increases with the percent reduction in emissions, using the Mass. DPU externality values, and for the cost-effective emissions reduction results presented in Figures Three through Five. As can be seen, sizable reductions in emissions can be obtained at costs significantly less than those allowable with the use of the DPU's externality values—even when the total change in direct costs between two strategies is being attributed to reducing a single emission.

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7 Approximately 3.1 million tons for NO_x, and 1100 million tons for CO_2. (EIA, 1991)

Figure Four: Cost-Effective Emissions Reductions vs. Equivalent Social Costs for NO_x Emissions (Flat Emissions Limit Comparison)

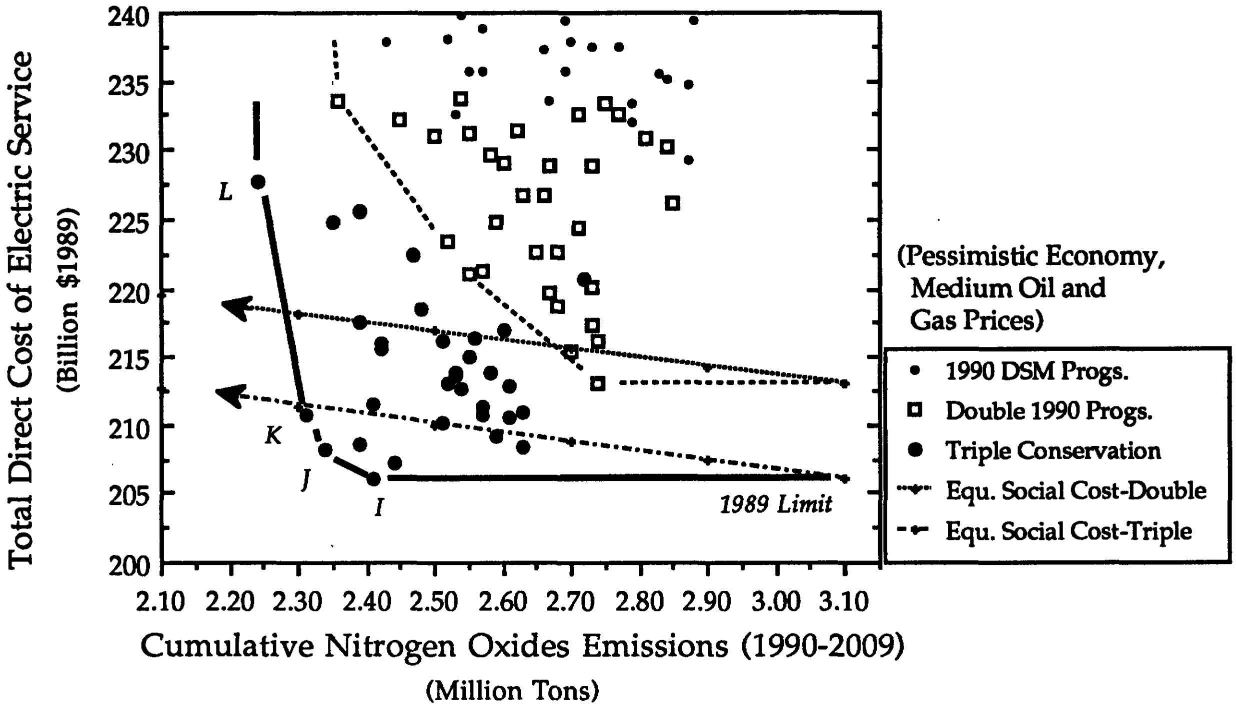


Table Four: Cost and Nitrogen Oxides Emissions Comparison – Triple Conservation Decision Set

Decision Set Strategy	Total Direct Costs	Cumulative Nitrogen Oxides Emissions	Change in Direct Costs vs. I		
			Delta Direct Costs	% Total Direct Costs	% Change Annual Average
Limit	*206.12*	*3.10*	—	—	—
I	206.12	2.41	—	—	—
J	208.24	2.34	2.12	1.03	0.05
K	210.78	2.32	4.66	2.26	0.11
L	227.70	2.24	21.58	10.47	0.50
	(B$'89)	(Million Tons)	(B$'89)	(%-20 yr.)	(%-1 yr.)

Decision Set Strategy	Change in Nitrogen Oxides Emissions				Cost-Effective Emissions Reduction Rates	
	vs. Limit		vs. I			
	Delta Emissions	% Change Emissions	Delta Emissions	% Change Emissions	vs. Limit	vs. I
Limit	—	—	—	—	—	—
I	0.69	-22.23	—	—	**$0**	—
J	0.76	-24.48	0.07	-2.90	**$2,793**	**$30,286**
K	0.79	-25.32	0.10	-3.98	**$5,936**	**$48,542**
L	0.86	-27.87	0.18	-7.26	**$24,977**	**$123,314**
	(Million Tons)	(%-20 yr.)	(Million Tons)	(%-20 yr.)	($'89/ton)	

Figure Five: *Cost-Effective Emissions Reductions vs. Equivalent Social Costs for CO_2 Emissions (Flat Emissions Limit Comparison)*

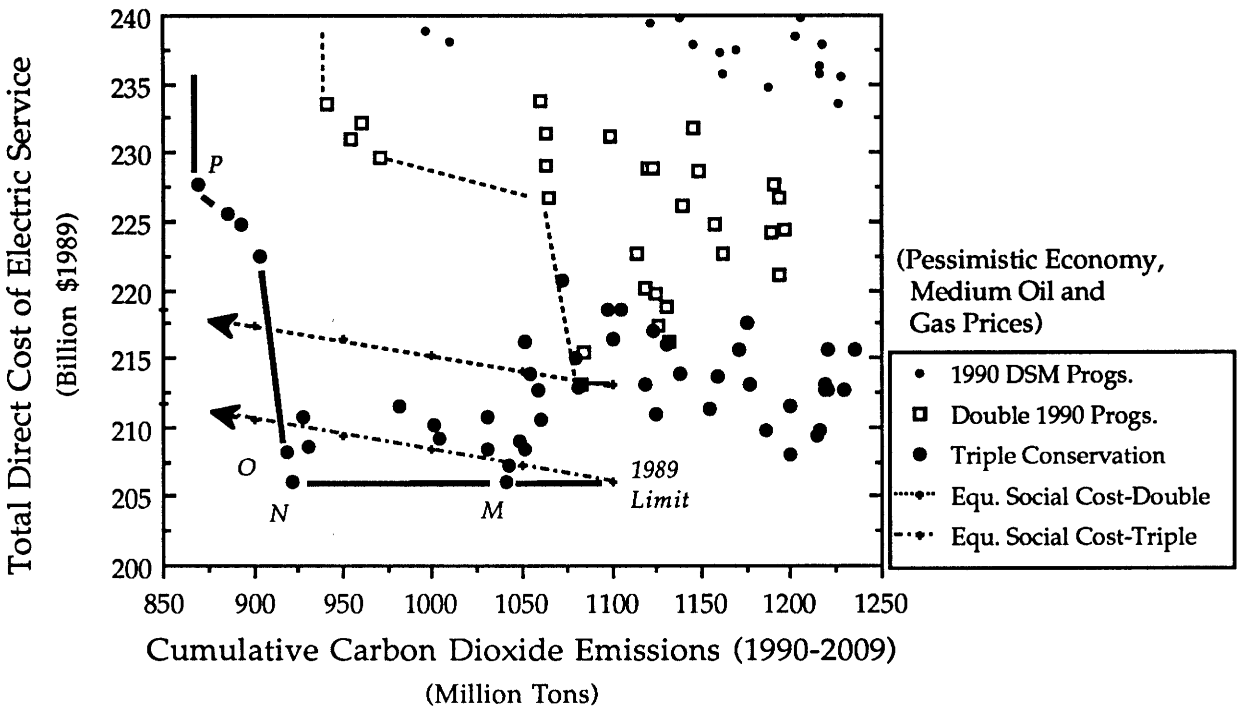
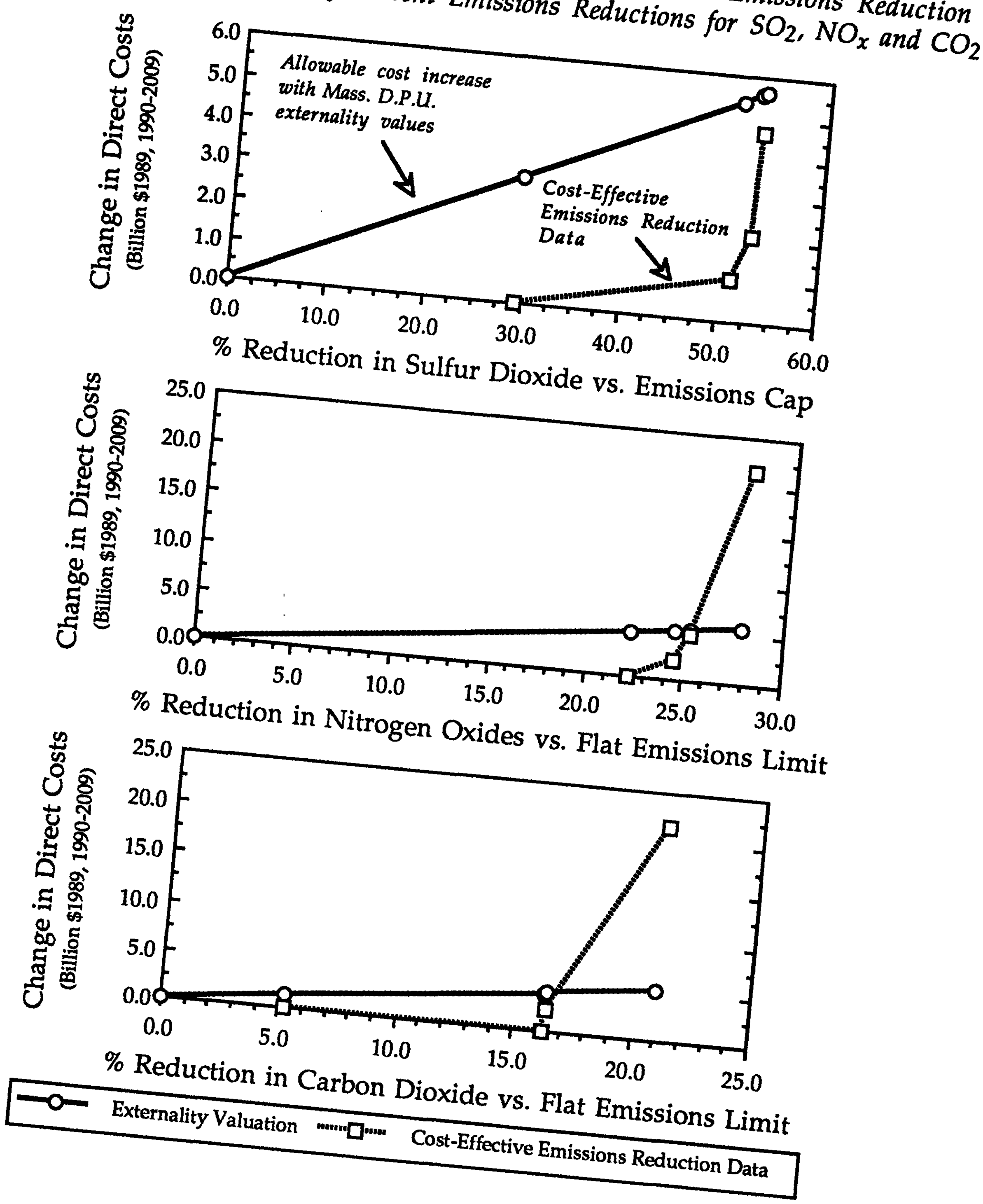


Table Five: *Cost and Carbon Dioxide Emissions Comparison – Triple Conservation Decision Set*

Decision Set Strategy	Total Direct Costs	Cumulative Carbon Dioxide Emissions	Change in Direct Costs vs. M: Delta Direct Costs	% Total Direct Costs	% Change Annual Average
Limit	*206.07*	*1100.0*	—	—	—
M	206.07	1041.8	—	—	—
N	206.12	921.2	0.05	0.02	0.00
O	208.24	919.3	2.17	1.05	0.05
P	227.70	869.6	21.63	10.50	0.50
	(B$'89)	(Million Tons)	(B$'89)	(%-20 yr.)	(%-1 yr.)

Decision Set Strategy	Change in Carbon Dioxide Emissions vs. Limit: Delta Emissions	vs. Limit: % Change Emissions	vs. M: Delta Emissions	vs. M: % Change Emissions	Cost-Effective Emissions Reduction Rates: vs. Limit	vs. M
Limit	—	—	—	—	—	—
M	58.20	-5.29	—	—	**$0.0**	—
N	178.80	-16.25	120.60	-11.58	**$0.3**	**$0.4**
O	180.70	-16.43	122.50	-11.76	**$12.0**	**$17.7**
P	230.40	-20.95	172.20	-16.53	$93.9	$125.6
	(Million Tons)	(%-20 yr.)	(Million Tons)	(%-20 yr.)	($'89/ton)	

Figure Six: *Externality Valuation and Cost-Effective Emissions Reduction*
Direct Cost Increases by Percent Emissions Reductions for SO_2, NO_x and CO_2



Identifying the Characteristics of a Least-Social-Cost Strategy

In this section we will look at the effectiveness of externality valuation in identifying least-cost, least-emissions strategies by converting the direct costs in the above strategies to social costs, using the Mass. DPU externality values.

Since many strategies may reduce several emissions simultaneously, it would be helpful if the portion of the direct cost increase attributable to a single emission's reduction could be calculated. This is difficult to do without a detailed analysis of what occurred in each scenario to introduce low emissions resources, and displace high emissions ones. One way to allocate the relative contribution of each emission's reduction to total system performance is use externality values to convert direct costs to social costs, thereby collapsing several emissions into the cost attribute. While this hides the relative reduction of individual emissions, it allows us to look at the overall performance of a strategy across emissions.

Figure Seven shows how strategies' positions shift when direct costs are converted into social costs. Figure Seven takes the Double 1990 Programs and Triple Conservation DSM strategies, and adds to the direct cost of those strategies the environmental externality costs associated with the change in emissions from a 1988 emissions baseline. The New England Project data includes annual emissions for SO_2, NO_x, CO_2 and Total Suspended Particulates (TSP). For SO_2, NO_x, and CO_2, the externality value for each emission was multiplied by the annual emissions–simulated in the model run–minus 1988 electric sector emissions. This emissions cost is then added to the direct cost to obtain the social cost for that strategy[8]. Since no historical reference data was readily available for suspended particulates, changes in particulate emissions were calculated against the emissions in the first year of the production costing model run.

Because social costs are calculated based upon net emissions, any strategy which reduces emissions relative to the baseline receives an environmental credit,

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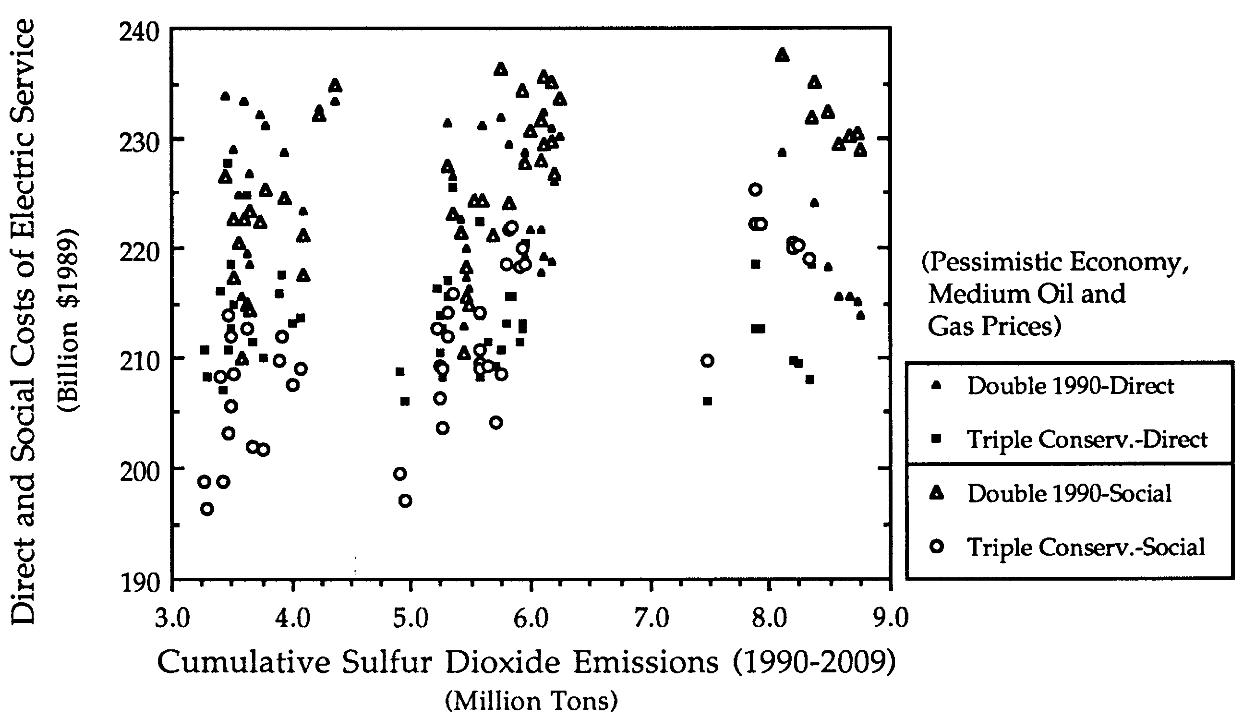
8 The externality value can be multiplied by total systems emissions as well. However, since Mass. DPU focused on the net system impacts associated with resource additions, and that the use of total versus delta emissions only serves to shift the entire group of strategies upwards in cost, the delta emissions approach has been used in this discussion.

and therefore a social cost less than its direct cost. Figure Seven demonstrates this point. The transformation of direct costs to social costs shifts the set of data points counter-clockwise. Strategies with lower SO_2 (and other) emissions shift down, and high emissions strategies shift up as environmental costs are added to direct costs.

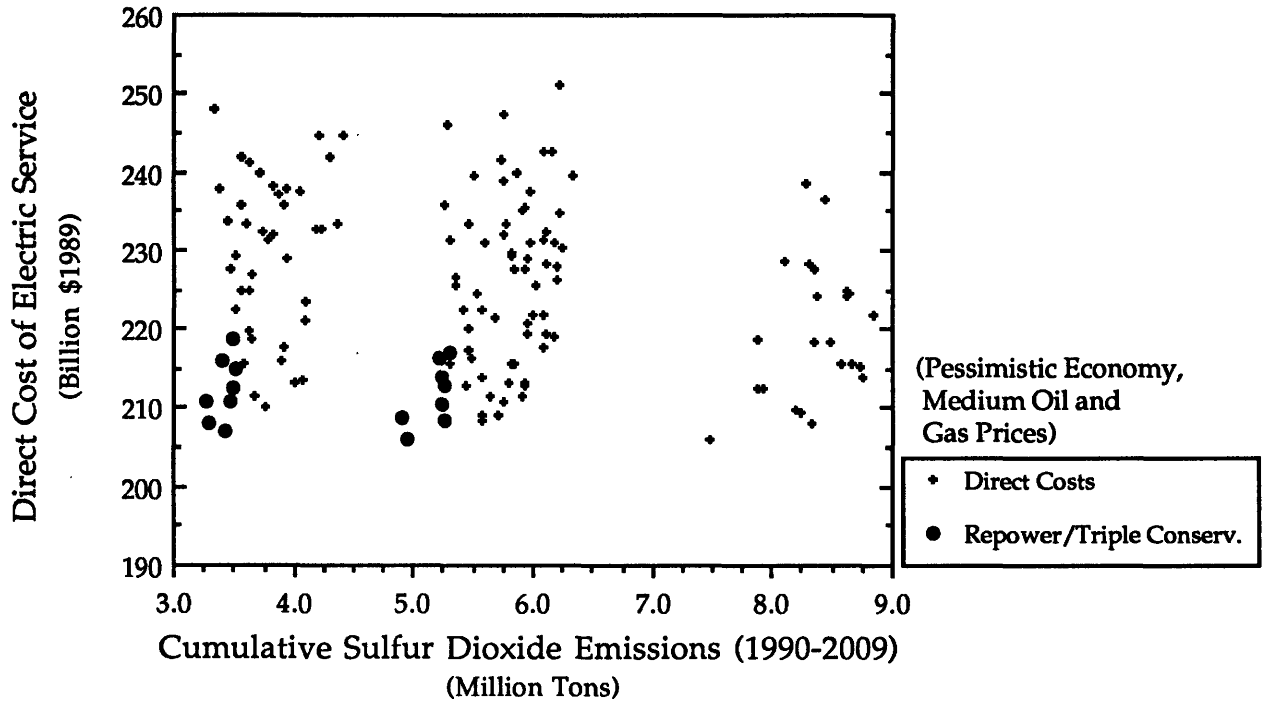
Figure Seven: Direct Cost vs. Social Cost Comparison for Two Levels of Demand-Side Management



Shifting strategies on the left–down, and on the right–up, may be an accurate representation of the relative social cost of these strategies, but this knowledge adds little to the decisionmaking process since those strategies which had low direct costs and low emissions to begin, end up having low social costs and emissions as well.

Strategies in the direct cost decision sets reappear in decision sets for the social cost and emissions comparisons. Figures Eight and Nine illustrate this point. In Figure Eight, for direct costs and sulfur dioxide emissions, strategies with both Triple Conservation and Repowering of existing units are highlighted. This collection of strategies (with varying technology mixes, boiler fuel choice, and reserve margins) has a tendency to remain on or near the tradeoff curves for a range of costs and emissions, and across the range of load growths and fuel price uncertainties analyzed for the The New England Project.

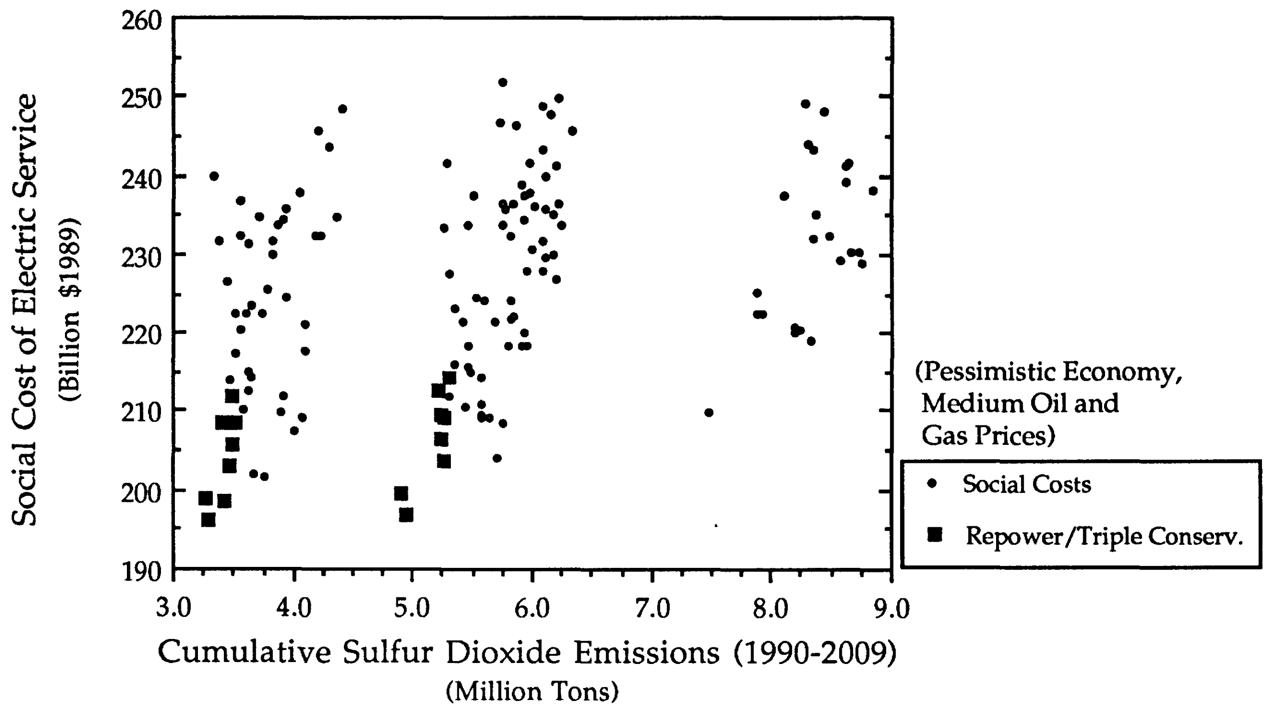
Figure Eight: Performance of Repowering and Triple Conservation Strategies for Direct Costs and SO_2 Emissions



The repowering component of these strategies promotes supply-side efficiency improvements faster than relying upon capacity additions that meet incremental new load alone. Similarly, additional cost competitive conservation programs increase the efficiency at which electricity is used by upgrading existing electricity customers, and ensuring that new end-users are of a higher efficiency as well. It was found that by looking at the relative performance of the 288 strategies, that the cost and CO_2 reductions achieved through increased conservation were complemented by a relatively cost-neutral repowering strategy that substantially reduced SO_2 and NO_x emissions.

Because these coordinated strategies reduce both costs and emissions, when their direct costs are converted to social costs they remain in the decision set. Figure Nine highlights the same strategies as in Figure Eight, but with social costs replacing direct costs on the vertical axis. As can be seen, the strategies emphasizing complementary supply-side and demand-side efficiency improvements remain in the low cost, low emissions corner.

<u>Figure Nine:</u> Performance of Repowering and Triple Conservation Strategies for Social Costs and SO_2 Emissions



Papers by Andrews and Connors take a detailed look at the existing New England electric industry and explore the dynamics between existing resources and new, in developing low cost and emissions strategies. (Andrews 1991; Andrews and Connors 1991; Connors 1991a; Connors 1991b) As these papers show, placing too great an emphasis on either supply-side or demand-side resources can lead to an unbalanced strategy. Failure to coordinate conservation initiatives with supply-side efficiency improvements can have perverse impacts, as older generating capacity–inferior to new generating technologies in both efficiency and environmental characteristics–is not displaced, keeping emissions high.

What do the analytic trends described here imply for the use of externality values in resource planning? What is clear from the above results is that the use of such values does not identify which combinations of resources result in low cost, low emissions strategies. Although society *might* be willing to pay substantially more to reduce emissions, it would prefer to pay less *and* have lower emissions. Performing detailed analysis which allows the interactions among new resources and the existing system to be modeled *is essential* to provide the data necessary for determining which strategies consistently perform well for both cost and emissions.

Where externality values can play an important role is in deciding which of the least-cost, least-emissions strategy–identified through a broad-based set of detailed analyses–should be pursued. Here a problem arises as well. Externality values do not communicate the level of direct costs that will become internalized, and therefore collected through electricity rates as a result of their application. Nor do they communicate the expected level of reduced emissions.

In deciding which "value society places on pollution control," regulators should make their decisions with the knowledge of the resulting costs, and level of emissions reduction that will result from any such valuation, whether those costs are associated with continued emissions, or acting to avoid their release.

Conclusions

In an effort to get electric utilities to include environmental impacts in their planning, regulators have begun to rely upon the use of environmental externalities in resource planning and acquisition. Without good information on the damage costs associated with pollutant emissions, they have turned to other methods of external cost estimation. Such methods as the "implied valuation technique," are justifiable from a historical cost, and solid data perspective. They have several shortcomings however. Selection of a rate is uninformative as to the aggregate direct, internal cost and emissions impacts associated with their use. Furthermore, they fail to identify, describe or promote those strategies which concurrently reduce emissions and costs.

Systemwide analysis, incorporating the technological dynamic of an evolving electric power system with new and existing resources entering and leaving the system's infrastructure, allows decisionmakers to evaluate strategies with complementary options. When comparing strategies which perform well for both cost and emissions, it was found that significant opportunities for emissions reduction existed, at well below the values set for externality valuation. Externalities can play an important role, as a tie breaker, in electric power systems planning. However, they must be derived from a knowledge of the strategies, and resource combinations available to a given system. Once the tradeoffs between costs and emissions are known, values can be selected which signal the marketplace of the level of costs and emissions society is willing to endure in the provision of electric service.

Resources

Andrews, Clinton J. "The Marginality of Regulating Marginal Investments: Why We Need a Systemic Perspective on Environmental Externality Adders." Energy Policy *forthcoming* 1992.

Andrews, Clinton J. and Stephen R. Connors. Existing Capacity - The Key to Reducing Emissions. The M.I.T. Energy Laboratory, 1991. MIT-EL 91-001WP. Cambridge, MA.

California, Public Utility Commission. Decision 91-06-022. 1991.

Chernick, Paul and Emily Caverhill. "Monetizing Environmental Externalities for Inclusion in Demand-Side Management Programs." In DSM and the Global Environment. Arlington, VA. Synergic Resources Corp., pp. 73-79, 1991.

Connors, Stephen R. "Reducing Atmospheric Insults without Going Broke: How to Halve Acid Rain and Ground-Level Ozone Precursors from New England's Electric Power Sector." In Trace Substances in Environmental Health. Columbia, Missouri. 1991.

Connors, Stephen R. "The Role of Demand-Side Management in Strategic Emissions Reduction: Integrating End-Use Efficiency Improvements in the Electric Power Sector." In DSM and the Global Environment. Arlington, VA. Synergic Resources Corp., pp. 293-304, 1991.

Connors, Stephen R. The Social Cost of Potential Pollutants, Externality Valuation, and the Limits of Knowledge. The M.I.T. Energy Laboratory, 1991c. MIT-EL 92-002WP. Cambridge, MA.

EIA. Electric Power Annual 1989. U.S. Energy Information Administration, 1991. DOE/EIA-0348(89).

EPRI. Environmental Externalities: An Overview of Theory and Practice. Electric Power Research Institute, 1991. EPRI CU/EN-7294.

Massachusetts, Dept. of Public Utilities. Decision, Docket 89-239. 1990.

Massachusetts, Dept. of Public Utilities. Decision, Docket 90-141. 1991.

NEPLAN. Summary of Generation Task Force Long-Range Study Assumptions. New England Power Planning, 1989.

NEPOOL. NEPOOL Forecast Report of Capacity, Energy, Loads and Transmissions 1991-2006. New England Power Pool, 1991.

Nevada, Public Service Commission. Docket No. 89-752. 1991.