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PROCEEDINGS

NATIONAL CONFERENCE ON ENVIRONMENTAL EXTERNALITIES

Jackson Hole, Wyoming
October 1-3, 1990

FG01-89CE28301

National Association of Regulatory Utility Commissioners
Room 1102 ICC Building; P.O. Box 684
Washington, D.C. 20044

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PROGRAM AND INDEX TO PROCEEDINGS

NARUC ENVIRONMENTAL EXTERNALITIES CONFERENCE
THE SNOWKING RESORT
JACKSON HOLE, WYOMING
OCTOBER 1-3, 1990

CONF-9010245--

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SUNDAY, SEPTEMBER 30, 1990

12:00 Noon – 6:00 p.m. REGISTRATION

8:00 p.m. – 9:30 p.m.

Informal after dinner wine and cheese reception in the Teton Ballroom of the Snowking Resort Hotel.
Brief welcoming remarks by the Honorable Sharon Nelson, President of the NARUC.

MONDAY, OCTOBER 1, 1990

8:00 a.m. – Registration re-opens

8:00 a.m. – 9:00 a.m. Complimentary Continental Breakfast in Grand Hall outside Ballroom

9:00 a.m. Conference begins in the Grand Teton Ballroom

Welcoming Remarks by the Hon. John R. (Dick) Smyth
Chairman of the Wyoming Public Service Commission

Brief remarks and introduction by the Hon. Mary Lou Munts, Chair of the
NARUC Committee on Energy Conservation

KEYNOTE ADDRESS: "ENVIRONMENTAL CHALLENGES OF THE 1990's"

The Honorable J. Michael Davis; Assistant Secretary
United States Department of Energy

10:00 a.m. CONFERENCE THEME ADDRESS:

Brief remarks and introduction by the Hon. Ron Eachus; Commissioner;
Oregon Public Utility Commission

Speaker: Larry DeWitt; Director; Office of Energy Conservation & Environment;
New York Public Service Commission ..... Page 5

Address: "ENVIRONMENTAL EXTERNALITIES: WHAT ARE THEY AND WHY SHOULD THEY BE GIVEN CONSIDERATION IN THE PLANNING & REGULATORY PROCESS"

10:30 a.m. – 10:50 a.m. Coffee Break

10:50 a.m. – 12:30 p.m.

"INTRODUCTION TO THE ECONOMICS OF SOCIAL COST"

Moderator: The Hon. Gary Nakarado; Commissioner; Colorado PUC
Panelists:

1) Charles Stalon; Putnam, Hayes & Bartlett; Washington, DC ..... Page 13
2) Eric Haites; Barakat & Chamberlin; Toronto, Ontario, Canada ..... Page 27
3) Florentin Krause; Lawrence Berkeley Laboratory; Berkeley, California

12:30 p.m. – 2:00 p.m. Lunch

MASTER

Monday, October 1, 1990 (cont.)

2:00 p.m. – 3:30 p.m. Afternoon Session

"THE VALUATION AND QUANTIFICATION OF SOCIAL COST IN THE PRODUCTION AND CONSUMPTION OF ENERGY"

Moderator: Ralph Gelder; Executive Director; New England Conference of PUC's
Panelists:

1) Paul Chernick; PLC, Inc.; Boston, Massachusetts ..... Page 41
2) Daniel Violette; RCG/Hagler Bailly, Inc.; Boulder, Colorado ..... Page 63
3) Alan Destribats; Vice President; New England Power Service Co.
Westborough, Massachusetts ..... Page 85

3:30 p.m. – 3:45 p.m. Coffee Break

3:45 p.m. – 5:00 p.m. Late Afternoon Session

"REGULATORY PROCESSES: LEGAL & INSTITUTIONAL BARRIERS"

Moderator: The Hon. Hank Williams; Commissioner; New York PSC
Panelists:

1) Richard Ottinger; Professor of Law; Pace University ..... Page 100
2) Daniel Patrick O'Tierney; Commissioner; Alaska PUC ..... Page 122
3) Gerald Browne; Director of External Coordination;
New England Power Pool ..... Page 133

EVENING SESSION – 8:30 p.m. – 9:30 p.m.

One hour Academy Award Winning Documentary Film: **"The Four Corners: A National Sacrifice Area?"**
Introduction & Discussion Leader: Dr. John Beldock; U.S. Department of Energy ..... Page 140

TUESDAY, OCTOBER 2, 1990

8:00 a.m. – 9:00 a.m. Complimentary Continental Breakfast
Hallway outside the Grand Teton Ballroom-- (Informal Discussions)

9:00 a.m. – 10:30 a.m. Morning Session

"REGULATORY PROCESSES AND EXTERNALITIES"

Moderator: The Hon. Kenneth Gordon; Chairman; Maine PUC
Panelists:

1) Shep Buchanan; Economist; Bonneville Power Administration ..... Page 141
2) Stephen Bernow; Tellus Institute ..... Page 151
3) Jan Beyea; Director of Environmental Policy; National Audubon Society .... Page 173

10:30 a.m. – 10:50 a.m. Coffee Break

Tuesday, October 2, 1990 (Cont.)

10:50 a.m. – 12:30 a.m. Late Morning Session

"EXTERNALITIES AND RATES - WHO PAYS AND HOW MUCH?"

Moderator: The Hon. Frederick R. Duda; Commissioner; California PUC
Panelists:
1) John Smith; Director; Policy Analysis; New York State Energy Office
2) David Moskovitz; Consultant ..... Page 201
3) Myron Katz; Chairman; Oregon Public Utility Commission ..... Page 210

12:30 p.m. – 2:00 p.m. Lunch

2:00 p.m. – 3:45 p.m. Afternoon Session

"EXTERNALITIES: FEDERAL VIEWS, SOCIAL COSTS, AND ENVIRONMENTAL ASSESSMENT REGULATIONS"

Moderator: The Hon. Nels Smith; Commissioner; Wyoming PSC
Panelists:
1) Robert San Martin; U.S. Deputy Assistant Secretary of Energy ..... Page 227
2) Janine Finnell; Senior Energy Analyst; Meridian Corporation ..... Page 242
3) Alex Cristofaro; Director; Air & Energy Policy Division; U.S. Environmental Protection Agency ..... Page 279
4) Allen Lee; Batelle Pacific Northwest Laboratories ..... Page 281

7:30 p.m. Evening Sessions A & B

Session A: 7:30 p.m.–9:00 p.m. – Grand-Teton Room – Panel Discussion on Global Climate Change
Moderator: The Hon. Cheryl Harrington; Maine PUC
Panelists:
1) John Hoffman; Director; Global Change Division; U.S. Environmental Protection Agency ..... Page 305
2) Roger Naill; Vice President; Applied Energy Services, Inc. ..... Page 306
3) Florentin Krause; Staff Scientist; Lawrence Berkeley Laboratory

Session B: 7:30 p.m.--9:45 p.m. -- Summit II Room -- **"Developing an Environmental Externality Regulation: Searching for Consensus"**

Leader: Mr Jonathan Raab; Massachusetts Department of Public Utilities

Using a hands-on simulation developed by Mr. Raab for the MIT-Harvard Public Disputes Program, participants will have one hour to modify a proposed environmental externality methodology to be incorporated in a State's least-cost planning rule or regulation. Working in groups of five, each person will assume a particular role (eg. utility, regulator, environmentalist and with the assistance of confidential instructions will attempt to forge a consensus. In addition to providing conference attendees with an excellent vehicle to synthesize the substantive presentations from the conference, it will allow participants to learn more about the collaborative processes and to better understand their own negotiating style.

WEDNESDAY, OCTOBER 3, 1990

8:00 a.m. – 8:30 a.m. Complimentary Continental Breakfast – Hallway Outside Grand Teton Ballroom

8:30 a.m – 10:00 a.m. Morning General Session

"STATE REGULATORY EXPERIENCES IN ATTEMPTING TO QUANTIFY AND INCORPORATE ENVIRONMENTAL EXTERNALITIES"

Place: Grand Teton Ballroom
Moderator: The Hon. Richard Cowart; Chairman; Vermont Public Service Board
Panelists:

1) Mr. David Morse; California PUC ..... (late submission -- see appendix) Page 410
2) Mr. Thomas Schneider; Consultant; Schneider & Associates, Inc. ..... Page 321
3) Ms. Cynthia Mitchell; Consultant ..... Page 328

10:00 a.m. – 10:20 a.m. Coffee Break

10:20 a.m. – 11:20 a.m. Continuation of Morning General Session

Place: Grand Teton Ballroom
Moderator: The Hon. Richard Cowart; Chairman; Vermont Public Service Board
Panelists:

1) Mr. Richard Prestin; Northern States Power Co. ..... Page 341
2) Mr. Henry Yoshimura; Massachusetts DPU ..... Page 352

11:20 a.m. – 12:00 Noon Closing General Session

"REFLECTIONS ON THE FUTURE CHALLENGES OF PUBLIC UTILITY REGULATION IN MEETING THE COMPETING GOALS OF ENERGY RELIABILITY AND ENVIRONMENTAL PROTECTION"

Moderator: The Hon. Stephen Wiel; Commissioner; Nevada PSC

Speaker: Mr. Ralph Cavanagh; Natural Resources Defense Council ..... Page 376

National Conference on Environmental Externalities
Jackson Hole, Wyoming, October 1-3, 1990

Laurence B. DeWitt
New York State Department of Public Service
Director, Office of Energy Efficiency and Environment

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AN OVERVIEW OF ENVIRONMENTAL EXTERNALITIES

Endicott was in the ice business, as his father, grandfather and great grandfather had been before him. After so many years of collective wisdom, a dependable system had been developed. Nothing in this operation had changed for many, many years, so it was settled and reliable. His customers could count on Endicott and they did. He and his horse, Ol' Dobbins, with the ice house, lorry, and sawdust and all, were an integral part of the way of life in turn-of-the-century Bloomfield. Quaint.

Bloomfield was a one ice company town. Competitors had cropped up during the early years of great grandpa Endicott, but the town had decided that it was inherently more expensive to have two horses, two lorries, two ice houses and two icemen, when one of each was sufficient to meet Bloomfield's needs. And there was only one pond in the town to make ice in the winter anyway. The Bloomfield Ice Management Board was established and it determined the price Endicott could charge, in return for which the Endicotts did not have to worry about competitors.

Time went on. Bloomfield grew. Things changed. And thinking changed. The need for ice was outstripping the capacity of Busbar Pond. Young Endicott had improved his ice harvesting and ice storage efficiency -- he was now delivering 40% more megaweights of ice from the one pond than had grandpa Endicott. But Bloomfield continued to grow. With a great loss of pride, Endicott was increasingly having to resort to purchasing ice from a neighboring town, and this was increasing his costs. And each year, in late autumn, he increasingly had to reduce his deliveries. Rationing was definitely not the Bloomfield way. The final straw came when Endicott's young son left the ice shed door open all of an Indian Summer day -- the resulting meltdown created quite a crisis.

An emergency meeting of the Ice Management Board was convened. Many disgruntled townsfolk attended and spoke up. Plans for constructing a new pond, a larger ice shed and a second horse and lorry were presented, along with estimates of the very large jump in prices that would result -- not quite doubling. Disgruntlement became anger. There was no agreeable location for

the new pond ("a big mosquito factory"), no one wanted yet another horse and all its fall-out littering respectable Bloomfield's streets, and surely no one wanted the price increase.

The banker suggested they allow others to see if they could provide additional ice less expensively than Endicott's plan for extra ice. The doctor proposed that they make Endicott clean up after Ol' Dobbins, even if it did cost more in the short-run, because it was a serious health problem and would cost less in the long-run avoidance of illness. (He won over the many skeptics with his summation: "If Endicott can't afford a horseless buggy, he should at least have a bugless horsey.") The chairlady of the Bloomfield Temperance Union suggested that everyone cooperate and just use less ice and then everything would be fine, but, as usual, she was hooted down.

The science teacher said she had read about some new highly advanced icebox which kept food even cooler and used less ice. Some wiseacre piped up "what are we supposed to do, have Endicott buy us all new iceboxes?" Everyone laughed, especially Endicott. After the laughter subsided, the science teacher spoke again: "I realize it sounds ridiculous, but it actually would be far less expensive in the long-run to buy everyone a new icebox than to pay for Endicott's plan. And we won't need to build a new pond and get an extra horse and buggy. Our food will be colder, and we'll all save through reduced spoilage. The bank should give Endicott a loan so he can help us all buy new ice boxes rather than giving him a loan so he can build a new pond and ice shed and so forth. The efficiency approach is so much cheaper than building a new pond that we could even give Endicott Ice slightly higher profits and we'd <u>all</u> gain."

After much shouting (some things never change) the Ice Board decided to pursue <u>all</u> of the proposals (except the one from the Temperance Union). Any need for new ice capacity would be put out for public bid; Ol' Dobbins would have his act cleaned up; and Endicott would help everyone buy a new icebox or do anything else that would help his customers use the ice more efficiently -- as long as doing so was less expensive than providing more ice. Since Endicott would still be making the principal decisions about whether to build new ice making capacity, or "import" ice, or improve everyone's efficiency in using ice, the Ice Board established a new profit incentive for Endicott: the lower their average ice bills, the greater his profits.

* * * * *

The foregoing "fable" is an effort to summarize the major principles of Integrated Resource Planning as we have begun to develop it in the United States. A simpler and more prosaic way of describing Integrated Resource Planning is:

> We should look at all the costs and all the benefits of all the options and do what is most cost-effective over the long haul.

This "approach" is so common-sensical and "obvious" that one is inclined to respond:

> What's so new about that? What is the big deal? Why do we have to use a jargon tag like "Integrated Resource Planning" when what we really mean is plain old "smart planning"?

The answer is that somewhere along the line we, collectively, got into the habit of ignoring some of the costs, some of the benefits, and some of the years during which costs and benefits would occur.

The purpose of this workshop is to explore in some detail one of the most important costs that until recently, we have chosen to ignore: environmental externalities.

What are Externalities?

Imagine a primitive electric generating plant. The total costs incurred by the plant are 100 -- for all the inputs and capital and profits for which the company must pay. It receives this 100 from sales. The plant also damages the environment by 50 each year and does not pay anyone for having done so. This is what we call an environmental externality. It is external to the pricing system. It is an environmental "free lunch," an environmental "free rider." An externality, though, is very real. It is a cost. And it is paid -- but not by the electric company or its customers -- except to the extent that they live within the externality damage zone.

Internalization

Imagine that the electric plant has a scrubber installed. The cost of the scrubber is 10. The total costs of the plant now are 110. Assume that the scrubber reduces environmental externalities by 15, so that total damage is now 35. There are two main points here. First, costs have gone up by 10, but benefits (i.e. reduced damage) have gone up by 15: there is a net social gain of 5. Second, we have internalized -- into the pricing system -- some of the externalities.

Suppose we continue this course of action adding yet another scrubber. The second scrubber costs 5 and it reduces damages by 5. There is no net social gain because formal costs have gone up by 5 while social benefits -- reduced damage -- have also gone up by 5. This is pure internalization.

Many would view this as a better state of affairs because there is a more just allocation of costs and because prices now more accurately reflect true costs.

Externalities

"Externalities" is a general term for a wide variety of costs and benefits which are not included in prices. Such external costs and benefits can be environmental or non-environmental. The focus of this workshop is deliberately on environmental externalities: it was felt that the whole realm of social externalities was too broad for one workshop. But we should all bear in mind that leaving out non-environmental externalities may provide an unduly negative cast to the full-range of "side-effects" associated with the generation, transmission and use of energy. The creation of jobs and the attraction of industry through reliable energy supplies are examples of positive, non-environmental externalities.

Major Challenges

There have been and there will be major challenges to the idea that public utility commissions should require utilities to take into account environmental externalities.

First, the point will be made that including externalities will make rates higher, and that this is therefore a bad idea. Second, it will be argued that it is unwise for any given state to do this because it will place its businesses at a competitive disadvantage since other states may not be including externalities. Third, some may challenge the legal authority of the public utility commissions to take these new steps. Fourth, some may claim that the numbers used to estimate environmental externalities are unsubstantiated. Finally, some will question whether their particular state should internalize into its rates the costs of externalities which cause damage outside of its borders.

These objections can not be lightly dismissed. They will be discussed at some length in the course of this workshop.

Why Act

Given all of these difficulties and uncertainties, why would a sane public utility commission want to act on externalities? There are several good reasons. First, many Commissions have been moving toward Least Cost Utility Planning or Integrated Resource Planning. A central theme of these approaches is that utility planning decisions should be made on the basis of a comprehensive review of all of the costs and benefits of all of the options. Environmental externalities are real costs and they are significant ones. For this reason alone they should not continue to be ignored.

Second, there may be a rational approach which we could call "planning anticipation." If we know that as a society we are headed in the direction of increasingly restrictive

environmental standards, perhaps we are best off anticipating that possibility now so that we will not confront premature obsolescence or costly pollution control retrofits in the future.

Finally, it seems clear that most of the environmental problems with which we are dealing are inherently national or international in nature. Acid rain and global warming know no boundaries. Yet in recent years the federal government has demonstrated little proclivity for "showing the way" with developing national and international solutions to these kinds of problems. At many points in history the states have served as "democracy's laboratories," and this role may have fallen to them yet again. In the best case, different states will experiment with different methods of treating externalities; superior approaches will eventually be developed and tested so that the federal government may proceed with national and international implementation. In the worst case, different states will devise conflicting and inconsistent approaches which force the federal government to preempt, and, thus, act. Either case is probably preferable to the current situation.

As we discuss environmental externalities in the course of these three days, a handful of issues will come up again and again. The following is my current perception of the major issues....but I expect to change the list by the end of the workshop!

1) Measurement. How do we measure externalities? Do we use estimates of the cost of controlling pollution; do we make an a priori "policy decision" about what its value is (such as a flat 15% of avoided cost for fossil fuels); or do we begin to make estimates of the actual damages? We probably have to start with one of the first two, but do we then move to estimates of actual damages? If so, how do we quantify these impacts? If we quantify them how can we put dollar price tags on them and how important is it to do so?

2) Rate and Economic Impacts. Everyone is rightly concerned about the size of the rate and economic impacts. One

particular problem with the economic impact is not just that the cost of doing business in the state may rise, but also that the allocation of resources might be skewed if only one sector of the economy (eg. the electrical one) is required to pay for pollution.

3) Mechanism for Incorporation. There are a large number of different mechanisms for incorporating externalities into the decision-making process. "Shadow prices" can be used for planning purposes to provide weightings so that the correct energy alternative is selected -- the shadow prices can then be eliminated so that there is a lesser rate impact. Alternatively, the entire estimate of damage (however derived) can be internalized into rates. There are a number of other variations possible including partial internalization and gradual phase-in through stages.

4) Total Cost Dispatch. A number of states are beginning to move toward inclusion of environmental externalities in the algorithm by which the various generation plants are dispatched. (Some have referred to this as "environmental dispatch," which seems like a counterproductive misnomer).

5) Demand-Side Management Analysis. A number of states include environmental externality estimates in their analyses of the benefits of demand-side management.

6) External Externalities. As discussed above, there are very real political and economic questions about the extent to which states can be expected voluntarily to penalize themselves in order to provide environmental benefits to other states and countries. Some practical compromises probably have to be struck -- what one state does about its external externalities might be related to what neighboring states do about their externalities.

7) Federal and International Role. What the issue of "external externalities" really does is point out the need for federal and international policies and rules.

8) Strategies. There are many different ways to include environmental externalities in our decision-making

process. Anyone contemplating such inclusion needs to think very carefully about how they are going to do so. The following are some preliminary ideas about how to develop programs for incorporating externalities into energy decision making.

STRATEGIES

First, consider establishing the principle conservatively. A full-bore program that calls for an instantaneous internalization of environmental costs, with a resulting 20% increaase in rates may prove unworkably unpopular. The single most important thing to do is to establish the principle that environmental externalities do not equal zero. Seek to establish the principle first; consider ways to gradually roll-in impacts.

Second, ways must be found for explaining externalities programs to interested parties: energy industry, general public, media, business, and politicians. Creative approaches -- based upon development of convergent interests -- must be sought. For instance, some states are seriously exploring environmental taxes -- not just because of environmental concerns, but also because of revenue needs.

Third, it is essential that any commission which considers internalizing externalities be legally sophisticated about doing so for two somewhat opposite reasons. It is possible that the commission will be challenged on whether it has the legal right to internalize externalities. But just as important, it is also possible that a commission be challenged for why it has not included externalities in the energy planning process - given many commissions' broad powers and responsibilities to protect public health and the environment.

Lessons from Economics for Regulators Desiring to Reduce Harmful Environmental Externalities Produced by Utilities

by

Dr. Charles G. Stalon
Director, Putnam, Hayes & Bartlett, Inc.

to the session

Introduction to the Economics of Social Costs

at the

NARUC Environmental Externalities Conference

Jackson Hole, Wyoming
October 1, 1990

INTRODUCTORY REMARKS

For many reasons, the social costs of producing a good or service in a market economy can be higher or lower than the private costs, that is, the costs experienced by the producing firm(s). For example, a profit-maximizing unregulated monopolist whose private and social costs are equal will tend to charge some or all of its customers a price higher than its private marginal cost and, by assumption, higher than marginal social costs. Consequently, its customers will experience private costs higher than social costs. In a society that values economic efficiency as an objective, such pricing is to be deterred. Economic regulators are created to do that. It follows, therefore, that one definition of economic regulation — one seldom used — is regulation to ensure that private cost and social costs are kept approximately equal when market forces are insufficient to do that. Regulators who emphasize the importance of keeping

private and social marginal costs approximately equal will, logically, emphasize the importance of utility rates and rate designs for the improvement of efficiency. This conference, however, has chosen not to emphasize that aspect of economic regulation, but, instead, to look at a different subset of the causes of differences between private and social costs, namely, environmental externalities. I, consequently, will interpret my assigned task to emphasize that subset of social cost analysis as well.

The management of economic externalities is an essential part of the management of a market economy. As we all understand, however, failures in such management is a recurring theme in America's history. As the economic system grows in complexity, the management skills needed to manage the complex economy also become more complex. When David Stockman, Director of the Office of Management and Budget, noted that "None of us really understands what's going on with all those numbers,"[1] he was reflecting the problems of economic complexity just as John Adams had done 200 years earlier in a letter to Thomas Jefferson when he wrote,

> All the perplexities, confusions, and distresses in America arise not from defects in their constitution or confederation, not from want of honor or virtue, so much as from downright ignorance of the nature of coin, credit, and circulation.[2]

I emphasize these observations as a preface to noting that the management of economic externalities is one of the most complex parts of managing a complex market economy. The difficulty of the task, however, cannot be an excuse to avoid the task. The system must be managed if it is to efficiently serve the interest of its citizens. For those few in the audience who are attracted to a laissez-faire ideology — I suspect there are not many at a conference with the subject matter of this one — I support my view by offering interpretations from Lionel Robbins in his study of classical political economists, that is, economists from David Hume and Adam Smith through John Stuart Mill.[3] These interpretations I share and much of what I have to say derives directly from them. First, classical economists emphasized that,

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1 Suzy Platt (ed.), *Respectively Quoted: A Dictionary of Quotations Requested From Congressional Research Service*, (Library of Congress, Washington, D.C., 1989), No. 810.

2 Platt, No. 1200.

3 The contrast should not be overdrawn. Compare: "Even the most ardent enthusiasts of laissez-faire have always seen a role for the state. The traditional list of government tasks — defining property rights, enforcing contracts, producing public goods, and correcting externalities — is relatively uncontroversial." William Bishop, "A Theory of Administrative Law," *The Journal of Legal Studies*, vol. XIX, No. 1 (Part 1), June 1990, p. 497.

> The pursuit of self-interest, unrestrained by suitable institutions, carries no guarantee of anything except chaos.[4]

Second, classical economists emphasized,

> The invisible hand which guides men to promote ends which were no part of their intentions is not the hand of some god or some natural agency independent of human effort; it is the hand of the lawgiver, the hand which withdraws from the sphere of the pursuit of self-interest those possibilities which do not harmonize with the public good.[5]

In short, "the market itself is an artifact."[6] For this social artifact to produce goods and services efficiently (as economists define efficiently), incentives and deterrents are necessary to induce and coerce the production of socially optimal amounts of not only all goods and services, but also all externalities, both beneficial and harmful ones.

THE THEORY OF ENVIRONMENTAL POLICY

Just as some scholars have studied the evolution of English common law and concluded that judges have decided cases and built into the law precedents *as if* an important objective of common law were economic efficiency, one might look at local and national political actions concerning externalities and conclude that politicians have acted *as if* economic efficiency were an important objective.[7] While both conclusions are somewhat pretentious, they do support the conclusion that practical government officials have always been forced to reconcile conflicts among citizens — sometimes among citizens as consumers, sometimes among citizens as producers and sometimes between producers and consumers — and many of the results appear to be reasonably good approximations to efficient ones. As small towns grew into big ones, pigs were pushed out of town; as the technology of medicine improved, inoculations for infectious diseases were subsidized; as internal combustion engines developed, exhaust mufflers were required. The list of social decisions to subsidize the production of beneficial externalities and to tax or otherwise constrain the production of harmful ones is endless. The question before the conference is: What lessons can be drawn for current policymakers from contemporary economic analysis that would allow improved performance in an increasingly complex economy?

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4 Lionel Robbins, *The Theory of Economic Policy in English Classical Political Economy*, (MacMillan and Co., London, 1965), p. 56.

5 Ibid.

6 Ibid., p. 57.

7 Richard A. Posner, *The Economics of Justice* (Harvard University Press, Cambridge, MA, 1981) is a useful place to start to explore this thesis.

The cornerstone of economic efficiency is that people's preferences count. Two ways in which those preferences are revealed are by market purchases and votes for candidates and issues. In the marketplace, the weighting system is one dollar equals one vote, but in the political arena, the weighting system is one adult equals one vote. It is not surprising, given the different voting systems, that sometimes the two systems reveal conflicting priorities. By and large, however, interpreters of both systems of voting (and of other procedures for discovering preferences) find support for the conclusion that most citizens support government efforts to preserve or improve environmental amenities.[8]

The growing consensus supporting the preservation of environmental amenities is probably the result of rising incomes, the crowding effect of a growing population, the relative stability of the national economy and improved knowledge, and extensive media coverage, of harms and potential harms of some environmental insults.[9]

As a consequence of growing environmental consciousness, and in order to provide leadership to that movement, many utility regulators have embraced the idea that utilities should be induced to recognize in their planning and operations the externalities they create for other decision units in society. Concerns seem to be directed primarily at the externalities created by generation.[10] It is important to stress that regulators have for decades recognized externalities. What is new is the types of programs being considered. In the past, generating plants were moved from urban to rural areas in order to improve urban air quality, distribution lines were occasionally undergrounded to improve vistas and repair work in some urban areas was limited to non-business hours to reduce traffic congestion. Furthermore, beneficial externalities were subsidized by ratepayers. Cooling ponds were stocked with fish, and parts of the shores were landscaped to become parks and campgrounds for public use. The noteworthy feature

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8 Louis Harris, *Inside America* (Random House, Inc., New York, NY, 1987) describes 1986 public views as follows:

- 93% are convinced that pollution of lakes and rivers by toxic substances from factories is a serious problem.
- 92% believe that disposal of hazardous waste is a serious problem.
- 86% believe that contamination of drinking water is a serious problem.
- 29% believe that pollution from radioactive waste from nuclear power plants is a serious problem.
- 79% believe acid rain is a serious problem.
- 75% believe air pollution by coal-burning electric power is a serious problem.

However, 73% believe utility shareholders should pay for the cleanup of acid rain. pp. 246-250. Harris notes that these views were stable over the period 1981-1986.

9 An additional factor that is potentially reversible is the reduction in international tensions of recent years. When one's life or basic security is threatened, time horizons become short and discount rates become high. Middle East developments might soon force a re-ranking of relative priorities.

10 The rising concerns about the health effects of EMF may soon change this emphasis.

of these actions is that one can make a strong case that both the cost and benefits of such regulatory actions accrued to the citizens to whom the regulator was accountable.

My task today is not to evaluate the wisdom of particular actions by utility regulators who want to recognize production externalities. Instead, my task is to distill from the body of principles developed by the economics profession some guidance for regulators who value allocational efficiency and who believe it to be a part of their responsibilities to constrain the production of harmful externalities by utilities and to encourage the beneficial ones.[11]

Definitions and Principles

Despite the familiarity with, and the long history of, discussions of economic externalities, the concept is a difficult one to define in a useful manner.[12] Since our objective is not rigorous economic analysis, we can avoid a lengthy discussion of that subject. However, some of my conclusions depend upon rigorous analysis done by others, so it is worthwhile to look briefly at the definition used in such analysis. I choose the one used by Baumol and Oates in their 1988 study on the theory of environmental policy. B&O's definition is as follows:

> An externality is present whenever some individual's (say A's), utility or production relationships include real (that is, nonmonetary) variables, whose values are chosen by others (persons, corporations, governments) without particular attention to the effects on A's welfare. (Emphasis in original.)[13]

This definition conforms fairly closely with less rigorous ones, such as "third-party effects" and "neighborhood effects," but certain elements of the definition need to be clearly understood by those who use the conclusions of the analysis. In order to focus attention on some of the disagreements I expect to see at this conference, and, more

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11 For a brief and easy-to-read criticism of neoclassical economic analysis as applied to environmental assessment, see Charles C. Harris and Mary McGown, "The Propriety of Applying Economic Methods to the Allocation of Public Amenity Resources: Paradigms, Property Rights, and Progress," *Economic Valuation of Natural Resources*, Rebecca L. Johnson and Gary V. Johnson, eds. (Westview Press, Inc., Boulder, Colorado, 1990), pp. 51-65.

12 To my knowledge, the first book-length analysis of the economics of externalities is A.C. Pigou, *The Economics of Welfare*, (MacMillan and Co., Ltd., London, 1920). William J. Baumol and Wallace E. Oates, *The Theory of Environmental Policy*, 2nd ed., (Cambridge University Press, New York, 1989), p. 28, note 23, cite a discussion of market failure that could be called an analysis of externalities in "one of the first textbooks of economics," published in 1819.

13 Baumol and Oates, p. 17.

importantly, to make as clear as possible my chosen points, two elements in the definition are noted:[14]

1. Externalities refer to the effects of real, not monetary, values. The fact that someone or some group imposes a cost, or increased cost, on me, perhaps by increasing their demands for gasoline and, thereby, requiring me to pay a higher price for gasoline, may lower my welfare, but that does not constitute an externality.[15] In short, although an externality will raise or lower my cost if I am a producing unit, or raise or lower my welfare if I am a consuming unit, the normal workings of a market with no externalities can do that also. Externalities are a subset of phenomena that cause such cost changes.

2. The definition presumes a selected set of direct participants of relevance, namely, producing units and consuming units. Policymakers who choose to use the theory that incorporates the definition for guidance in policymaking must assume responsibility for defining the direct participants of relevance. Consequently, one should not be surprised to find differing views among policymakers, and would-be policymakers, about costs and benefits since different users of the theory will emphasize different sets of direct participants. Producing units may be persons, legal entities or parts of governments. Consuming units may be persons, nonprofit organizations or parts of governments. It is the welfare of these consuming units and the welfare of the owners of these producing units that is relevant in the theory that uses the definition. Elephants, dolphins, puppy dogs, snails and amoeba are not direct participants in the model. These and all other gifts of nature are inputs to either or both the producing and consumption processes. Their values, and the values of environmental amenities (inherited or manmade), in the welfare and production relations are those assigned by the direct participants.[16]

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14 A third element also deserves recognition, namely, that the definition is designed for use in analyzing the interactions of self-interest-motivated decision units; charitable or malevolent behaviors are beyond the boundaries of the definition. The reasons for so limiting the definition are obvious. The objective of the exercise is to understand the incentives and constraints necessary to induce a set of rational, self-interested decision makers to produce the optimal mix of goods and services, including the optimal mix of beneficial and harmful externalities. The task of encouraging charity and discouraging malevolence is set aside for another day.

15 Some writers have used the term "pecuniary externality" to describe this result.

16 The interests of unborn humans also enter the theory only through the utility and production functions of direct participants.

Selected Conclusions of the Analysis

With the definition in mind, it is time to turn to some of the conclusions that orthodox economic analysis contributes to issues before this conference. I choose to emphasize four conclusions. As I review the chosen conclusions, keep in mind that the language of economic analysis tends to be much harsher than the language of politics, law and regulation. All of these professions deal with analysis and with resolution of social conflicts, but their emphasis differs. Politics, law and regulation emphasize reconciliation rather than analysis, and, consequently, tend to generate jargons that mask tradeoffs and make it difficult for losers to determine the magnitude and sources of their losses. The multiple meanings of the term "fairness" that are so widely used in politics, law and regulation serve that purpose well. Economics, on the other hand, perhaps because it is practiced primarily by academics who have no responsibility to reconcile social conflicts, tends to emphasize analysis and to emphasize the inescapability of tradeoffs. Calling attention to the welfare reductions of some groups, or in some dimensions of life of some groups, in order to gain benefits for other groups, or in other dimensions of life, is the essence of their activity.

Now to the four conclusions of contemporary economic theory of environmental policy that I have chosen to emphasize:[17]

Lesson One. Conclusions of the theory are derived from a model which postulates economic efficiency as the objective of economic activity. In particular, the distribution of income and changes in the distribution of income as a result of the "recommended" policy actions are ignored. The latter is especially important because it implicitly assumes that just as a competitive market eliminates inefficient beneficial interests in the status quo when increased total welfare can result, so governments will eliminate inefficient externalities without regard to inefficient beneficial interests in the status quo.[18] Since regulators cannot easily ignore distributional consequences of their actions and, furthermore, since they find it especially difficult to remove beneficial interests in the status quo, the ever familiar (to regulators) conflict between efficiency and status fairness arises here as it does elsewhere in economic regulation.[19] The

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17 The conclusions chosen are intended to emphasize principles of importance to the topic of this session. For applications analysis see "Uncertainty and the Choice of Policy Instruments: Price or Quantity Controls," and Part II: "On the Design of Environmental Policy," in Baumol and Oates, op. cit. See also the chapters on Externalities and Internalities in Daniel F. Spulber, *Regulation and Markets* (The MIT Press, Cambridge, MA, 1989).

18 For a discussion of the difficulty regulators have in pursuing efficiency and respecting beneficial interests in the status quo, see E.E. Zajac, *Fairness Efficiency: An Introduction to Public Utility Pricing*, (Ballinger Publishing Co., Cambridge, MA, 1978), and E.E. Zajac, "Perceived Economic Justice: The Example of Public Utility Regulation," *Cost Allocation: Methods, Principles, Applications*, H.P. Young, ed. (North Holland Publishing Co., 1985) and Bruce M. Owen and Ronald Braetigam, *The Regulation Game: Strategic Use of the Administrative Process* (Ballinger Publishing Co., Cambridge, MA, 1985).

19 The conflict between the pursuit of efficiency as defined in orthodox economic analysis and status fairness as commonly viewed in regulatory circles can be illustrated with a comparison of two cases. (continued...)

distributional issues are particularly difficult when dealing with generating plant emissions that harm non-ratepayers since the costs and benefits of any available remedy will tend to accrue to different decision units.

Obviously, the theory does not describe the responsibilities of political leadership. In this area of economic policymaking, as in many others, elected and appointed leaders must decide for themselves the extent to which they will use their powers to satisfy existing preferences of citizens or preferences that would exist if citizens had better knowledge and/or were more "community minded." In short, the theory doesn't answer the hard questions; it merely helps the policymaker to understand his/her options.

Lesson Two. Economic efficiency does not call for the elimination of all externalities, not even all harmful ones. Instead, the efficiency objective calls for accepting certain harms as an inescapable consequence of producing the goods and services that maximize the welfare of the decision units that are direct participants in the economy of relevance. The difficult task is to determine the optimal rate of externality production. Consequently, the pursuit of efficiency cannot usefully be described as an attempt to minimize environmental damages.

Lesson Three. The theory suggests that compensating those harmed by externalities will likely lead to reductions in economic efficiency by reducing their incentives to evade or minimize such harms. This conclusion does not mean that property owners should not be compensated for damages to their property. Negotiating such damage claims, the theory suggests, will tend to lead to the optimal level of such damages. Property rights analogies, however, must be carefully circumscribed. For example, making policy *as if* those harmed had property rights in collectively owned resources is likely to lower efficiency since the essence of property rights, that is, the ability to sell the property right, or sell rights to its use, cannot be meaningfully granted. Consequently, citizens with an imputed property right in collectively owned property cannot negotiate an optimal level of damages.

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[19](...continued)

Case one. Person A locates his religious commune of vegetable farmers in a rural area next to a large number of pig farms and then demands that the government "do something" about the odor. Case two. The Commune's farm neighbors convert their farms to pig farms and Person A demands that the government "do something" about the odor. Economic efficiency suggests that "who disturbed the status quo" is of little if any relevance to the issue. The ideal solution is a tax on the externality produced by the pig farmers equal to the marginal social cost of sufferers. Furthermore, no compensation should be paid to the sufferers. The efficiency objective, in effect, calls for incentives for the creators and the sufferers of the externality to separate themselves. I suspect that policymakers who value status fairness highly would opt for different solutions in the two cases.

[This conclusion supporting a tax (commonly referred to as a Pigouvian tax) should not be read to deny the wisdom of finding another alternative if the taxing solution is administratively infeasible. It should, instead, be read to say that efficiency calls for supporting the imposition of incentives on both producers and sufferers of the externality to reduce the real cost of the externality without regard to who was first in the field.]

Lesson Four. The measures of harms and benefits that arise from externalities must be based on the utility and production functions of the direct participants of relevance. Estimates of the costs of externalities must ultimately be derived from the revealed preferences of consumers or from the production functions of producers. Expert-based mitigation cost estimates or expert-based resource damage estimates are relevant only when related to such utility and/or production functions. In particular, "the economic value assigned to a good does not necessarily measure the value assigned to the objective served by the good."[20]

THE COST ESTIMATION PROBLEM

Since a cost estimate must precede any program to control the production of an externality by a utility — in fact, precede any decision that such an externality deserves special attention — Lesson Four deserves further attention. Two comments will suffice:

1. **The estimation of relevant costs is difficult. Agreement on which costs are relevant among parties with different constituencies may be impossible.**

- The marginal social costs of externalities change over time as additional knowledge is gained and as consumers change their valuation of environmental amenities vis-a-vis other goods and services. Since average incomes are increasing in the U.S. and population densities are growing, and population density tends to increase the significance of many types of externalities, it is plausible to expect the American public to continue to increase the value assigned to environmental amenities.

- Individuals in the economy should be expected to have widely varying valuations of environmental amenities vis-a-vis other goods and services. Consumers who live on high floors in Manhattan skyscrapers, ski in Aspen, fish with a guide, seaplane in Alaska and sun on Caribbean beaches are not likely to assign similar values to environmental amenities as do citizens who suffer the noise of Manhattan streets and who recreate in city parks, if at all. Policymakers who respect both types of preference functions will find it difficult to ignore the distributional effects of environmental policies.

- Technology is changing and such changes might well allow the nation to lower the cost of reducing harmful externalities. Although it has been noted that

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20 G.L. Peterson, B.L. Driver and P.J. Brown, "The Benefits and Costs of Recreation: Dollars and Sense," in Johnson and Johnson, op. cit.

Modern technology
owes ecology
an apology,[21]

It is also true that

Ecology
owes technology
an occasional doxology.[22]

> Those of us who recall that it was the development of high tensile steel pipes that allowed natural gas to displace coal as "the fuel of choice" for urban homes, stores and offices are very much aware that gas economics, more than legislation or regulatory policy, is the source of the clean air that many urbanites breathe.[23]

The difficulty of measuring externalities cost has prevented a consensus among economists on the cost of degradation of natural aesthetics or, in the case of nuclear power, for example, on the cost of the risk of catastrophic nuclear accidents. The difficulty of estimating externalities cost was addressed in a report to the Boston Gas Company by PLC, Inc. That report said:

> . . . the direct estimation of the costs of externalities is usually quite difficult and is frequently impossible, especially for environmental pollution, which has multiple effects on many biological and economic systems. Direct estimation requires that the effects of each pollutant be traced and valued to determine how much the pollution is actually costing society in terms of human deaths, poor health, and material, crop, forest, aesthetic and ecological damage.[24]

Despite such problems, estimates of environmental externalities cost have been attempted. The Pace University Center for Environmental Legal Studies (PUCELS) has just published a thorough work on the topic. This report contains estimates of externalities cost that appear to be very high. It suggested, for example, that the price increase necessary to recognize externalities would be 5.8 cents per kilowatt-hour for a plant which burns 1.2 percent sulfur coal, and 3.9 cents per kilowatt-hour for a coal

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21 Alan M. Eddison, *Worse Verse* (1969). *The Penguin Dictionary of Modern Humorous Quotations*, compiled by Fred Metcalf (1986).

22 Still worse verse by Charles Stalon.

23 Obviously a part of the credit for displacing coal furnaces must also go to the economics of low sulphur heating oil.

24 PLC, Inc., "The Valuation of Externalities from Energy Production, Delivery, and Use; Fall, 1989 Update," p. 38.

plant conforming to New Source Performance Standards (neither type of plant is assumed to have a scrubber).[25]

PUCELS' results were based in part on a cost estimate for sulfur dioxide emissions of $2.03 per pound. This value translates into $4,060 per ton, well in excess of the cost of such emissions implied by the new Clean Air Act Amendments. The Amendments will create a market for emission allowances (i.e., rights to emit sulfur dioxide), in which the price of emissions may be in the range of $400 to $800 per ton (in 1990 dollars), well below the $4,060 per ton in the PUCELS report. Has the Congress undervalued the cost of sulfur dioxide emissions by 80 to 90 percent, or has PUCELS overestimated such cost? Or, are the different estimates of different costs?

In particular, Congress may not be taking as an objective the creation of an emissions trading market in which the market clearing price would approximately equal the cost of sulfur dioxide emissions, in terms of its environmental damage and hazards. Congress could have ensured a higher price for emission allowances rather simply, by specifying in the legislation a fewer number of allowances. It didn't do so. In effect, Congress expressed a value for the externalities cost of sulfur dioxide emissions. That value was well below $4,060 per ton.

The imminent passage of the Clean Air Act Amendments means that perhaps the most costly environmental externality of electric generation, sulfur dioxide emissions, will soon be internalized by utilities in their planning and decisionmaking. Any further tax or constraint by regulators on sulfur dioxide emissions must be based on a judgment that Congress has underestimated the externality cost of sulfur dioxide for the nation or for the direct participants in the relevant efficiency model, or it must be that regulators are in pursuit of an objective other than efficiency.[26]

Another externality of electric generation of great potential significance is the emission of carbon dioxide. There have been a number of scientific studies that assert that carbon dioxide emissions are affecting the earth's atmosphere and there is strong evidence to support the conclusion that the earth's climate will be significantly affected. Federal legislation to effect a reduction in carbon dioxide emissions might assign a value on these emissions, as the Clean Air Act Amendments will likely do for sulfur

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25 "Environmental Costs of Electricity," prepared by Pace University Center for Environmental Legal Studies (Richard L. Ottinger, David R. Wooley, Nicholas A. Robinson, David R. Hodas, Susan E. Babb) for New York State Energy Research and Development Authority and U.S. Department of Energy, September 1990; see Table 1, p. 31.

26 It may not yet be properly understood that the Clean Air Act Amendments will require that the cost of sulfur dioxide emissions be internalized in utility planning and decisionmaking. If current language is enacted, this cost is as real as the cost of coal and the cost of operations and maintenance. Managers who do not take the cost of emissions into account when they make decisions about system dispatch, wholesale power purchases and sales, demand-side options, independent power options, new generation and transmission options and mergers and acquisitions are likely to make wrong decisions. Each ton of sulfur dioxide emitted by a plant represents a ton that cannot be emitted by another plant or an emission right that cannot be sold.

dioxide. When global warming legislation is considered, Congress will naturally be conscious of the benefits of reducing carbon dioxide emissions and will weigh the resulting cost to the nation against those benefits.

Congress is moving cautiously in this area, in part because of the uncertainty in scientific knowledge about the global warming process and because the costs of significantly reducing carbon dioxide emissions will likely be very high. Environmental activists and utility regulators may not be willing to wait for Congress to act. The authors of the PUCELS report, for example, are confident that utility regulators can accurately estimate the cost of environmental damages and assess a fair and efficient externality tax. An early draft of the PUCELS report observes:

> Some experts feel that utility regulatory commissions (as opposed to agencies with environmental expertise like EPA) would have difficulty in dealing with technical matters like valuation of human life and non-monetized costs like valuation of recreational facilities. It should be recognized, however, that utilities regularly estimate values that are difficult to quantify, such as demand forecasts and rate impacts, and state regulatory commissions are able to deal with these estimates.[27]

As an aside observation, I would note that the economic cost of forecasting failures of the 1970s produced political reactions that shook the foundation of utility regulation.

2. Alternative Means of Production and Consumption Have Externalities

An externality tax on sulfur dioxide from coal plants may have the effect of substantially reducing the construction of new coal-fired generation capacity and the utilization of existing capacity. Inevitably, the demand for nuclear power and/or residual and distillate oil by utilities and utility customers would grow. Concerns about the externalities of nuclear power are widespread, and it must be clear to all, at this time of crisis in the Persian Gulf, that oil combustion also has externalities beyond environmental effects.

In its lead editorial on August 19, 1990 entitled "The True Cost of Energy - Pay It: For Security, the Economy and the Air," *The New York Times* said:

> Every extra barrel consumed makes the U.S. that much more vulnerable to oil cartel cutbacks. The price Americans pay for imported oil covers none of the likely costs of future supply interruptions brought on by such dependence.

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27 PUCELS, p. 41.

With the application of a Pigouvian tax recognizing only environmental harms, our society would tend to use and import too much oil. To redress the imbalance, it would be necessary to assess a Pigouvian tax also for the non-environmental impacts of oil combustion.[28] The externalities associated with nuclear power is a topic better left to another time.

CONCLUSION

One program that pursues the objective of reducing harmful emissions on infra-marginal outputs is dispatching plants as if a Pigouvian tax were added to the marginal cost estimate based on private cost only. Such a program would likely lead to substantial reductions in harmful emissions on such outputs. It is also likely to lead to useful incentives for planning capacity additions. Regulators, however, may not find the unit cost increases that result attractive, although such cost increases would, *ceteris paribus*, provide end-users with incentives to cut back on quantities purchased. Such cutbacks would, *ceteris paribus*, be efficiency furthering.

The previous remarks were pitched at a high level of abstraction in order to keep them relevant to a diversity of policy interests. In closing, I would like to emphasize a few points of particular relevance to that subset of the audience which has a particular program in mind, namely, to estimate externality costs of utility generation not for the purpose of raising the price of electricity so that social and private costs are brought closer to equality, but to demonstrate the avoided cost of generation to be higher than the private cost reflected in normal utility accountings and, thereby, to strengthen the case for demand-side management programs. Three points will convey my message.

First, although the theory emphasizes the advantages of a Pigouvian tax equal to the marginal externality costs so that both producers and consumers of the harmful externality have incentives to reduce the externality costs, there is nothing in the theory that rules out alternative programs to generate similar incentives. Many practitioners have shown great creativity in developing approximation programs for that purpose.[29]

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28 The basis for calculating an oil import tariff, which takes these factors into account, was discussed by Harry G. Broadman and William W. Hogan in an article entitled "Is An Oil Tariff Justified? The Numbers Say Yes," *The Energy Journal*, July 1988.

29 Economics provides many lessons of value to regulators who value economic efficiency as an objective. A few of those lessons have constituted the theme of my remarks. The relevance of those lessons is not limited to those who emphasize the importance of efficiency, however. Those who postulate intrinsic values for specific diversity, gene pools and/or particular gifts of nature or particular artifacts, or those who believe that these and/or similar gifts are not adequately valued by others, should gain from these lessons some understanding of the economic welfare burdens they seek to impose on their fellow human beings as they lead them to enlightenment by pursuing policies that conflict with the efficiency objective. The discussions noted in footnote no. 17 discuss this topic extensively. See, also, the essays in the book cited in footnote no. 11.

Second, a demand-side management program, by itself, does nothing to encourage the utility to reduce the output of externalities on inframarginal units of output. If the regulator is serious about pursuing economic efficiency and bringing private and social costs closer together, a program complementary to the demand-side management program is needed to reduce the generation of harmful externalities on inframarginal units of output.

Third, to the extent that programs imposed on a utility to reduce harmful externalities raise its private cost, the position of the utility in competitive power markets is weakened vis-a-vis generators not subject to similar regulatory policies, for example, industrial cogenerators or self-generators, municipal generators, federal generators and out-of-state generators. Furthermore, regulators who find programs to impose on utilities that reduce harmful externalities without raising their private costs are regulators who find either inefficient utility managers or a free lunch.

Here, as elsewhere in the management of a complex, modern economy, policies that promote efficiency when applied nationally are often sources of inefficiency and unfairness when applied in some areas and not in others. That, however, has always been the real world of state regulators.

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INTRODUCTION TO THE USE OF SOCIAL COSTS IN UTILITY PLANNING AND REGULATION

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Environmental quality has become an issue of worldwide concern. Both the use and the deterioration of the environment are examples of what economic jargon refers to as a social cost, that is, a cost to society.[1] Electricity generation incurs social costs. The social costs associated with different modes of generation vary significantly. Thus, to select the generation mix with the lowest overall cost to society requires knowledge of the relevant social costs.

Regulatory commissions have a mandate to ensure that utilities act in the public interest. One way to fulfil this mandate with respect to the environmental impacts of electricity generation is to require utilities to minimize the social cost rather than the cost to the utility. For this reason, regulatory commissions are becoming increasingly interested in the social costs of electricity generation and use.

This paper provides an introduction to social costs and how they can be used in utility planning. I start with a discussion of social costs. Next, I cover approaches to measuring social costs. With this background, I then summarize the use of social costs in utility planning processes. Finally, I review the reasons for regulatory interest in social costs and current regulatory practices as they relate to the use of social costs.

WHAT ARE SOCIAL COSTS?

Put simply, social costs are costs to society. Any reduction in value of society's resources that occurs as a result of the consumption, deterioration, or destruction of a

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[1] The social costs of electricity generation and use extend beyond environmental impacts to include impacts on production, trade balances, the depletion of nonrenewable resources, and other effects. See Olav Hohmeyer, Social Costs of Energy Consumption (Berlin: Springer-Verlag, 1988). This paper focuses on the social costs of environmental impacts because these costs have been the main focus of utility regulatory activity to date.

resource is a social cost.[2] The prices that a utility pays for the resources it acquires often do not reflect the full social cost of the use of those resources. For example, the emissions of atmospheric pollutants that accompany the generation of electricity lead to damages that are a cost to society, but these costs are not borne by the utility.

The components of the value of a resource to society are shown in Figure 1. The first three components relate to the use of the resource. In most cases, the use of the resource involves partial or complete consumption. This is the case for materials and energy as well as for land and labor employed for specific periods. Public goods, such as water bodies and the atmosphere, may suffer deterioration through use. However, some resources can be used without being consumed; birds and scenery can be enjoyed with no diminution. Similarly, resources can be used indirectly through films, books, or other means.

Resources also have value by reason of their existence. The Grand Canyon is a valuable resource because it exists and people value its existence. Although economists are still debating the components of the existence value of resources, two themes can be distinguished. First, stewardship and generosity motives value resources in such a way that they ensure that the resources are well managed and available for use by others. Second, the option value of resources is the value of postponing irreversible actions, such as converting agricultural land to urban use.

HOW ARE SOCIAL COSTS MEASURED?

How can the existence value of a hydroelectric site be determined? What is the use value of the atmosphere? Is the cost of coal to the utility equal to its social cost?

To start with the last question, market prices of resources are not necessarily equal to their value to society.[3] Market prices are often a good first approximation of social costs, but only if there are no market distortions. In the case of exhaustible resources, such as oil and coal, market prices generally do not reflect the full scarcity value of the resources. When used to estimate social costs, market prices should exclude taxes because taxes are transfers among members of society rather than a net cost to society.

Other components of social cost, such as the use value of the atmosphere and the existence value of an undeveloped hydroelectric site, are not approximated by market prices. They must be estimated by other means. To estimate such social costs, it is

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[2] Products and services that are of value to society and that enhance society's resources are social benefits; the value of electricity generated is a social benefit.

[3] The issue of the relevant "society" must first be settled. Is it the population of the service territority, the state, the country, or the world? To date, most regulatory commissions have considered all impacts regardless of where they occur.

Figure 1

Components Of Social Cost

Social Cost = Net Change in

+ Consumptive Use Value
  - private goods: costs of land, labor, materials, and other resources
  - public goods: damage to soil, water, the atmosphere, and other resources for which no explicit charges are levied
+ Non-consumptive Use Value
  - uses such as bird watching that do not consume the resource
+ Indirect Use Value
  - value of resources used indirectly through books, films, photographs, etc.
+ Existence Value
  - bequest value: value of the existence of the resource as a matter of stewardship and generosity[a]
  - option value: value of having the resource available to use in different ways in the future[b]

[a] R. C. Bishop and T. A. Heberlein, "Contingent Valuation Methods and Ecosystem Damages from Acid Rain," University of Wisconsin-Madison, Department of Agricultural Economics staff paper no. 217, 1984, identifies the following five components of existence value:

- bequest motives: the ability to leave an endowment of natural amenities for heirs
- benevolence toward friends and relatives: the ability to give friends and relatives an endowment of natural resources to enjoy
- sympathy for people and animals: sympathy for people and animals adversely affected by environmental deterioration
- environmental responsibility: the personal desire to help prevent or mitigate the damage to the environment that stem from one's own activities
- environmental linkages: the desire to stop deterioration of the environment

[b] The value of postponing irreversible actions. (See, for example, W. M. Hanemann, "On Reconciling Different Concepts of Option Value," Department of Agricultural and Resource Economics, University of California, Berkeley, 1984.) The term "option value" is also used to denote a risk premium associated with uncertainty about the future value of the resource. (See, for example, A. M. Freeman, III, "Supply, Uncertainty, Option Price and Option Value," Land Economics 61 (1985): 176-181.

first necessary to know the approach likely to be adopted to deal with the environmental impacts: prevention, mitigation, or adaptation. Only then can the magnitude of the impact and the social cost per unit of impact be estimated. However, some social costs, such as loss of the Grand Canyon, cannot be assigned a value.

Responses to Environmental Impacts

I have already noted that responses to environmental impacts can be categorized as prevention, mitigation (measures to reduce the impacts), and adaptation (measures to adjust to the impacts). This categorization gives rise to two approaches to estimating the social costs of environmental impacts: one is based on prevention costs, and the other is based on estimated damages. The first approach is based on the theory that, if society is willing to implement prevention measures, then the cost of the prevention measures is a proxy for how much society is willing to pay not to have the impacts. The theory behind using the damage estimates is that environmental damage will occur as the result of the project, and the social costs should reflect this damage. Mitigation and adaptation approaches to environmental impacts involve some prevention or reduction of impacts and some damage due to the residual impacts.

Which approach is "correct"? Prevention costs or damage estimates? Theoretically, prevention costs should only be used if society has "revealed a preference" for the techniques that would be used to reduce or prevent the environmental impacts. Damage estimates are always appropriate in theory, but they can be extremely difficult to estimate. Prevention costs are frequently used in utility environmental evaluations because prevention or mitigation measures are often implemented and these costs are easier to estimate than damages.

Determining the Social Costs

If, for regulatory or other reasons, a utility takes the strategy of preventing environmental impacts, the social cost is the cost of the measures needed to prevent the environmental impacts. If prevention occurs, the utility bears the cost of the preventive measures, and the social cost of the impacts is "internalized." No residual environmental impacts need to be valued. It is tempting to use the cost of prevention as a proxy for the social cost of environmental impacts, even if the preventive measures are not implemented, because the amount is easier to estimate.

If an impact on the environment is not prevented, it often has multiple effects. Emissions of sulfur dioxide, for example, can have adverse health effects and lead to acid rain damage to forests, lakes, and other resources. In the case of multiple effects, the social cost is the sum of the damage associated with each of the individual impacts.

To estimate the social cost of an impact requires two pieces of information:

- the magnitude of the impact; and
- the social cost per unit of impact.

The magnitude of the impact is usually determined from a damage function.[4] A damage function relates the severity of an impact (e.g., the incidence of respiratory illness) to specific discharges (e.g., sulfur dioxide) and other relevant factors (e.g., the ambient concentration of SO_2 and smoking history).

The social cost per unit of impact is applied to the magnitude of the impact to calculate the total social cost. A variety of techniques have been developed to estimate the social costs of different impacts. These techniques include the following:

- **Market prices.** It is possible to use market prices as the basis for estimating the social costs of impacts, for example, the damage to crops or commercial forests that results from air pollution.
- **Hedonic pricing.** Residential property prices are presumed to reflect the amenities of the house, its locational characteristics, and the environmental conditions at the site, so the values of environmental conditions can be estimated statistically from property prices.
- **Revealed preference.** Revealed preference compares behavior in response to different prices and characteristics. The cost of travel to recreational areas is taken to be an estimate of the value of the recreational amenity.
- **Surveys and awards.** People can be surveyed to determine what they would be willing to pay for a particular improvement in environmental quality. Damage awards by judges or juries are sometimes used to value environmental damages.

It is evident even from this quick overview that developing detailed estimates of the social costs of environmental impacts can involve considerable effort. And the results, as shown in Figure 2, are not very precise. The estimates compiled for a specific atmospheric pollutant often vary by a factor of ten.

It is also well established that people consistently demand higher compensation for a given deterioration in environmental quality than they are willing to pay for an equivalent improvement in environmental quality.

[4] The damage function is also referred to as a dose-response function or exposure-response function.

Figure 2

Value of Emission Reductions
($/ton)

	Smog		Greenhouse Gases			Acid Rain
	NO_x	ROG[e]	CO_2[f]	CH_4	N_2O	SO_x[f]
SCAQMD[a, g]	$24,500	$17,500				$18,300
Beach[h]	19,000					
Hertel[i]	40,000					
Marcus[j]	18,800					1,800[j] 590[p]
New York[k]						
ACT[b]	3,417		$44.00			669
MCT[c]	2,700		18.00			486
Chernick[l]	3,000		21.80			700 to 1,560
Nordhaus[h]			18.35			
Steinberg And Cheng[o]			56.00			
IEP[d] Recommendation[m]						
SCAQMD	24,500	17,500	14.70	375	3,700	18,300
California	18,800	1,130	14.70	375	3,700	1,800
Out-of-state	2,700	665	14.70	375	3,700	1,000

Notes:

[a] SCAQMD = South Coast Air Quality Management District (California)

[b] ACT = Advanced Control Technologies

[c] MCT = Mixed Control Technologies

[d] IEP = Independent Energy Producers (California)

[e] Minimum value based on vapor recovery devices. Subject to upward revision if local air quality management districts prescribe more costly regulations to control reactive organic gases (ROG).

Figure 2

Value Of Emission Reductions
(Continued)

[f] Values for SO_x and CO_2 are developed in dollars per ton of pollutant. For dollars per ton of elemental carbon, multiply by 3.67. For dollars per ton of elemental sulfur, multiply by 2.0.

[g] South Coast Air Quality Management District, "Draft Best Available Control Technology Guidelines," October 7, 1988.

[h] R. Thomas Beach, prepared testimony on behalf of Pacific Gas Transmission Company, CPUC 011, 88-12-027, June 1989.

[i] Dennis Hertel, testimony for Southern California Edison Company. Hearing on SCAQMD Rules 1134 and 1135, June 14, 1989.

[j] W. B. Marcus, prepared testimony on Marginal Cost and Revenue Allocation on behalf of Toward Utility Rate Normalization, CPUC App. 88-12-006, Exhibit 235, April 1989.

[k] New York State Energy Office, Division of Policy Analysis and Planning, Environmental Externality Issue Report, February 1989.

[l] Paul L. Chernick, unpublished Paper on Externalities prepared for Boston Gas Company, January 1989.

[m] Gayatri M. Schilberg, Jeffrey A. Nahigian, and William B. Marcus, Valuing Reductions in Air Emissions and Incorporation into Electric Resource Planning: Theoretical and Quantitative Aspects, August 25, 1989, CPUC Docket 88-ER-8.

[n] William D. Nordhaus, "Economic Policy in the Face of Global Warming," March 9, 1990 (unpublished).

[o] H. C. Cheng and M. Steinberg, "Effects of Energy Technology on Global CO_2 Emissions," prepared for the Carbon Dioxide Research Division of Office of Basic Energy Sciences of U.S. Department of Energy, November 1985.

[p] W. B. Marcus, prepared testimony on behalf of the Small Power Producers Association of Nova Scotia, Nova Scotia Public Utilities Board, N.S. Power Corp. Work Order to Construct Point Aconi Coal Plant, March 1989.

HOW CAN SOCIAL COSTS BE USED IN UTILITY PLANNING?

It is useful to distinguish three utility planning processes:

- the approval of new facilities;
- the evaluation of supply- and demand-side bids; and
- least-cost planning.

A new facility, such as a generating station, is first evaluated by a utility from a corporate financial perspective. To gain regulatory and other approvals for the project, a cost-benefit study may be needed to demonstrate that it yields net benefits to society. Environmental impacts should be included among the social costs in the benefit-cost study.

Increasingly, utilities are using bidding processes to acquire additional supplies or to reduce demand. The bid evaluation process is the utility's opportunity to obtain the best match between supplies, demand reductions, and its own plans. Environmental considerations are being integrated into the scoring systems used to evaluate bids.

In a least-cost planning process, a utility develops forecasts of its future electric loads, assesses the costs and remaining lifetimes of its existing supply facilities, and identifies the requirement that it needs to meet through demand-side management programs and/or new generating capacity. Then, the utility evaluates a broad range of supply, demand, and pricing options for meeting the requirement by using appropriate computer models to arrive at a least-cost plan.

The financial costs of each demand and supply option are a key input to utility least-cost planning. The social costs of environmental impacts can be used in the computer models in the same manner as the financial costs. The resulting plan is the least-cost plan from society's perspective rather than from the utility's perspective.

The social costs of environmental effects can be incorporated into benefit-cost studies of new facilities, least-cost planning processes, and the evaluation of supply- and demand-side bids.[5]

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[5] Utility planning processes that do not involve the estimation of social costs are also available. Point scoring systems for environmental impacts have been developed for use in the evaluation of bids. Least-cost plans can be developed to meet various environmental targets and constraints, and lowest emissions dispatch algorithms can help meet new environmental targets with existing facilities.

WHY ARE UTILITY REGULATORY COMMISSIONS INTERESTED IN SOCIAL COSTS?

All facilities are designed and operated to comply with applicable environmental laws and regulations. The social costs of residual environmental impacts are difficult to estimate and subject to wide margins of error. It is relevant to ask whether utility planning is improved by incorporating such unreliable data into utility planning analyses.

Consider the implications of not including environmental costs in utility planning processes. Ignoring the residual environmental impacts implicitly assigns them a value of zero, which is clearly wrong. It can be argued that even a crude approximation of the social costs is better than assuming that these costs are zero.[6] The social costs of the residual environmental impacts are quite different for various supply- and demand-side options. Ignoring the cost of residual environmental impacts favors the options with the largest impacts.

The implications of not considering the social costs of environmental impacts when preparing utility plans lead to two arguments in favor of regulatory action to require such consideration:[7]

- Utilities are granted a monopoly franchise in return for an obligation to serve the public interest. The public interest includes an obligation to consider and mitigate environmental impacts.

- Power plant investments have a long life. More stringent legislative and regulatory requirements to address environmental impacts can be anticipated over that period. It is prudent to anticipate such requirements and thus to minimize future retrofit expenditures.

If the environmental costs of electricity generation are so large that they cannot be ignored, will including them have dramatic consequences for rates? In most cases, the impact on rates will be quite small. The social costs are not cash expenditures that the utility has to recover from rates. Rather, using social cost for planning purposes leads to the selection of supply- or demand-side options whose cost to the utility may be somewhat higher than if the social costs had been excluded. But the incremental cost will be less than the social costs. It is the incremental cost for the new resources acquired that constitutes the impact on rates. When this increment is spread over the rate base, the impact will generally be quite small.

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[6] Vermont Public Service Board, Proposal for Decision, Docket no. 5270, July 1989, Volume III at 84, and P. F. Bland, "Problems of Price and Transportation: Two Proposals to Encourage Competition from Alternative Energy Resources," Harvard Environmental Law Review 10 (1986): 345.

[7] Richard L. Ottinger, "Getting at the True Cost of Electric Power," The Electricity Journal, vol. 3, no. 6 (July 1990): 14-23.

WHAT ARE THE CURRENT REGULATORY PRACTICES?

Regulatory practices relating to the inclusion of environmental costs in utility planning practices are evolving rapidly. In such an environment, it is not surprising that the ability and intention to address the issue outstrips actual experience by a wide margin.

Action to require utilities to incorporate environmental costs in planning and/or bidding has been taken, or is under active consideration, in 26 states.[8] In 18 of these states, legislation has been passed or orders have been issued by the public utilities regulatory commission.[9] As yet only California, Colorado, Massachusetts, New Jersey, New York, Oregon, Vermont, and Wisconsin have adopted orders that involve the establishment of quantitative measures of environmental impacts.[10] Only a few cases have as yet applied social costs to the environmental impacts of proposed resource acquisitions.

Pacific Power and Light (PP&L) in Oregon has filed a long-term integrated resource plan that addresses environmental costs. In the short term, the inclusion of environmental costs has little effect on PP&L's plans because "alternatives without such impacts (energy-efficiency and system-efficiency programs) already have higher priority ... based on internal costs, and the amount and timing of these alternatives is not particularly sensitive to the costs assumed for externalities."[11]

Procedures for incorporating environmental costs into the analysis of options are most advanced for the evaluation of bids. As shown in Figure 3, several states have developed "social cost adders," which they use before selecting a successful bid, to adjust the monetary costs to the utility for projects that give rise to specified environmental impacts.[12] The environmental impacts, and hence the social costs, of each project are unique. Estimating these project specific social costs can be time-consuming and costly. A social cost adder approximates the project specific impacts with social costs estimated for a "typical" project.

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[8] Richard L. Ottinger, "Getting at the True Cost of Electric Power," The Electricity Journal, vol. 3, no. 6 (July 1990): 21.

[9] See Figure 3.

[10] S. D. Cohen, J. H. Eto, C. A. Goldman, J. Beldock, and G. Crandall, "Environmental Externalities: What State Regulators are Doing," and L. O. Foley and A. D. Lee, "Scratching the Surface of the New Planning: A Selective Look," The Electricity Journal, vol. 3, no. 6 (July 1990): 24, and 48, respectively.

[11] Pacific Power and Utah Power, *Planning for Stable Growth: The Pacific Power and Utah Power Resource and Market Planning Program*, 2 vols., 1989, 1:10.

[12] Alternatively the costs of projects that do not give rise to the specified environmental impacts can be reduced before the winning bids are determined.

Figure 3

States that Require Consideration of Environmental Impacts in Utility Plans

Ottinger[a]	Cohen et al.[a]
Alaska	Arizona
Arizona	California
California	Colorado
Colorado	Connecticut
District of Columbia	Idaho
Idaho	Kansas
Kansas	Massachusetts
Massachusetts	Minnesota
Michigan	Nevada
Nevada	New Jersey
New Jersey	New York
New York	Ohio
Ohio	Oregon
Oregon	Pennsylvania
Pennsylvania	Texas
Texas	Vermont
Virginia	Wisconsin
Wisconsin	

- **Northwest Power Planning Council:** recommends 10% cost discount for conservation programs
- **Wisconsin:** requires 15% cost discount for non-combustion resources
- **Oregon:** requires 10% cost adder on supply-side projects
- **New York:** environmental factors represent 15% of possible points in the bid scoring system
- **Vermont:** provides 10% discount for demand-side management programs plus a 5% adder for supply-side resources
- **California:** collaborative process recommends 10-25% supply-side cost adder

Figure 3

States that Require Consideration of Environmental Impacts in Utility Plans (Continued)

Note: [a] The differences in the states identified reflect differences in timing and methodology. Ottinger reports (fn. 17) legislation as pending in Connecticut, Minnesota, and Vermont whereas Cohen et al. report that PUC activities are operational in these states. Cohen et al. surveyed utility commissions; Ottinger considered legislation in addition to utility commissions.

Sources: Richard L. Ottinger, "Getting at the True Cost of Electric Power"; S. D. Cohen, J. H. Eto, C. A. Goldman, J. Beldock, and G. Crandall, "Environmental Externalities: What State Regulators are Doing," and L. O. Foley and A. D. Lee, "Scratching the Surface of the New Planning: A Selective Look," The Electricity Journal, vol. 3, no. 6 (July 1990): 14, 24, and 48, respectively.

Applying the social costs of a typical project to specific projects has two advantages. First, they provide an easy way to approximate the full social costs of a project. The environmental impacts of each project are explicitly recognized and their social costs are attributed to the project. Second, the effort required to estimate the social costs of various environmental impacts can be spread over numerous projects. The social cost adders currently in use are crude approximations of environmental impacts. Principally, they are estimates of atmospheric emissions that are based on the estimated cost of prevention.

Once regulatory agencies and utilities have decided to incorporate social costs into utility planning processes, regulatory commissions can facilitate the process by determining:

- appropriate values for the social costs of environmental impacts; and
- how to use the social costs in specific planning processes.

Decisions on these matters can greatly simplify the process of incorporating social costs into utility planning.

CONCLUSIONS

Policy measures dealing with environmental impacts attempt to have all goods and services bear the full social cost of production. The principle that the polluter pays for the impacts of his or her actions reflects this objective. Regulations requiring firms to eliminate the source of an impact or to reduce it to an acceptable level are a common way to deal with environmental impacts. Because the polluter is forced to bear the cost of alleviating the problem, it gets reflected in the cost of production. Using the social costs of electricity generation and consumption in utility planning simulates this situation even if the utility is not required to bear the full cost of its impacts on society.

Increasingly, utilities will need to know the social costs of environmental impacts to help them with their planning. Unfortunately, estimating social costs can be conceptually demanding, time-consuming, and expensive. Hence, techniques to reduce the effort needed to estimate social costs without significantly compromising their accuracy have considerable appeal. Generic social cost estimates, such as "social cost adders," are added to the financial costs of projects in some jurisdictions in an effort to approximate the social cost of each project. The social cost adders may not be accurate for specific projects or environmental impacts but ignoring the impacts may be an even larger distortion.

By incorporating the social costs of environmental impacts into its planning processes, a utility is able to develop a plan that minimizes the overall cost of electricity generation to society. This type of planning may not yet be a formal requirement, but it is quickly becoming an explicit obligation. Eventually, regulatory

changes are likely to force utilities to move closer to socially optimal planning. Anticipating such requirements in plans may be financially more attractive than complying with environmental regulations after they have been promulgated.

MONETIZING EXTERNALITIES IN UTILITY REGULATIONS: THE ROLE OF CONTROL COSTS

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Introduction

Monetizing environmental externalities provides an approximation of the societal value of reducing impacts on human health and the environment from electrical energy supply, including utility and non-utility fossil-fired generation, DSM and off-system power purchases. A dollar estimate of the full societal cost of the supply option is established by placing a value on the air, water and terrestrial effects of each supply option and adding that to the option's capital, operating and maintenance costs. Repeating this exercise allows different electric power supply options to be compared on a full-societal cost basis. In monetization, these externalities are expressed as a cost/unit of the externality, such as $/lb of emissions or $/gal of water consumed, and the full societal cost is usually stated as a cost/kWh generated.

In this paper, externalities are briefly defined, and the strengths and weaknesses of four techniques for monetizing externalities are then discussed with examples of the application of each method. A rationale for monetization of externalities is provided, and the authors' preferred technique for incorporating externalities into utility planning in the near term, implied valuation through the estimation of the marginal cost of abatement, is discussed in detail.

Definition of Environmental Externalities

We use the term "externality" to refer to any cost or benefit that is not reflected in the price paid by a utility or its customers for energy-related goods or services. Only environmental externalities are considered in this paper, although other important economic and social externalities also exist. Examples of environmental externalities include the health and environmental damages caused by the emission of air pollutants, and impacts on aquatic ecosystems from the water consumption of a power plant cooling system.

Energy production and consumption, like most human activities, produces a range of external environmental effects. Some of those effects are well-understood, predictable effects, such as the amount of land required by a facility. Other effects

are strongly supported by empirical evidence, such as ambient pollution effects on human health. Some represent risks, which may be well-understood, both as to probability and effect, or may be highly uncertain. For example, the designers of a dam may know that there is a one-in-a-million chance of the dam's failing and killing 2,000 people. Similarly, the number of people who will be killed in grade-crossing accidents involving coal trains is unknown, but the probability distribution may be highly predictable. Still other consequences are not fully understood in a technical sense, such as the effect of trace gas emissions on global warming and the effect of global warming on human and ecological systems. Finally, the net effects may be difficult to determine: the construction of a water reservoir may provide recreational benefits and habitat for waterfowl, but destroy other recreational opportunities, flood wetlands and disrupt the habitat of other ecosystems.

Scope of Analysis

The complexity and results of an analysis of externalities are influenced by geographic scope. Some analyses of externalities are specifically designed to evaluate only those effects that occur in a specific service area or state. For example, Massachusetts Department of Public Utilities has determined that externalities of electric power sources must be considered regardless of where they occur, while Vermont will include only costs that have some connection to state residents. This type of limitation can simplify the assessment process, by excluding some impacts, or complicate the process, by requiring the identification of the location of each externality. For example, if oil spills were to be included in the analysis only if they occurred in New England waters, it would be necessary to determine the port through which marginal supplies of oil were imported.

Geographic scope also affects the evaluation of specific externalities in other ways. For instance, some results of energy production, such as suspended particulate emissions, have varying effects, depending on the area in which they are deposited.

The scope of an externality analysis may also be affected by decisions to exclude classes of effects, or to limit the method of valuation. For example, an analysis that valued all effects at market prices (e.g., an otter at the price of its pelt, a human life at the present value of lost wages, wilderness at the income it generates in tourism) would miss

some important aspects of many effects, but would be somewhat simpler to perform than a study that attempted to determine a total social value for each affected system.

One reasonable approach to limiting scope is to identify in advance the marginal sources of energy and related products and services. For example, if we can trace the marginal source of residual oil for utility boilers in New England (e.g., Venezuelan oil, refined in the Caribbean, and imported by tanker), then we can largely ignore the externalities produced by other supplies (e.g., new wells in the Rocky Mountains or enhanced oil recovery in Alberta.) Similarly, if we know that the marginal source of transmission capacity is an upgrade of an existing line, rather than a new line on a new right-of-way, then we can limit our analysis to identifying the externalities from the pipeline upgrade. The identification of fuel source, transportation method, technologies employed and their related externalities may not be easy. Indeed, the externality values we are estimating may ultimately influence the choice of new power supply technology and fuel options.

The choice of externalities to be included in utility planning and the scope of the evaluation are largely independent of the method of estimating the externalities. The methods discussed in this paper were developed to estimate externalities for decisions concerning utility and non-utility fossil-fired generation facilities, DSM, and off-system power purchases that are fossil fuel-fired at the margin. However, they are also applicable to the evaluation of the externalities of hydro-electric, nuclear or other energy supply or demand reducing options.

Valuation Methods

In general, four basic approaches have been used to estimate environmental externalities:

1. Estimating the relative physical, chemical, or toxicological potency of various pollutants;

2. Polling of experts or other people;

3. Direct estimation of the environmental effects of a pollutant, and the valuation of each of those effects; and

4. Determination of the implied societal value of reduction of the pollutant, from the maximum cost society has committed (or appears about to commit) to pay for reductions of this pollutant.

In the first two approaches, relative potency and polling, the relative values of specific externalities are estimated. These relative values can then be translated into cost (monetized) by estimating the value of one of the externalities, and relating the other related externalities to it.

Relative potency, works quite well for estimating the relative importance, or value, of the major energy-related greenhouse gases (CO_2, methane, N_2O, CO and NO_x). The relative values of reducing emissions of the greenhouse gases can be related to the value of reducing CO_2 emissions, by correcting for the shorter lives and lower molecular weights of the other greenhouse gases, and properly discounting the effects of the gases over time. Lashof and Ahuja (1990)[7] estimate that the instantaneous global warming potentials (GWP) of the greenhouse gases relative to CO_2 are: 10 for CH_4, 180 for N_2O, and 2.2 for CO. (That is, CH_4 is ten times as potent as CO_2 on a weight basis.) Chernick and Caverhill (1990a)[2] discounts the value of future emissions of the greenhouse gases and uses Lashof and Ahuja's results to estimate the relative <u>value</u> of reducing emissions of the greenhouse gases as: 76 for CH_4; 320 for N_2O; and 6 for CO. These results are based on a discount rate of 6% real.

Relative potency might also be used for estimating the relative importance of other externalities. Data in Hendrey (1986)[5] implies that the acid rain damages caused by NO_x are 83% those of SO_2, per pound of emissions (Chernick and Caverhill, 1989).[1] Hohmeyer (1988)[7] cites work by Grupp (1986),[4] which finds that the toxicity of SO_2, particulates, and VOCs are equal per pound of emissions, and that NO_x is 25% more toxic per pound. Grupp's estimates appear to refer only to acute human toxicity, although Hohmeyer applies them for all purposes. While relative potency provides probably our best estimates of the relative value of reducing greenhouse gas emissions, it may be inferior to the more direct monetizing techniques, described below, for the other major air pollutants.

The second approach, polling, can be employed in valuation if the polling instrument is designed carefully, and the poll respondents are experts in the field in question and are informed of the intended use of the poll results. For example, it may be useful to poll epidemiologists on the coefficients of the dose-response functions relating human illness and death to pollution levels. However, the results of a polling effort can be useless for valuing externalities, or worse, misleading. A good polling effort must: (1) poll a representative sample of experts in the field of interest,

and publish the names and credentials of the respondents for public review; (2) provide a clear statement of the question to be answered in the poll, and the intended use of the answer; and (3) make the polling instrument and the respondents' answers available for public review. If the polled respondents are not experts in the field in which they are responding, or the results of the poll are used for a purpose unintended by the respondent, then the results will be useless for valuation. If the question posed is vague, then the respondents' answers may not be interpreted in the way they were intended. If the credentials of the respondents and their answers are not available for public review, it is difficult to rely on the integrity of the results for decision making. Polling is unlikely to provide better information than the other methods of estimating externalities presented here. Certainly, its usefulness is critically dependent on the quality of the polling instrument and credentials of the respondents. New England Electric Service (NEES) appears to be the only utility (or any other analyst) that has attempted to value externalities using a polling approach.

Direct assessment and valuation, the third approach, attempts to identify all quantifiable effects of an externality to society. In general, each effect must be quantified, and a unit cost must be established. This procedure is generally treated as if it were a technical exercise, but the definition of relevant externalities, selection of important effects, choice of quantification measures and techniques, and determination of unit cost are often highly judgmental and subjective.

For environmental externalities, such as air pollution and water pollution, the relevant effects might include impacts on: human life and health; human comfort and pleasure including effects of noise levels, visibility, and odors; domesticated plants and animals, such as commercial forests, livestock, crops, and lawns; wild plants and animals in a variety of habitats; and non-living materials, such as those exposed on buildings (especially stone and paint), at archeological and historical sites, on monuments, on vehicles, and in natural landforms.

Determination of at least some of the social costs of some environmental externalities is feasible, although this process is complex. In principle, direct estimation requires the determination of how the pollutant moves through the atmosphere, how it changes chemically (especially for precursors to ozone and to particulates), how it is deposited on various surfaces (lungs, soil, water, paint, etc.), how much it affects each system (including visibility, human health, crops, materials, wildlife, etc.), and the unit value

of the effects on each system. In fact, the transport calculations are very complicated, and the atmospheric chemistry and dose-response relationships may be highly uncertain.

Even when these difficult technical issues have been resolved, tough policy questions remain in the valuation of effects. Costing of market-valued goods such as agricultural production and paint can be relatively straightforward. It is more controversial to assign values to human morbidity and mortality (which are themselves complicated by many subcategories including age, health, duration of illness, and the extent of suffering and dread), as well as to visibility, historic monuments and forests, wildlife and ecosystems.

Direct estimation of environmental costs is a daunting and time-consuming task, given the multi-disciplinary background needed by those responsible for assigning values to human life and health, visibility and other non-market costs. Yet if the assessors exercise caution in understanding data sources, correcting errors and reflecting regional differences, all to the extent feasible, direct estimation serves as a highly clear and workable method to value what seem to be intangible external costs. For a more detailed discussion of direct estimation of externalities see Ottinger, et al. (1990, in print)[10] or Chernick and Caverhill (1989).[1]

The fourth approach, implied valuation, relies on the costs of required or anticipated regulations or control measures to estimate a societal value of reducing emissions of particular externalities. For example, the new Clean Air Bill, once adopted, gives us specific information about what society is willing to pay, on a national basis, to reduce SO_2, NO_x, VOC and toxic air emissions. Similarly, other federal or state regulations provide estimates of the value of reducing externalities at the margin. This method is also referred to as shadow pricing, revealed preference and marginal cost of abatement. There is increasing use of the cost of abatement to determine the value of reducing externalities, specifically in California, New York and most recently Massachusetts. The strengths and limitations of this method are discussed in more detail in the following sections.

In the third and fourth approaches, direct estimation and implied valuation, the value of reducing each externality is monetized. Typically, values are expressed in such terms as $/pound of pollutant emitted, or $/unit of the externality. The combined value of all of the externalities of a power source (expressed in $/kWh, for example) is then the sum across externalities of the following product:

Amount of each pollutant emitted (in units such as pounds/kWh)	X	Unit value of that pollutant (in this case, $/pound)

In the next two sections, we discuss why monetizing externalities is appropriate, tractable and provides reasonable estimates of the value of reducing externalities, and concentrate on the implied valuation technique in more detail through a discussion of its application and associated uncertainties and analytical difficulties. For simplicity, we will discuss generic approaches in the context of externalities for which $/lb valuation is appropriate.

Why Monetize Externalities?

There are several reasons why explicitly monetizing externalities is the best way of including these external effects in supply planning.

1. Externalities are already assigned values, or monetized, in utility planning. Since power supply decisions necessarily consider the capital and operating costs of supply options, the assumptions made about other non-price factors, such as the inclusion (or exclusion) of external effects, imply a value for those non-price effects.

2. Currently, most jurisdictions assign externalities a value of zero by ignoring effects beyond permitted levels. Utility planners who do not consider environmental effects of energy supply in their decisions are implicitly (or explicitly) valuing externalities at zero. Clearly, the emissions from a utility plant located in the Northeast contribute to ambient air quality problems and therefore an emissions reduction has positive value; similarly, reduction of externalities in other jurisdictions has positive value also.

3. Some states have adopted generic price adders for externalities to account for the environmental benefits of DSM measures. Even though these are not disaggregated into individual externalities, they do provide a rough monetary estimate of the total value of reducing the environmental (and other) costs of supply-side options when compared to DSM measures. However, adders are generally related to the cost (or price) of the supply option, and bear no relation to actual environmental effects or societal preference for reductions. In some cases this has the exact opposite effect than was

intended: cheap but dirty existing coal and oil power plants are given a lower externalities adder than cleaner but more expensive new coal or gas plants.

4. The New York Public Service Commission and the California Energy Commission have explicitly valued several externalities including major air emissions and, in the case of New York, water and land use externalities. In some cases the values chosen are placeholding values, but they clearly support specific non-zero values for these externalities. The inclusion of externalities has thus been established in regulatory decision-making in these and other jurisdictions.

5. The estimates developed through monetization are based on various measures of our society's willingness to pay for reducing externalities, such as regulations, and are independent of the price of supply options or, in many cases, individual utility regulations.

6. Explicit monetization can be locally or regionally consistent, as appropriate for the externalities under consideration. The societal value of reducing a regionally or globally important externality should be largely independent of the source of that externality, while the location of a source with an externality causing local effects will be much more important.

7. Explicit monetization is reviewable and reproducible. Unlike other methods proposed for incorporating externalities in utility supply planning, such as ranking or rating and weighting, the estimated externality values from monetization replace judgement of objective analysis and reasoning, and can be refined in an iterative process through information provided by interested parties.

8. Explicit monetization can be consistent across utility options. While a simplistic percentage adder can reflect the environmental benefits of energy conservation, it can not distinguish between dirty and clean, but possibly more expensive, supply technologies and fuels. A pound of SO_2 emissions reduced through the use of scrubbers or lower sulfur fuel is as valuable as that reduced through conservation or any other means, and the cleaner supply options should be credited with that benefit.

9. Explicit valuation encourages individual plant innovation to improve efficiency, reduce emissions and reduce other externalities beyond required levels, while percentage adders do not.

As we will show, it is feasible to generate credible estimates of the value of reducing environmental impacts through at least one valuation approach, implied valuation.

Implied Valuation and Cost of Abatement

As used in this method, the cost of pollution control is sometimes described as if it were a proxy for the cost of emissions. In fact, the costs of control provide direct information on the societal value of emission reductions, under two theoretical approaches.

First, the cost of required control measures serves as an estimate of the price that society is willing to pay to reduce the pollutant. If legislators and regulators require measures that cost as much as $2/lb to reduce sulfur emissions, it seems reasonable to assume that reducing emissions from those sources must be worth at least $2/lb, and that reductions from other sources (due to conservation or fuel choice) must also be worth $2/lb at the margin. This is the rationale behind the "implied valuation or revealed preference" approach to the use of control costs for valuing externalities.

Second, the costs of required controls may directly establish the social benefits of reducing emissions, to the extent that they define the direct pollution-control costs that can be avoided by an exogenous reduction in emissions. If the objective of environmental regulation is to maintain a given level of ambient air quality, the construction of a less polluting plant or the reduction in output requirements due to energy conservation will allow regulators to back out the most expensive control measures that would otherwise have been required.

One important aspect of the implied valuation approach is that only the marginal cost of control matters. From the "implied preference" perspective, the fact that many required controls are inexpensive, or even that some inexpensive controls have not yet been required, is irrelevant to the determination of the marginal price society is willing to pay. From the avoided-control-cost perspective, the appropriate estimate of the social cost of control is the highest-cost item that will be required, since conservation (or low-pollutant generation) will allow that most expensive measure to be avoided.

One general criticism of this approach is that the highest cost of control is a reasonable estimate of the value of reducing emissions only under a mandate requiring an additional reduction. The costs of controls required in the past to correct historical environmental problems are not directly relevant to determining the value of reductions in

pollution today, especially if the environment is now much cleaner. In our earlier work, and most recently in our analysis of the implications of the New York State Energy Plan regarding the costs of required controls, we have used current and future costs to maintain or improve air quality.

Further, for the foreseeable future there is a clear mandate for reductions in ambient levels of SO_2 and NO_x, and in CO_2 emissions in many states. For instance, the goals and objectives of the New York State Energy Plan recommend specific emissions reductions to improve air quality in New York including a 50% reduction in SO_2 emissions from 1980 levels, a 25% reduction in NO_x emissions from 1988 levels for stationary sources and possibly a 25% or greater reduction in NO_x emissions from mobile sources. For the greenhouse gas CO_2, the recommended target is a 20% reduction in emissions by 2008. These targets respond to the deficiency of current emissions regulations to meet ambient air quality standards. In other words, an individual source may be in compliance with its emissions permits, but its remaining emissions, no matter how small, contribute to degraded ambient air quality.

Wherever future measures (including application of current regulations to future facilities) will be necessary to achieve or maintain acceptable pollution levels, the incremental cost of the required control for that pollutant provides a reasonable value for reducing emissions of that pollutant at the margin. Note that we are not simply urging the use of the highest cost we can imagine, or that has been proposed; we refer to the highest cost among those that are likely to be imposed in the absence of reduced energy generation. Further, we are interested in the incremental cost of control. We use the term "incremental" because pollution control options tend to occur in discrete blocks, corresponding to particular rules, although the term "marginal" would also be appropriate. By definition, the incremental cost is the highest cost of required controls.

Given this definition, the marginal control cost represents the highest cost society has explicitly demonstrated a willingness to pay for recent or future reductions of an externality. Obviously, society is happy to pay less, if it can get the reductions for a lower cost. However, the amounts which are effectively available at the lower price must be exhausted, or else the higher-cost measures would not have been required. However, the marginal cost of control is probably lower than the value of reducing an externality at the margin. The next-more-expensive option may be so much more expensive that it is deemed to be above the societal value or it is unfeasible for other technical or policy reasons. Examples of abatement options which are at least

partially constrained by technical and policy constraints include the use of CO_2 scrubbers or the use of nuclear power to replace fossil fuels. This concept is illustrated in Figure 1 where the estimated marginal cost of abatement is shown to be below the highest cost of control currently required under regulations, significantly below the cost of the control option rejected because it is currently too expensive, and below the "true" societal value (labelled "optimum value").

Our estimates of the marginal control costs are actually understated by even more than implied by this argument. We have deliberately selected values somewhat lower than the very highest marginal cost we have identified, so they are probably lower than the actual value of reducing externalities at the margin.

It seems unlikely that the marginal value of reducing externalities would drop sharply in the range of reductions individual states are considering. Indeed, the cancer-promoting characteristics of NO_x, the carcinogenic properties of NO_x reaction products, and many other externalities, probably have no threshold for their effects. Our use of the implied valuation method does <u>not</u>, as some critiques have assumed, estimate the value of eliminating an externality (Figure 2, cross-hatched area). Even if the more ambitious of the utility DSM programs were replicated state-or country-wide, no major externalities would be eliminated. We are estimating the value of marginal improvements in air quality by relating emissions reductions to air quality improvements. Therefore, the value of reducing the <u>next</u> unit of an externality is close to (and perhaps indistinguishable from) the value of reducing the <u>preceding</u> unit. This is shown in Figure 2 as the darkly shaded area.

Even if the environmental damage of emissions dropped sharply as successive emissions reductions were achieved, the marginal cost of abatement <u>still</u> represents a minimum estimate of the marginal value of reducing emissions, to the extent that society will be able to back out or avoid expenditures on the most-expensive control measures on new plants or future retrofits. This concept is illustrated in Figures 3 and 4. Figure 3 illustrates that if a conservation program is adopted, the demand for supply side controls will shift downward thus allowing the most expensive supply-side emissions reduction options to be backed out. Figure 4 illustrates the same point somewhat differently, in that the requirements for supply-side emissions reductions, which are shown as a constraint, will be reduced by a conservation program, again avoiding the most expensive control measures. Until all of the SCR, which is and will be required on new

Figure 1

Supply Curve for Emissions Reductions

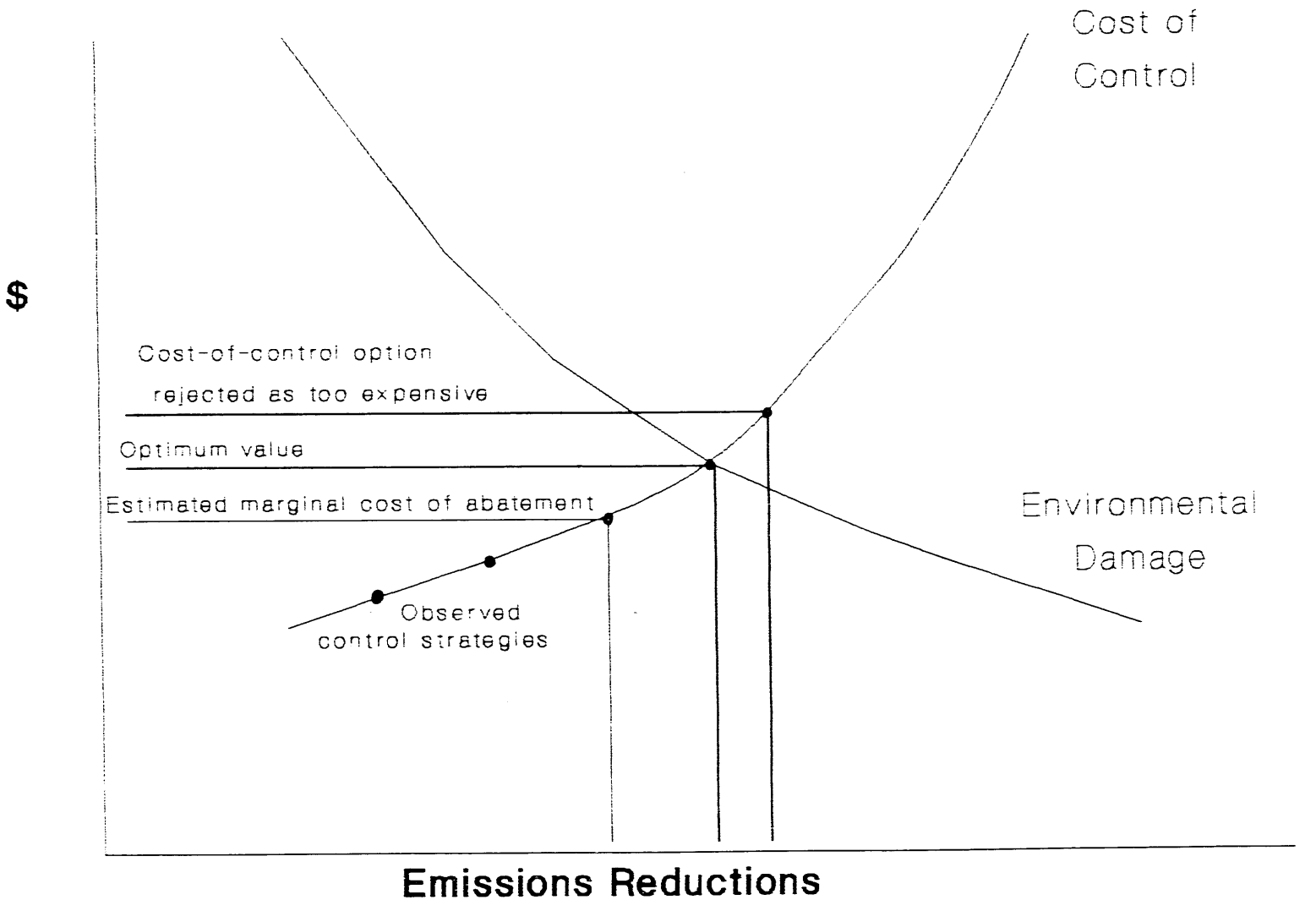


Figure 2 .
Valuing Realistic Reductions
in Externalities

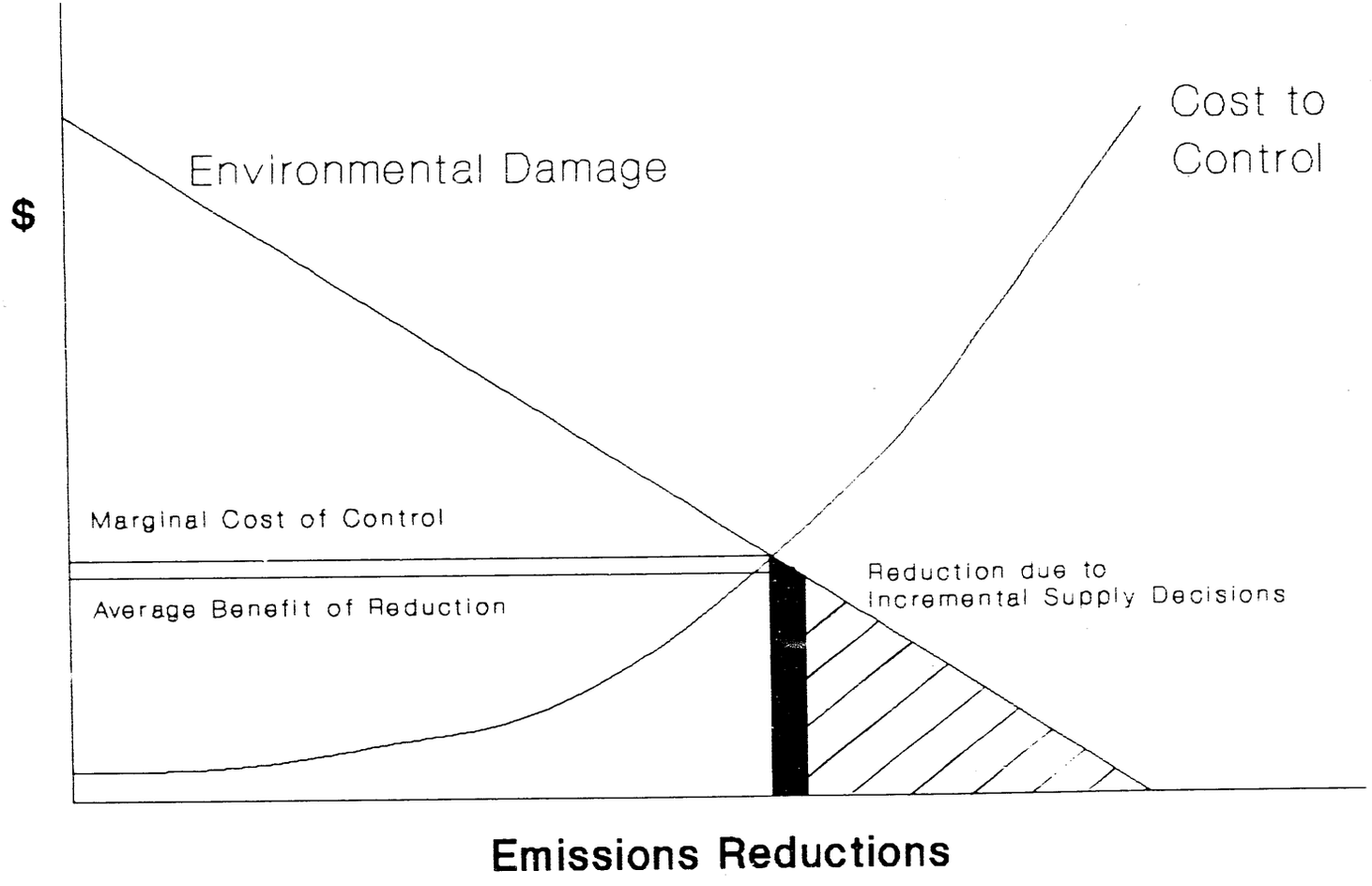


Figure 3: Reduction in Demand for Supply-Side Controls

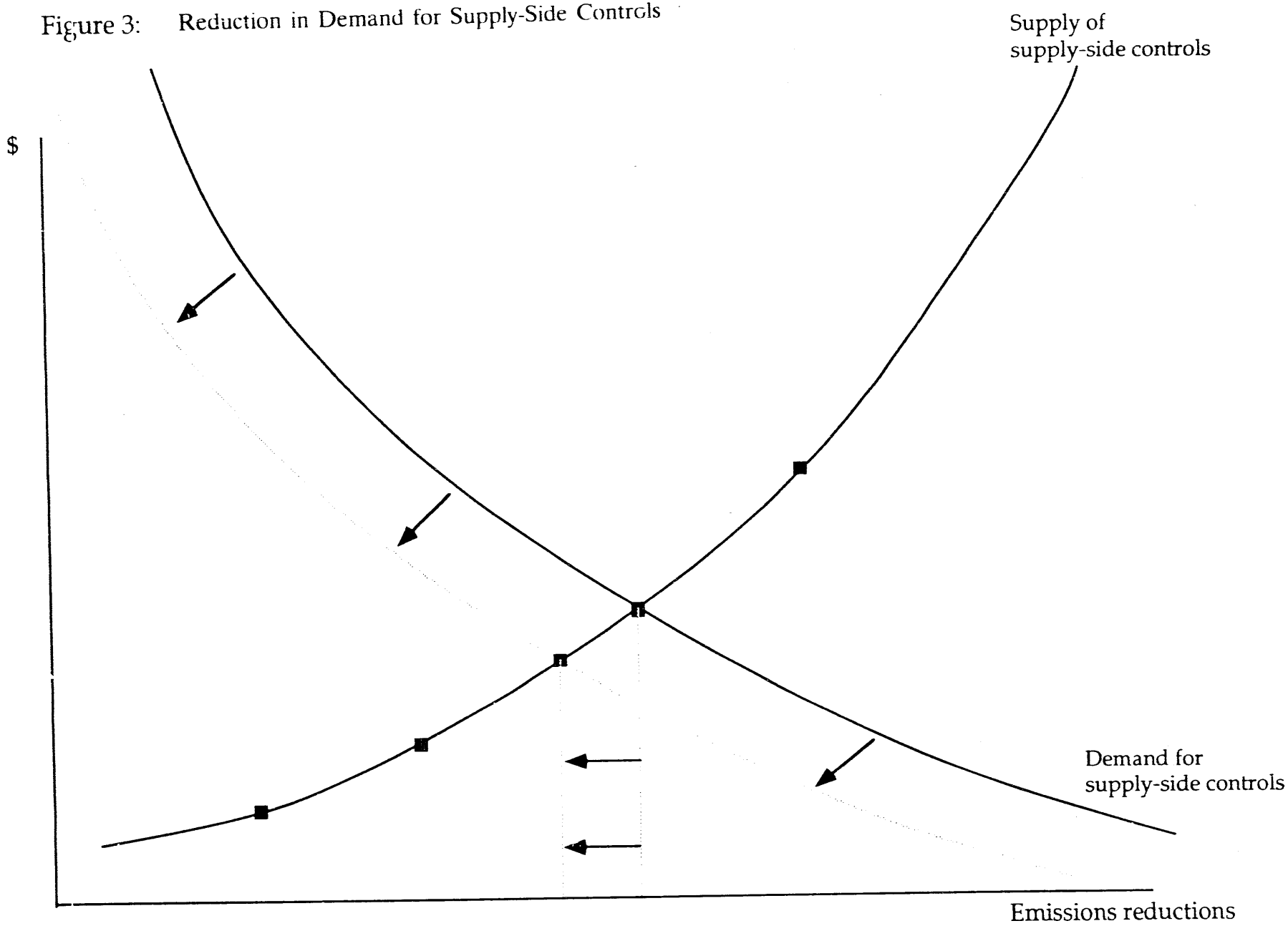
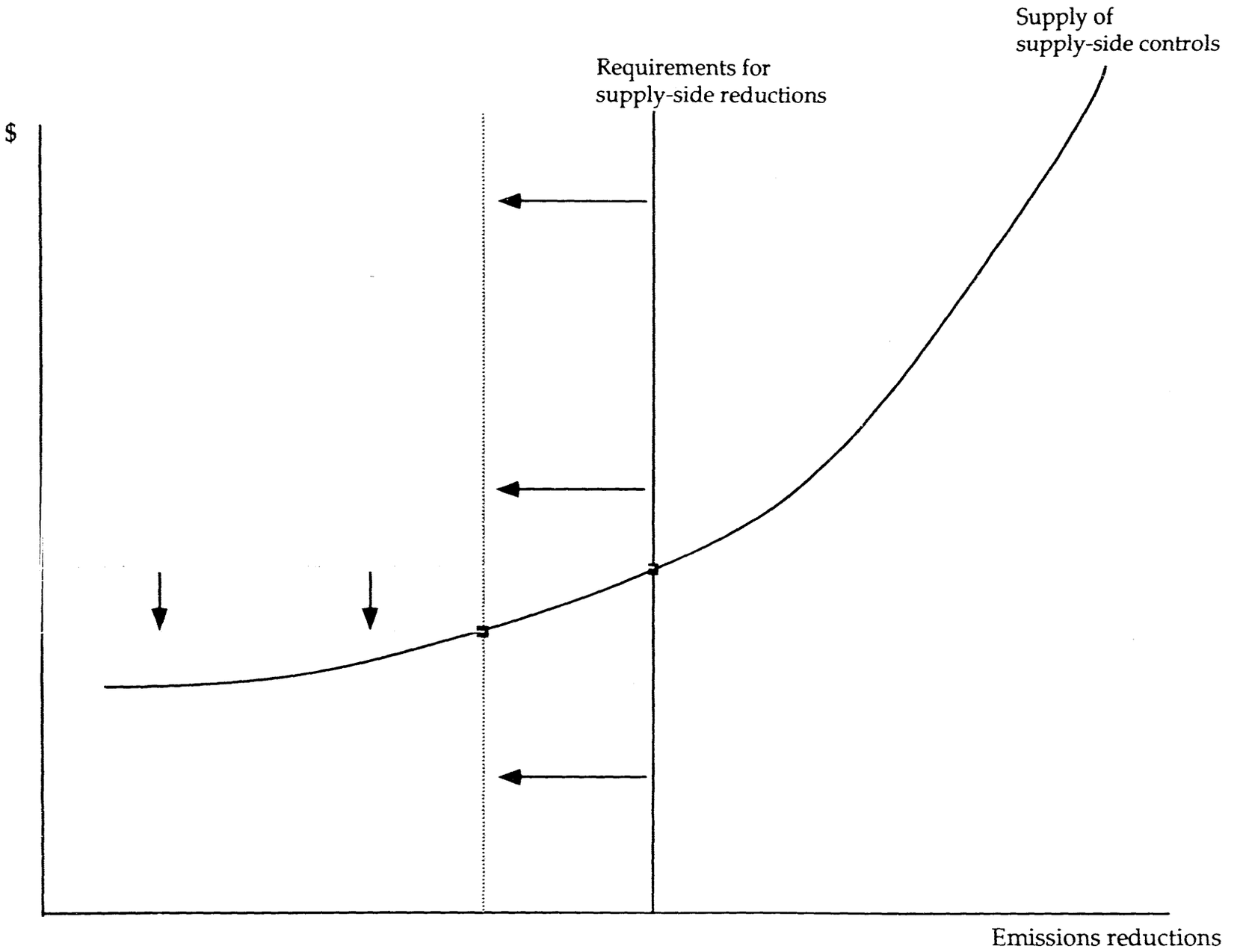


Figure 4: Reduction in Requirement for Supply-Side Emissions Reductions



plants in most states to control NO_x, is no longer necessary because of dramatic improvements in local and regional air quality, the marginal cost of SCR will be a reasonable estimate of the value of reducing NO_x emissions. While this scenario is theoretically possible, it is unlikely in the foreseeable future, given the current degradation of the now limited air resource and the continual growth of regional and national populations and economy, with associated upward pressure on energy use and on air pollutant emissions.

In addition, the use of expected costs of control is also a way of reflecting the additional costs of uncertain but likely future regulations, such as SO_2 scrubber retrofits and allowance purchase requirements under the Clean Air Bill or the adoption of a carbon tax on fossil fuels.

Implied Value of Unregulated Externalities

The previous discussion is presented as if all externalities under consideration were regulated. For externalities that are not yet regulated, such as the greenhouse gases, costs of control are also a valid way of estimating the value of reducing emissions. First, there is considerable discussion of adopting a federal carbon tax, and several states are moving to reduce CO_2 emissions by a target percentage. While these measures may not be immediately adopted, primarily due to concerns about the macro-economic effects of taxes and the lack of an international structure for requiring reductions, some measures to control global warming are likely to be adopted in the utility planning horizon.

Second, the weight of evidence indicates that we must stabilize the CO_2 concentration in the atmosphere in order to slow the current accelerated rate of global warming. The stabilization effort is going to come either from reducing CO_2 emissions or increasing CO_2 sinks. Krause, Bach and Koomey (1989)[17] estimate that reductions (or abatement) of CO_2 emissions on the order of 80% are required to stabilize global climate.

Our options for stabilizing global climate include: reducing CO_2 emissions through improved energy efficiency, decreased use of fossil fuels by eliminating wasteful uses and increased use of non-fossil energy sources, and halting the destruction of forests; and increasing carbon sinks, including tree-planting and CO_2 scrubbing, to the extent feasible. While we are beginning to get an idea of what certain mitigation strategies will cost, we do not yet have a complete supply curve for CO_2 abatement strategies showing how much abatement is available at what cost.

However, we can attempt to describe the supply curve for CO_2 abatement. At negative and very low cost, there is some energy efficiency potential and potential for reduction of CO_2 emissions through halting the destruction of forests. Some of the cheaper or negative cost options of both of these strategies are currently being pursued, however there is potential for further reductions from these measures. Higher cost energy efficiency options are also available. We know also, based on our analysis in (Chernick and Caverhill, 1989)[1], that reasonable tree planting costs fall in the range of 2-10 cents/lb carbon sequestered. The premium for non-fossil energy technologies ranges from slightly positive (for some hydro, and some geothermal, wind and solar-thermal energy in California) to moderate, including CO_2 scrubbing at a cost of greater than roughly 10 cents/lb carbon, and expensive for nuclear, renewables located in less optimal sites, and other technologies.

Given the current uncertainty of the availability of cheap efficiency and renewable options, the limited potential for new hydro sites, the cost and general opposition to nuclear, and the moderate cost of some tree planting sites, we expect that some tree planting will be done as part of a CO_2 mitigation strategy designed to reduce ambient CO_2 levels by any meaningful percentage. For this reason we use the costs of abatement, in this case reasonable costs of tree planting, to estimate the marginal value of reducing CO_2 emissions.

Some Complications in Determining Implied Values

The proper usage of cost-of-control in the valuation of externalities raises numerous complications. These can be grouped into problems regarding the definition of the marginal control cost, and imperfections in the political/regulatory system. The first set of issues is primarily technical in nature, while the second is more philosophical, raising questions regarding the use of regulatory decisions as guides to social values in any context.

Defining the Margin. Determining the marginal unit of externality control difficult for at least three reasons. First, legislative and regulatory requirements for the control of externalities often appear to be mutually inconsistent, with some required measures having much higher costs than much less expensive measures that are not required. Second, the margin is often in flux. Third, the complexity of pollution control often complicates the computation of the cost of controlling any one environmental externality.

The first difficulty, apparent inconsistencies in regulatory behavior, will generally produce underestimates of externality

costs. Controls are often not required on all sources of an externality, for any of several reasons. Legislation and/or regulation may attempt to protect vulnerable (or powerful) economic interests or sectors, and thus may exempt such groups as small businesses, marginal industries, and households from controls imposed on other generators of the same externalities. Similar exemptions may be granted to sectors that are perceived to be contributing in other ways to the solution of the same or related problems. Exceptions are especially likely to be granted if those contributions are viewed as burdensome. For example, the Bush-Dingell Clean Air Act amendments would defer application of the air toxics provisions to electric utilities, even though arsenic emitted by a power plant is as dangerous as arsenic emitted by a smelter. The apparent rationale for the exemption is that the utilities will be responsible for most of the acid rain reduction, and in some cases for much of the local air quality improvements, mandated in other sections of the same bill, and that equity requires that utilities be temporarily exempted from the burdens of complying with the air toxics provisions.

The cost of administration may also restrict the application of controls on externalities. Some producers of externalities, especially those that are small and dispersed, may be very difficult and expensive to police. Regulators may also find their scarce resources are more efficiently used on new proposed sources (where the applicant must receive the regulator's active approval to proceed) than on existing sources (where the regulator may need to expend significant effort to force a change in the status quo).

The second problem, that of a potentially changing margin, is particularly clear in the present case of acid rain. Acid rain has been a heated issue for at least a decade, and at the present time, legislation addressing acid rain seems very likely to be enacted within the next year or so. The nature of this legislation and the impact it will have on redefining the margin are far from clear.

The third problem, the complexity of externalities, encompasses several aspects. First, some control measures reduce the emission level of multiple pollutants. A relevant example of this situation is the equipment of automobiles with catalytic convertors. Catalytic convertors reduce emissions of carbon monoxide, nitrogen oxides and reactive hydrocarbons. In such cases, it is sometimes difficult to determine which pollutants have motivated the imposition of the controls, and to apportion the cost of the controls among pollutants. In addition, one level of convertor effectiveness is currently required nationally, a higher level is required in California, and a still higher level is due to go into effect in

California in 1992.

The second aspect of complexity relates to the effects of the externalities, rather than to the effect of the controls. A single pollutant or other direct effect of energy production may have several ultimate effects, each imposing its own costs on society. As a result, the same pollutant may be regulated under several different rules. For example, nitrogen oxides are regulated as a respiratory pollutant and as a precursor to smog. Essentially all of the proposed acid rain legislation would regulate nitrogen oxides as a precursor to acid rain. In addition, recent evidence indicates that nitrogen oxides may contribute to the release of methane from soils, which would make nitrogen oxides a candidate for regulation as a greenhouse precursor.[14] These multiple effects may also confuse the valuation of the externalities, due to the need to distinguish between additive and cumulative controls.

Imperfections in the Regulatory System. The decisions of the legislative and regulatory system provide us with useful information, including some sense as to how social and political structures (sometimes at local, state, federal, and international levels) have valued the externalities in which we are interested. However, we must recall that these structures are imperfect. We should not delude ourselves into believing that required levels of pollution controls, for example, represent revealed truth regarding the social valuation of pollution.

Environmental regulation, like any other kind of regulation, occurs in a political context, as the balancing process of many complex interests. For the most part, society does not collectively pay the cost of reducing externalities: individual persons and corporations pay different shares of the costs, and receive different shares of the benefits. The distribution of the costs and benefits across interest groups and constituencies may have a greater effect on the eventual level of regulation than does the aggregate social value. The control of acid rain, for example, has been severely impeded by the states which produce the most acid emissions, and who would have to pay for a significant portion of the control measures. Regulation also may be too weak (in which case the true value of the externality may be much higher than the value implied by regulatory standards), too strong (in which case reductions of the externality through choice of energy technology may still save society the costs of the controls, so the implied value may be a correct valuation), or a mixture of the two.

Even if legislators and regulators strove solely to identify

and serve the social good, no one is omniscient. Given the multitude of interests and valuations, the choice made by the regulators may not match a reasonably defined social value.

In practice, neither the regulatory agencies nor the courts are normally given the responsibility of determining the public interest and pursuing it without restraint. Legislatures enact laws, and regulators and courts put them into effect. The regulatory and legal interpretation of the statute may not always be what the legislature expected or intended. Indeed, in some cases, such as the National Environmental Protection Act that established the requirement of Environmental Impact Statements for major federal actions, it is clear that the legislature as a whole did not know how its language would be interpreted, and various legislators held very different views of just what the law would require.

Even if the legislature knows what it wants, and gets it, the public may not be well served. The public is not always able to follow complex and detailed public policy issues or to affect their representatives' votes.

Most of these issues are quite tractable, although rapidly changing regulations inevitably create some uncertainty. With a proper conceptual framework, and due diligence, the implied valuation technique can produce highly relevant and useful estimates of the social cost of externalities. One of the most desirable features from the perspective of the analyst and decision-maker is that the toughest social choices, assigning dollar values to human life and health, to wildlife, to natural ecosystems, to historical monuments and to visibility, are made by the legislators and environmental regulators such as the EPA.

In summary, externalities can be monetized for near-term use in utility regulation using at least one method, implied valuation, or marginal cost of abatement. Monetizing environmental externalities provides an approximation of the societal value of reducing impacts on human health and the environment from electrical energy supply. The externalities estimates generated through the use of the marginal cost of abatement are conservative (low) estimates of the actual marginal values of reducing the externalities.

Bibliography

1. Chernick, P., and E. Caverhill. 1989. The Valuation of Externalities from Energy Production, Delivery and Use. PLC, Incorporated, Boston.

2. --------. 1990a. Report to the Boston Gas Company on Including Externalities in 89-239.

3. --------. 1990b. Comparison of Total Costs of Supply options for 89-239.

4. Grupp, H. 1986. "Die Sozialen Kosten des Verkehrs." Verkehr und Technik, Teil 1 und 2, in.

5. Hendrey, G.R. 1988. "Acid Deposition: A National Problem." Acid Deposition: Environmental, Economic and Policy Issues. Plenum Press, New York.

6. Hohmeyer, O. 1988. Social Costs of Energy Consumption: The External Effects of Electricity Generation in the Federal Republic of Germany. Springer-Verlag, Berlin.

7. Lashof, D.A., and D.R. Ahuja. 1990. "Relative Global Warming Potentials of Greenhouse Gas Emissions." Nature. 344(6266):529-531.

8. New England Electric System. 1990. Comments by Massachusetts Electric Company.

9. New York State Energy Office. 1990. Environmental Externality Issue Report.

10. Ottinger, R. et al. 1990. Environmental Externality Costs from Electric Utility Operations.

11. Putta, S. 1990. Consideration of Environmental Externalities in New York State Utilities' Bidding Programs for Acquiring Future Electric Capacity. New York Public Service Commission.

12. SCAQMD. 1990. Comments of the South Coast Air Quality Management District on Draft Electricity Report 90 (ER-90).

13. Schilberg, G.M., J.A. Nahigian, and W.B. Marcus. 1989. Valuing Reductions in Air Emissions and Incorporation into Electric Resource Planning: Theoretical and Quantitative Aspects. JBS Energy, Inc. for Independent Energy Producers, Sacramento, Calif.

14. Science News. September 30, 1989, p. 213.

15. Shimshak, R., B.Biewald, H. Salgo, D. Marron, and S. Bernow. 1990. Comments of the Division of Energy Resources on Environmental Externalities. Commonwealth of Massachusetts Department of Public Utilities.

16. U.S. Environmental Protection Agency. 1989. Policy Options for Stabilizing Global Climate: Draft Report to Congress.

17. Krause, F., W. Bach and J. Koomey. 1989. Energy Policy in the Greenhouse, Volume 1.

A FRAMEWORK FOR EVALUATING ENVIRONMENTAL EXTERNALITIES IN RESOURCE PLANNING: A STATE REGULATORY PERSPECTIVE

by

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INTRODUCTION

Environmental externalities are gaining new importance in utility resource planning. This paper proposes a framework for addressing environmental externalities within a utility integrated planning process. This framework was previously proposed by Violette (1990), and has also been suggested by other researchers.[1] For the purposes of this paper, this approach is termed the "environmental constraint" method.

Prior to presenting this framework, the general "environmental externalities" problem is discussed. In characterizing the externalities problem, some of the "simple truths" that have appeared in recent literature will be examined and, while not necessarily showing them to be untrue, the discussion will hopefully illustrate that these "truths" are not so simple. The purpose of this examination is to help clarify the policy issues facing state commissions, and the assumptions that are implicit in the decision to take action on incorporating environmental externalities in integrated planning. While the authors believe that it is, in fact, important for commissions to adopt a policy regarding residual environmental externalities, we are not as sanguine as some about what has become the "conventional wisdom" on the issue (at least as it is expressed in the recent literature), and believe that commissions should broaden the scope of analysis and the policy tools that they are considering for use when incorporating or valuing externalities as part of the planning process.

1.0 BACKGROUND

State commissions have been pressing ahead with provisions to quantify environmental externalities in utility least-cost planning proceedings.[2] A number of arguments have been

[1] These include Bernow and Marron, 1990; Cropper and Oates, 1990; Ottinger, 1990; Brick and Edgar, 1990.

[2] By one count, 24 jurisdictions have at least started to formally consider the incorporation of externalities into utility planning; see Cohen, S.D. et al. (1990).

advanced for this and many of these are well stated in Ottinger, et.al. (1990)[3]. These arguments include:

- Allowing utilities to only meet applicable governmental laws and regulations that require emission limits or rate standards ignores the externality costs of emissions in excess of the legal limits. These emissions will have some impact on the environment, and should be taken into account in utility planning.

- It is the state commissions' purview to require these costs to be accounted for in a least-cost plan, since it is the commission's responsibility to protect consumer welfare. By including environmental externality costs, commissions are simply assuming their traditional role of assuring prudent resource allocation by utilities.

- Granting that any monetary valuation or other quantified weighting of environmental externalities is extremely uncertain, commissions must take the general position that approximate damage estimates are better than implicitly valuing these externalities at zero. This position is probably best expressed by the Oregon Commission in a recent decision (Order No. 89-507) where it states "when the certainty of external costs is known, but the amount of the costs is not, zero is the least desirable and least accurate cost to apply."

There are several different procedures for incorporating environmental externalities in planning. The procedure selected will depend, in part, on the commission's objectives. Several approaches have been suggested for explicitly incorporating externalities in utility least-cost planning. The two methods most often cited[4] are: one, the cost of control approach; and two, the direct valuation of damages using economic methods. An appendix to this paper discusses approaches available for directly valuing environmental damage to resources.[5]

A third method that does not involve a monetization of the externalities, but instead uses a set of weighting criteria has also been suggested. This type of method would include an evaluation matrix that could, for example, range from 1 to 100, with 70 points allocated to

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[3]See Ottinger, D., D.R. Wooley, N.A. Robinson, D.R. Hadas, and S.R. Babb, Environmental Costs of Electricity, Oceania Publications, Inc., 1990.

[4] See Ottinger, et al., Ibid; and Paul Chernick and Emily Caverhill, "Incorporating Environmental Externalities in Utility Planning" in Demand-Side Management Conference Proceedings, sponsored by the Canadian Electrical Association, May 1990.

[5]Several surveys of direct valuation methods have been compiled by the authors. These include Peterson, D., D. Violette, R. Rowe, and L. Chestnut; **Benefits of Environmental Controls: Measures, Methods, and Applications**; EPRI EA-6030, Research Project 2661-10, Final Report, October 1988.

cost and operational considerations, and 30 points allocated to cost factors.[6]

The first approach, the avoided cost of control valuation, is based on the premise that if lawmakers require controls that, at the margin cost $500 per ton, then an additional one ton reduction in emissions is worth $500 to society. Thus, the cost of additional reductions is assumed to be equal to the marginal control costs. This assumes, of course, that lawmakers are acting as society's representatives and are applying reasoned economic judgement. For example, recent Clean Air Act analysis shows that cleanup of acid rain will require expenditures of up to $1,500 a ton to reduce SO_2. This method assumes that an additional one ton reduction is worth $1,500 to society. The second method, damage cost approaches, attempts to identify the specific resources at risk, the magnitude of the risk, and the value to society associated with that impact. The direct assessment of environmental damages is the conceptually preferred approach. The difficulty of direct assessment is in calculating the monetized values of damages and defending the estimates in public forums. Opinion is divided regarding the appropriateness of these different methods for different categories of externalities and their appropriateness for different jurisdictions. Each method has its proponents, its strengths and weaknesses, and each method requires certain leap of faith assumptions.

Before getting too far into discussions on incorporating environmental externalities in utility planning, it is important to recognize that the policy question is how to appropriately price and/or control residual emissions, i.e., emissions after applicable state and federal laws have been met. In this context, residual emissions can be broadly interpreted to include air, water, solid waste as well as land use and aesthetic externalities. The policy question, at its most basic level, is whether the residual emissions that are occurring or, more appropriately, is the future time path of residual emissions set to a socially optimal level. A corollary to this is: since different options for providing energy services result in different levels of residual emissions, should integrated utility plans that produce lower residual emissions be given some type of credit relative to a plan the produces higher residual emissions? In a comparison of planning options, the argument is that options, such as conservation, that produce fewer detrimental externalities should be given credit for this vis a vis other supply options. In this way, planning can occur on a level playing field.

This can be summarized in two questions:

One- Has society paid enough? That is, is the current level of residual emissions such that incurring additional costs to achieve greater reductions in residual emissions (for specific pollutants) are not worth the benefits they achieve?

Two- If additional residual emissions reductions are needed; then what mix of policy tools can best achieve this reduction?

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[6]Several fairly complex weighting schemes have been devised. See, for example, the California Energy Commissions ER-90 Report (July, 1990) and Destribats, A. F. et al. (May, 1990) for a matrix weighting system proposed by New England Electric System.

Related to the second question, it should be noted that there is an extensive literature in environmental economics on the choice of policy instruments. A policy maker can choose either pricing or quantity setting policy tools. If regulators set prices for externalities, then polluters (i.e., the market) determine the quantity in response to the set prices. If regulators set quantities, then the market sets an implicit price. Cropper and Oates (1990) show that with perfect knowledge, either prices or quantities can be used to achieve the desired result. With imperfect information, uncertainty and regulatory constraints, some arguments can be made that quantity tools may be preferred.[7] The policy tools considered by commissions to date have almost all been pricing tools either through the additions of cost or benefit adders on specific options, or indirectly through matrix weighting methods.

2.0 SOME "SIMPLE TRUTHS" THAT ARE NOT SO SIMPLE

The background presented above on the general methods used for incorporating environmental externalities allows several popular statements to be explored. The purpose in examining these statements is to place the problem to be addressed in the proper perspective. Hopefully, this will help to identify some of the important policy tradeoffs implicit in any decision to incorporate externalities in planning. Four specific statements will be explored. Again, the goal is not necessarily to prove these statements to be untrue, but simply to explore the assumptions embodied in statements that have commonly appeared in the debate on environmental externalities in utility planning.

- Assumed Simple Truth # 1: Full compliance with all applicable state and federal environmental laws by utilities is insufficient because there remains residual emissions and environmental impacts; and that this effectively assigns a value of zero cost to these residual emissions.

- Assumed Simple Truth # 2: Advocates of the avoided control cost approach indicate that it is important to use marginal control costs, i.e., the most expensive control

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[7]The policy tools considered by commissions to date have been almost exclusively pricing mechanisms within the resource plan. However, there is an extensive literature on which policy instrument to use, i.e., using prices as the policy tool or setting quantities for pollutants. For example, Cropper, M.L. and W.E. Oates (1990) have an extensive discussion of the appropriate choice of policy instrument in their recent survey of environmental economics. They show that in a world of perfect knowledge, the regulator can set either price or quantity and achieve the desired result (p. 13). Under uncertainty, the choice of price or quantity as the policy tool becomes more complex. Weitzman, M. (1974) establishes the theorem that the preferred policy tool depends on the relative steepness of the marginal damage and cost curves. When the damage curve is steep relative to the cost curve; then, a quantity standard is preferred. When the cost curve is steeper, then, a price instrument is preferred. Roberts and Spence (1976) further develop the Weitzman theorem by examining combinations of price and quantity instruments in different degrees and show that, in the presence of imperfect information and uncertainty around costs and benefits, these policies used in combination can provide welfare gains. Further research on policy instruments in a regulatory policy setting, (Bohm and Russell, 1985) illustrate advantages of quantity instruments when growth and uncertainty are present. This literature has not entered into this specific policy debate on incorporating externalities in utility planning, but may be directly relevant.

costs used to obtain the last ton of reduction to place a value on environmental externalities.

- Assumed Simple Truth #3: It is always cheaper to control new sources than existing sources; thus the correct policy focus is on new sources rather than existing sources.

- Assumed Simple Truth #4: That a value of zero is the least desirable estimate to apply when environmental externalities are known to exist with certainty, but the amount of the damages is unknown.

2.1 Discussion of these "Simple Truths

The first statement that current regulation implicitly assigns a value of zero to residual emissions requires further examination. The statement reads as a call to action for all those who are environmentally aware, because no reasonable person would support placing a zero value on additional emissions reductions. However, in setting a policy standard, the damages associated with additional reductions in emissions are usually represented by a declining curve; that is, the first ton reduction may have a very high value to society, but each subsequent ton reduction has a lower value.

The objective in setting a pollution standard is to equate the marginal benefits of control with the marginal costs. This is illustrated as point P in figure 1. This figure roughly approximates the political compromise that was struck on the acid rain provisions of the proposed Clean Air Act amendments - Senate Bill 1630. The bill calls for a cap of approximately 9 million tons per year on sulfur dioxide emissions. It is estimated that marginal control costs will be approximately $1,500 per ton of SO2 removed for the units with the highest cost of control.

Given the information contained in figure 1, is it true that the residual damages are assigned a zero value? The answer is no. They are simply assigned a value that is lower than the costs of controlling emissions to a lower level. The control actions that take place (i.e., those that are reported) are only those "transactions" where the value of the reduction outweighs the cost. Analyses of markets and estimates of consumer surplus for market commodities show that there is an observed price (or value) associated with the purchase only if the benefits of these transactions outweigh the cost. If not, then the only value observed is zero since no transaction has occurred.[8]

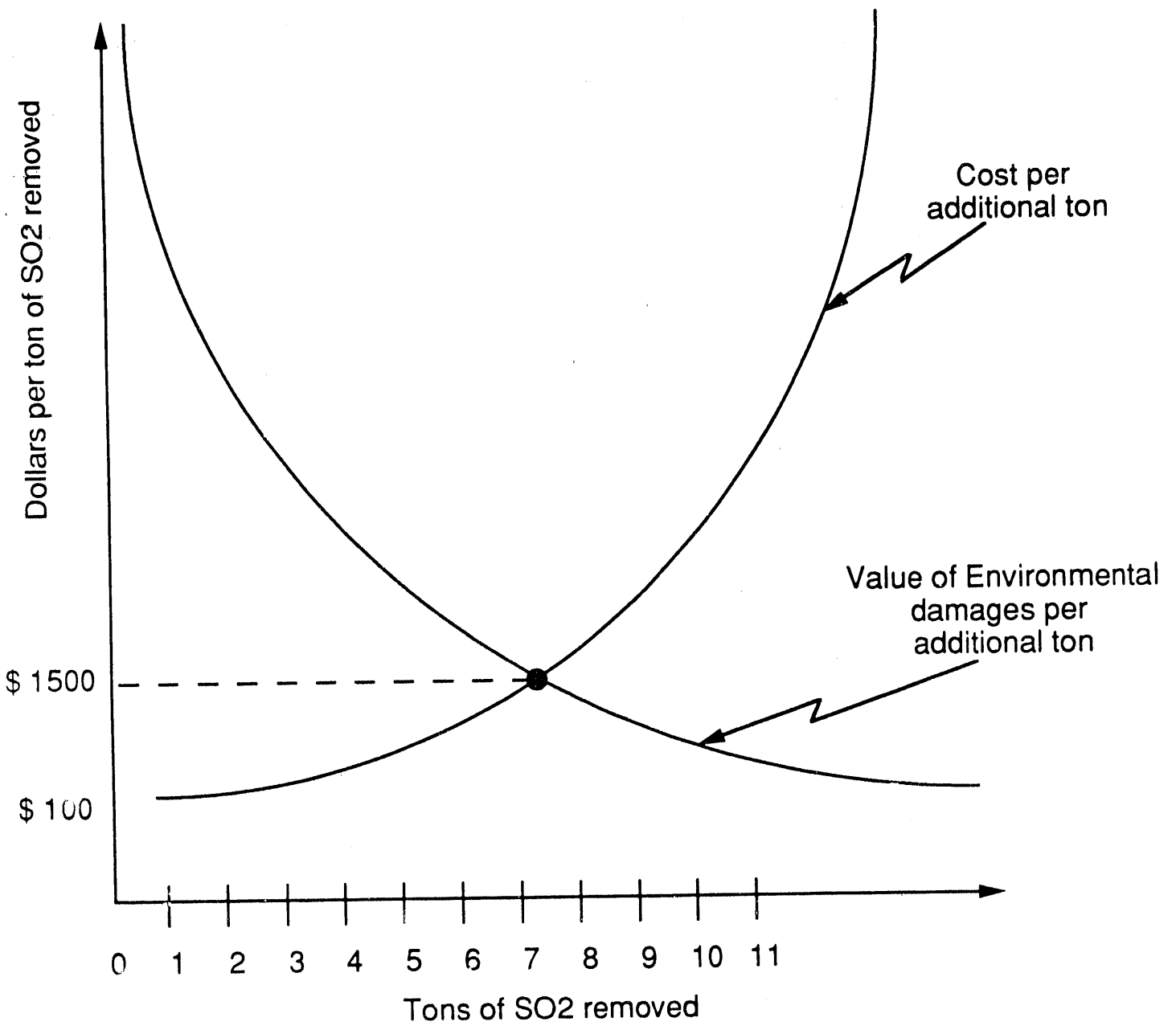
In the absence of an actual market, it is assumed that lawmakers analyze the costs of pollution abatement and attempt to find a market clearing price (i.e., cost of removal)

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[8]In fact, special econometric estimation techniques have been developed to address the problem where values in fact exist for a commodity, but are unobserved due to the lack of market transactions. The best known of these techniques is the Tobit estimation method. A description can be found in most intermediate econometric texts.

Figure 1

Comparison of Marginal Environmental Damages With Marginal Control Costs



and/or quantity.[9] If they are omniscient, then lawmakers take into account all control strategies and factors that contribute to, or reduce, emissions over time. This would include, in the acid rain example, all energy conservation options and the socially economic construction of coal fired power plants.[10] Thus, lawmakers and federal regulators may have already assumed specific levels of energy use and different mixes of fossil use for both utility and non-utility generation in their deliberations. To argue that additional costs should be incurred to reduce emissions, then there must be the assumption that the lawmakers have erred, and that their bias is towards under control of the pollutant in question. It is interesting to note that the advocates of the avoided control cost of valuing residual emissions support their position by appealing to the argument that lawmakers make decisions that at least approximate equating marginal benefits and costs (See Chernick, P. and E. Caverhill, 1989, Chapter 5).

Moving on to the second simple truth that addresses the use of marginal cost values in the avoided cost approach. This approach identifies the highest marginal cost reduction strategy required by legislation and, assuming that lawmakers are rational in their development of the regulations, this "marginal" value places a lower bound on the costs that society associates with an additional increment emissions. Again, appealing to Figure 1, it is clear that this statement is not necessarily true. If lawmakers are rational, then the highest control cost (i.e, the marginal cost) is actually the upper bound on the amount that society would be willing to pay for an additional ton reduction. If it were believed that higher costs of control would yield emissions reductions producing benefits that exceed the costs, then the standards would have been set tighter. However, marginal control costs may be a reasonable approximation for the costs of small changes in emissions around point P in Figure 1, but it is difficult to argue that it is an upper bound.

While most analysts have argued that the avoided control cost approach likely will underestimate true externality values compared to direct damage assessment, we believe this issue to be somewhat indeterminate, depending on the amount of reduction already obtained in a region and the corresponding pollutant damage.

The third "simple truth" is that it is easier to control new sources rather than existing sources. This conventional wisdom has stemmed largely from the assumption that all controls are similar to Best Available Control Technologies (BACT), such as flue gas desulfurization devices or scrubbers. Scrubbers have extensive space, venting, piping, and solid waste removal requirements that are easier to plan into new plants. However, studies of economic responses to the proposed acid rain legislation have shown that many of the most economic compliance actions are those at existing plants with high emissions rates. The compliance options involve operational rather capital intensive actions such as fuel switching, dispatching, or even the retirement of older, dirty plants. Again, if the real goal is to reduce residual emissions in the most cost-effective manner, PUCs may want to

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[9]A discussion of the appropriate policy tool, price or quantity, is described in footnote 7.

[10]For example, analyses of the amendments to the Clean Air Act have included many analyses where different mixes of DSM, fossil fuels, and construction plans have been used for forecast future emissions.

consider options within the least-cost planning process where tradeoffs between externalities produced by new sources can be offset by reductions in emissions and/or waste products at existing sources. This type of integrated compliance plan could produce the same, or reduced, level of residual emissions at a lower cost to the ratepayer. However, this could pose administrative and regulatory problems because of the increased planning and modeling effort required to develop an integrated plan incorporating even limited trading.

The fourth simple truth states that if residual emissions are known to occur with certainty; then, the least desirable estimate to apply to external costs is zero. While this statement has appeared in many papers and submissions to commissions, is it really an unarguable truth? The implication of this statement is that any action taken by commissions to incorporate a value for emissions within an integrated planning perspective will increase rather than decrease social welfare. While commission actions in addressing residual externalities may well be appropriate, is this level of confidence deserved?

The estimated level of sulfur dioxide emissions through the year 2030 without new acid rain regulation are shown in Figure 2. The projected emissions, given the provisions of Senate Bill 1630, are shown in Figure 3. Given that both figures project a decline in SO2 emissions and given that additional reductions from an already lower baseline level of emissions are expected to have produced lower benefits per ton; then, are policy analysts really confident that using a marginal cost of control value of $1,500 in 1988 dollars, causing ratepayers/utilities to implicitly pay that amount in terms of higher production costs for electricity to reduce an additional ton of residual SO2 emissions, will improve social welfare over another policy that does not place a price adder on emitting sources? What if the "true" social value could be known and turned out to be $500 per ton. Is a price adder of $1,500 better that the status quo? Again, the answer may be yes, but are analysts really that confident? Of course, the arguments made above are quite different for pollutants that are currently unregulated such as CO2 and certain air toxics.

2.2 How do the "Simple Truths" change Policies to Incorporate Environmental Externalities in Utility Planning

Explicitly assessing policies for incorporating environmental externalities within the utility planning process remains one of the most important questions currently facing both utilities and public utility commissions. What is clear from the exploration of the "simple truths, is that incorporating externalities in utility planning is a complicated process and that some of the simple arguments may incorporate a broader range of assumptions than might first be apparent. When these assumptions are accounted for, it is not quite as easy to dismiss some of the arguments utility analysts have proposed stating that their previous investment in pollution control, at least for some externalities already incorporates externality values. The position is that electric power companies have already invested billions of dollars meeting pollution control, land-use and other environmental and safety requirements; and that this process already internalize many externalities. If one accepts the argument that by meeting does not exceed the costs of control (i.e., the benefits of control do not outweigh the costs), then this position may have some merit. Still, this position is based on the

Figure 2

Sulfur Dioxide Emissions for the U.S.

Base Case Scenario

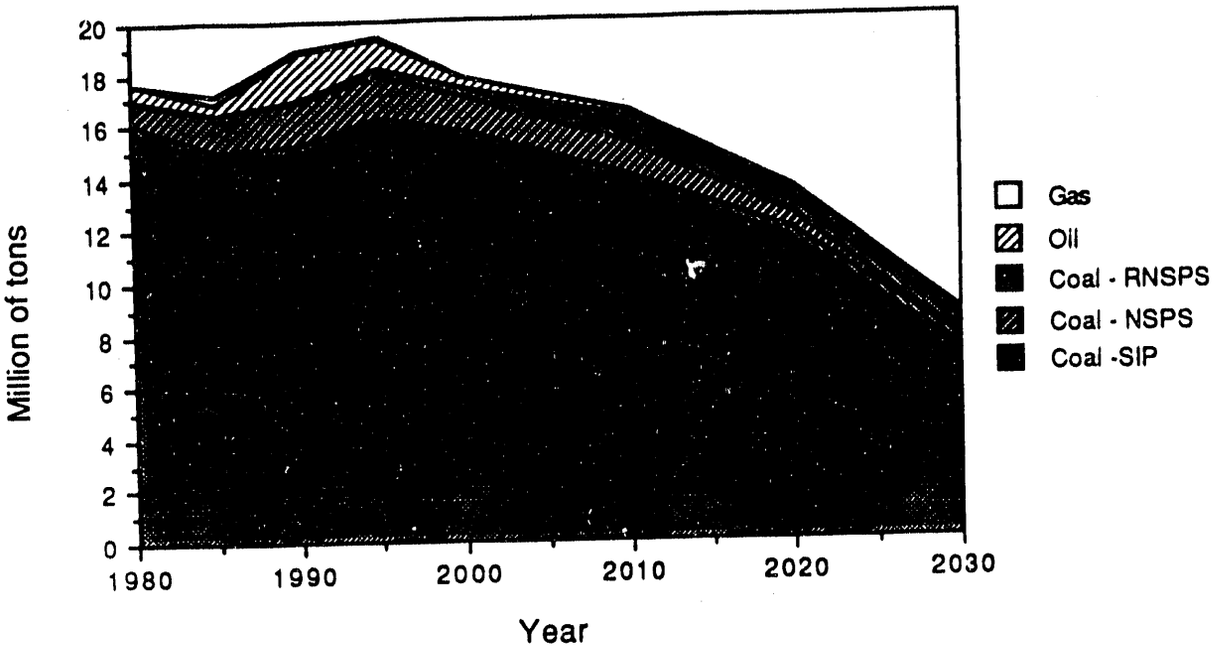
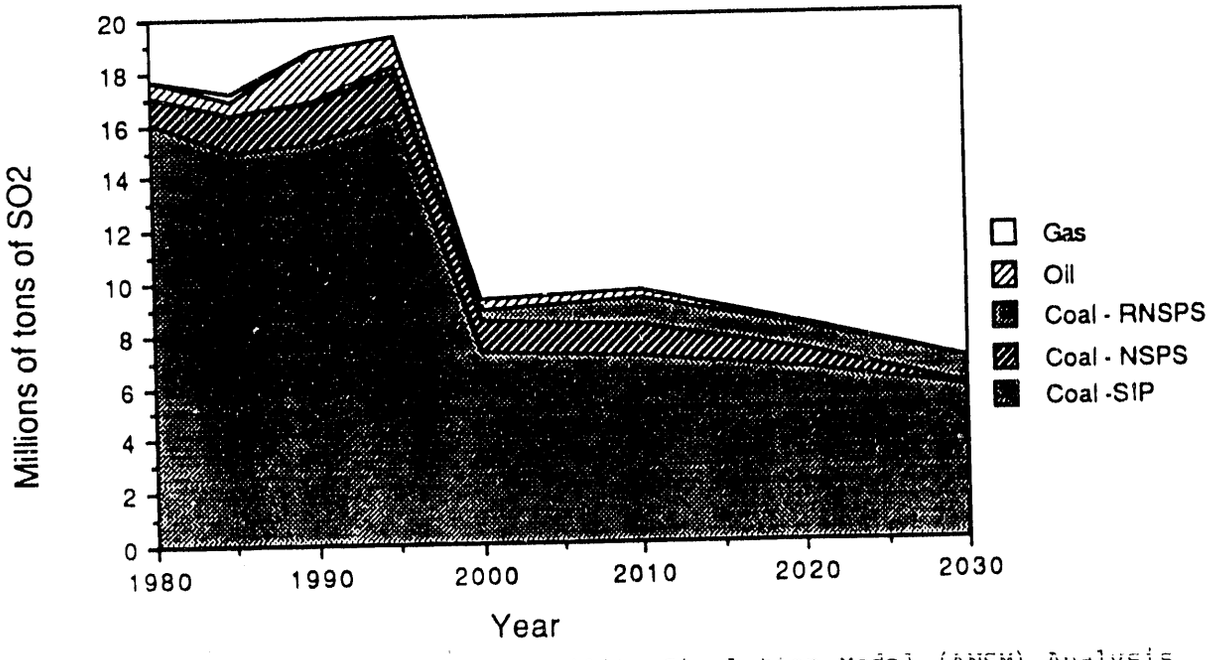


Figure 3

Sulfur Dioxide Emissions for the U.S.

Control Case Scenario



Results shown are from Advanced Utility Simulation Model (ANSM) Analysis by RCG/Hagler, Bailly, Inc. (1990) for the National Acid Precipitation Assessment Program and U.S. EPA.

assumption that the lawmakers/regulators that set the standards have considered the full range of energy use and supply options and factored them into the decision to set the emissions standard.

When setting externality policies, one of the factors that should considered is the projected path of emissions over time in a specific region.[11] The critical importance of the time dimension is illustrated by Hazilla, M. and R. Kopp (1990). Other factors that should be considered include: the stringency of current regulations on each externality, the current and projected levels of residual emissions in a region, and the regional political licensing and siting process in the region. For example, the public siting process can be effective at addressing aesthetic, amenity and land use externalities associated with a new power facility. This process may ensure that multiple sites for new sources are considered. Certain clean supply options, such as energy conservation, that avoid this siting review may reduce atmospheric emissions but move some risks (e.g., indoor air pollution and radon gas)[12] closer to urban areas, exposing more individuals than might a power plant in a rural area.

In conclusion, environmental impacts of energy use and production decisions are important and complex. Regulators should understand the environmental implications of any integrated least-cost plan proposed by a utility, at least, in terms of the change in emissions and wastes expected to be produced by the plan. A decision to place high values on residual emissions through price or cost adders should be carefully reviewed and fully account for the projected costs and reductions expected from existing emissions regulations. At a minimum, commissions should develop a check list of externalities and require utilities to quantify the change in quantities of emissions, pollutants, waste products and other externalities. This list could be available for public review and comment. Many commissions may want to go a step further and directly incorporate quantitative factors within the integrated planning models and screening processes. The next section discusses several procedures for integrating externality costs into resource planning.

3.0 OPTIONS FOR INCORPORATING ENVIRONMENTAL EXTERNALITIES IN UTILITY PLANNING

Most commissions that have taken quantitative action on incorporating environmental

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[11]Hazilla M. and R. Kopp (1990) state "specifically, regulations affect intertemporal microeconomic decisions and cause social cost [of pollution control] to increase over time. Failure to quantify and account for these intertemporal phenomena in a benefit-cost analysis will likely lead to errors of unknown magnitude. On the basis of our findings of significant intertemporal impacts, currently practiced methods are unacceptable" (p.871). While Hazilla and Kopp advocate a general equilibrium framework for benefit-cost analyses of environmental quality regulations, the basic message in their work does not unreasonably complicate the types of factors state PUCs and state environmental agencies should consider. As a side note, Hazilla and Kopp specifically attack the use of engineering costs based estimates as estimates of social cost of control.

[12]Most studies show that tighter homes and buildings when appropriately constructed and ventilated do not pose greater risks. However, this question is not fully resolved and it does assume that building contractors do, in fact, make the appropriate construction and ventilation decisions.

externalities have used pricing mechanisms that influence the resource selection or bidding processes. Another set of policy options available to commissions involve the use of quantity tools. As was discussed earlier, there is extensive literature in environmental economics on the relative merits of choosing emissions pricing or quantity setting tools (see prior footnote 7). To date, the discussion has focused on pricing methods. The pricing tools that have been proposed are both direct, through the use of price or cost adders, or indirect by setting up a matrix of weighting factors and selecting resources with the highest weighted score.[13] While pricing may methods have certain advantages, it is quite possible that the practical aspects of the regulatory process as well as economic theory may support PUCs considering the use of quantity constraints.

As was discussed in section 1.0 BACKGROUND, the direct pricing policy tools available include the use of avoided compliance cost estimates and direct damages estimates. These both have weaknesses: principally, engineering costs do not necessarily bear any relationship to the value of avoided environmental damages (particularly on a site-by-site basis); while the use of direct damage estimates often require data that are unavailable for many important categories of damages.

State commissions may want to consider a third option, in light of the concerns associated with direct pricing tools. The regulatory policy or environmental constraint option, involves the use of quantity policy tools rather than pricing tools. In this approach, commissions would set either emissions levels or externality quantity targets (e.g., a zero increase in air emissions) and then impose this as a constraint on the planning process. A number of authors have recently discussed and proposed this type of approach including Bernow, S. and D. Marron (1990) in a case study done for Vermont; Violette, D. and D. Peterson (1990); and Brick S. and G. Edger (1990).[14]

The environmental constraint approach has a number of potential advantages over direct pricing tools. As discussed earlier,[15] quantity policy tools can offer a number of advantages over pricing tools when there is uncertainty and imperfect information. While the avoided cost of control approach is based on national numbers that give the same value to emissions reductions in Texas as it does in New York, the environmental constraint method allows for

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[13]To see that a matrix of weights is actually an implicit pricing system, the analyst only has to show how the matrix changes the final selection of resources from the conventional revenue requirements minimizing mix of resources. The increase in revenue requirements implied by that change corresponds to a price. It would be possible to calculate an implicit price for each factor in the matrix, by examining how that factor changes the resource mix holding other factors constant and then calculating the increase in revenue requirements resulting from the new mix of resources. Of course, to calculate a price, that factor must change the mix of resources that would have been selected.

[14]Ottinger, D. (1990) states that F. Krause of Lawrence Berkeley Laboratory also has proposed an "Environmental LCUP" where emission reduction quantities for pollutant quantities such as CO2, SO2, NOx and particulates would be set and utilities would be required to meet these targets in a least cost manner; however, there was no reference cited for F. Krause on this point.

[15]See prior footnote 7.

a separate, unique determination of the emissions quantity (i.e., level) for cash jurisdiction. This method also avoids the complexity of a direct damage assessment method. Environmental constraints explicitly show the tradeoffs between environmental quality improvements and increased revenue requirements. Integrated planning methods can be used to calculate the costs of meeting different environmental quantity targets by developing an estimate of the revenue requirements under each proposed policy. Regulators, intervenors, utilities and ratepayers can then offer comments on whether they believe this expenditure to be appropriate, given the environmental constraints that will be achieved.

The use of a matrix weighting method can obscure the fact that meeting environmental objectives impose increased costs on the electric system. Explicit consideration of environmental costs and the comparison of these costs to the environmental improvements, even if performed in a subjective policy context is an important responsibility of the regulatory community. Of course, to the extent that direct monetary estimates of avoided environmental damages are available, as well as any other costing information, this comparison can be made easier and more concrete. The decisions that regulators will face is clear:

> Given that regulators will have a reasonably accurate estimate of the costs of achieving target environmental constraints, the policy judgement they will have to make is whether, given the evidence, they believe it is likely that the benefits of these environmental improvements will exceed the costs.[16]

Violette and Peterson (1990) point out that if regulators decide the benefits are not likely to outweigh the costs, then a new set of environmental constraints can be considered and the costs of meeting those constraints estimated. In this way, "sensitivity studies could be performed using different residual emissions levels or limits, and the change in revenue requirements could be calculated to show regulators how much more it would actually cost to further reduce or increase emissions" (p. 7).

The obvious problem with the environmental constraint method is the complexity of setting acceptable quantities of pollutants and externalities. While difficult, this process is expected to be easier than developing prices for each individual externality. In addition, the information available on benefits and costs can be used in a policy debate to assist in selecting targets. In this regard, PUCs could rely heavily on the various environmental agencies present in each state, as well as regional and headquarters U.S. EPA staff.

In discussing the general constraint approach, Bernow, S. and D. Marron (1990) state that "it is recognized that the valuation of environmental impacts is so fraught with difficulty that, at this time, public policy on the environment should precede and motivate technical analysis. For that reason, emissions reductions goals should be seen as an input to the electric evaluation, rather than as an output." While generally agreeing with this statement,

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[16]The benefits will never be known with certainty. As a result, one way to view this comparison is whether the higher costs of providing electricity are a reasonable price to pay to provide for insurance against potential current, future environmental risks.

it should be pointed out that the monetary damage valuations still can be very useful in setting the quantity limits/targets and in assessing the likelihood that the benefits of meeting the targets will outweigh the increased revenue requirements.

Brick, S. and G. Edger (1990) point out that the use of planning constraints is not at all new to utilities, stating "this is not a new twist to utility planning; quite the contrary. Operating reserve margins are routinely treated as planning constraints. Appropriate reserve levels are derived from assumptions about the value of unserved energy and system reliability standards based on past practice and conventional wisdom" (p.58). A similar approach could work in devising and meeting environmental constraints. Bernow and Marron also provide a practical application of this method in their Vermont case study which used a zero increase in air emissions as their residual emissions constraint.

4.0 SUMMARY AND CONCLUSIONS

One purpose of this paper was to present the concept of quantity constraint policy tools as another option in the set of planning tools available for incorporating environmental externalities into integrated resource planning. The goals of the commissions and the circumstances of the specific utility will plan a role in determining which choice of tools is most appropriate. However, the use of emissions quantity targets as an integral part of the planning process has the potential to provide for lower cost strategies for reducing residual emissions. Again, the concern with incorporating environmental externalities in planning is based on the fact that there are residual emissions that occur, even after all state and federal laws are met. Therefore, the overall goal should be the cost-effective, socially optimal reduction of these residual emissions. An overall constraint on emissions would allow the utility to devise least cost plans that meet that constraint. This could include adjustments to existing units, control strategies for new units, bidding processes, non-utility generation, load management, and conservation options. By letting the utility decide how to meet the targets, a wider array of options could be made available and less expensive strategies developed.

There are advantages and disadvantage with every proposal. One key issue with quantity targets is what action to take if the utility does not meet them. Should there be penalties for the utility or is the "good faith" development of a plan, approved by the state commission, which is designed to meet the quantity targets, adequate and, therefore, no penalties are warranted if the goals are not met. Of course, if the constraints are consistently violated, the utility could be asked to revise its plan.

Finally, there are a number of factors that commissions must consider when determining how to address environmental externalities within a planning context. The literature on this subject is in its early stages of development and the thinking in this area will surely evolve as these issues continue to receive attention. While it is important not to become so overwhelmed with all of the potential complexities and interdependencies implied by environmental externalities that action is impossible, it is equally important not to oversimplify the issues involved.

APPENDIX -- ECONOMIC DAMAGE COST APPROACHES FOR VALUING ENVIRONMENTAL DAMAGES

This section introduces some of the approaches used to perform direct damage assessments. More detail can be found in D.C. Peterson et al. (1986) and D.C. Peterson et al. (1988). For economic damages to occur as a result of an environmental injury, some linkage must exist between the change in the affected environmental resource, the service flows provided by the resource, and the well-being of individuals and society. Describing and quantifying these relationships can be extremely complicated. Linkages required to estimate environmental externalities associated with electricity generation include emissions inventories, ambient dispersion models, doses to sensitive receptors, damage function relationships, indirect impacts, and an overall economic valuation step.

Goods and services that are bought and sold have economic value because individuals (and firms) spend money to purchase them at market prices and forego purchasing other goods and services. Many environmental and natural resources, such as air quality, are public goods that are not exchanged in markets and, therefore, do not have explicit prices. However, this does not mean that these resources, as public goods, do not have value, or that injury to these goods cannot, in principle, be measured as environmental externalities.

A variety of methods are available to estimate economic measures of value associated with environmental externalities. This section selects several categories of methods and reviews their major strengths and weaknesses. The methods can be grouped into the following classifications:

- Revealed Preference Methods, or "Actual Valuation Methods" -- These methods infer values for changes in natural resources as "revealed" by actual behavioral data.

- Direct, or "Contingent Valuation Methods" -- These methods estimate values using survey techniques and the construction of contingent, or hypothetical, markets to reveal what expenditures and behavior would be if those markets existed.

The strength of revealed preference methods, in general, is that they rely on actual expenditures and behavior in response to changes in natural resources. Their major weakness is the limited number of issues that they can address due to the availability and quality of data, especially for newly emerging issues or unique sites. Also, it is often difficult to isolate the environmental values that are reflected in markets.

The strength of the contingent valuation methods is that they may be applied to estimate externalities associated with a wide variety of values. Their major weakness is that they rely upon predicted behavior within the context of hypothetical situations.

Revealed Preference Methods

Travel Cost Methods. Travel cost methods are one approach for estimating externalities at recreational sites. Travel cost methods assume that individuals will respond to the monetary costs of traveling to a site in the same way they would respond to changes in entry fees at the site. Recreationists incur out-of-pocket costs for gas and food when traveling to a site, as well as opportunity costs associated with the time spent traveling. These costs can be viewed as the "implicit price" of a visit to the site. Historically, most applications of the travel cost method have focused on use related values associated with eliminating adding recreational sites. New developments in travel cost methods have increased the applicability of the technique to encompass estimating the use-related value of a site with different levels of characteristics, such as water quality or fishing success.

The most significant strength of the travel cost method is that it is based on actual decisions of individuals. It is possible to observe the distances traveled to a site and the number of visits or days spent at the site, as well as the site's characteristics. Another advantage of this technique is that it has, to at least a certain extent, received professional acceptance. The most significant problems with applying travel cost models are associated with the availability of visitation data at the sites, and the sensitivity in results caused by selecting alternative model specifications. For sites that have been damaged for a period of time, it is often difficult to determine how many individuals would have visited for recreational purposes had it not been contaminated.

Hedonic Price Method. The hedonic price method (HPM) has been widely used to examine damages due to air pollution in urban areas. The method's essence is to gather data on goods and products actively traded in markets, and use that data to estimate an implicit price for the natural resource injury, in terms of the reduced value of the privately marketed good or service. Thus, HPM utilizes observed prices of market goods to impute values for natural resources. The most common application of the HPM has been to estimate the impact of air pollution on residential property values.

The principal advantage of this method is the fact that it is based on actual choices made by individuals and observed market prices. A second advantage of the hedonic method is the ability to capture the value household's place on aesthetic amenities.

There are, however, a number of potential problems that will vary in their severity across different applications. Two generic types of problems are present in most hedonic studies -- conceptual/theoretic problems and data/statistical problems. The conceptual problems refer to problems with the assumptions and restrictions embedded in the underlying model of consumer behavior, the market being modeled, and the problems of obtaining valid estimates. Data problems can arise and confound results even in a perfectly specified conceptual model.

Property value studies typically assume that the urban area as a whole can be viewed as a single housing market. This means that there are no impediments to an individual choosing to live in any part of the area, that individuals are fully informed about all their housing alternatives, and that the housing market is in equilibrium. Further, the approach assumes that all combinations of housing attributes are available. These assumptions never hold absolutely. The issue is whether they provide an adequate approximation to the urban housing market. It is difficult to determine the biases in the estimates that may result from deviations in these idealistic market assumptions. While some of these assumptions may be subject to empirical tests, hedonic practitioners must assume that deviations from the assumed market paradigm do not significantly bias the damage estimates. Whether this is, in fact, true is subject to debate among economists.

Operations Research Methods. Operations research encompasses a set of analytical techniques used to optimize or solve decision problems. For environmental effects, the emphasis has been on two techniques: mathematical programming and econometric-simulation modeling. The focus of these techniques has been on commercial production relationships, such as commercial forestry, fishing, and agriculture. These approaches attempt to model the structure of the industry and the impact of environmental changes. The plausibility of such models (as descriptors of economic or other phenomena) must be established by a validation process (comparing model performance against a series of empirical data).

The popularity of these techniques can be attributed to several factors. The analyst is able to evaluate effects of proposed policies or environmental changes, i.e., changes not yet realized that may occur under a new policy or environmental situation. The methods describe how a system should behave (to maximize profits or minimize cost), as defined by the economic representation of the objective function and constraints. As with any model oriented toward real world behavior, failure to accurately describe behavioral rules or goals produces biased estimates or predictions. The models are most helpful when they are properly validated, and used to predict or assess situations that are captured in the econometric structural and behavioral relationships. Application of these methods is constrained by difficulties in model estimation, verification and validation. In addition, they may require very large and complex data sets that are often difficult to obtain.

Contingent Valuation Methods

Contingent valuation methods (CVM) have been used to directly estimate values for numerous unpriced non-market goods. These methods attempt to elicit values through surveys of how respondents believe they would behave, assuming a change in the natural resources. In contrast to revealed preference approaches, CVM do not attempt to infer values by observing actual behavior in response to natural resource injury. Instead, they directly ask individuals how they would behave (or have behaved in the past) in response to resource injury. CVM may be particularly well suited for valuing environmental damage

because these methods can value different characteristics of natural resource injury simultaneously, and do not require variation in natural resource quality at the site. The use of CVM is based on two major behavioral assumptions:

1. People can determine their preference orderings between the public good and other goods and services in a hypothetical market.

2. People will offer bids that reveal their true preferences, and will not attempt to strategically bias the survey results in a manner consistent with their preferences.

The major strengths and weaknesses of CVM relate to the validity of these assumptions.

The principal advantage of CVM consists in its flexibility of approach and design. Using a CVM approach permits analysts to incorporate virtually any desired scope or combination of policies, effects, and benefits measures.

CVMs' independence from market data has been mentioned as a strength, but it is also a weakness. Critics have argued that damage estimates cannot be accurately developed or defended without demand or market values. Also, because the contingent markets are hypothetical, it is difficult to asses the degree to which contingent values conform to true values.

Economic Damage Approaches: Conclusions

The previous sections have outlined four categories of valuation methods that may be used to value environmental externalities. This section summarizes the conclusions from each of the preceding sections to assess the relative strengths and weaknesses of each.

Several general conclusions can be drawn. First, comprehensive valuation of environmental externalities may require the use of multiple techniques to adequately address all of the damage categories. Second, the results of all resource valuation methods are variable, depending on the specifics of the application. Third, if non-use values are to be estimated, CVM is the only technique available to researchers. As a result, if both use and non-use values are to be estimated, at minimum CVM will be used and quite possibly another technique will also be used.

A summary of the applicability of the different techniques and their strengths and weaknesses are presented in Table 1 and summarized below:

- Travel cost models will be useful for estimating use values associated with resource injuries at sites used for recreational fishing, boating, swimming, camping, hiking, hunting, and aesthetic appreciation.

- HPM will be useful for estimating damages in areas with property markets. Residential property value studies will be able to estimate the use values associated with increased health hazards, aesthetic effects, and possibly reduced recreation opportunities at the specific site. For this technique to be appropriate, release must be in or near a populated area with private property near to the site.

- Econometric-simulation and programming methods will probably have narrower applicability than the other techniques, but will be extremely useful for any applications where commercial markets are affected. These markets would include agriculture, commercial fisheries, rangeland, and wood products.

- CVM are the most flexible and can, in theory, be used to estimate values for the entire range of resource injuries. CVM techniques should be used whenever data necessary to implement other empirically-based methods do not exist. Typically, a complete damage assessment may require CVM for at least some damage categories.

Table 1
Summary of Economic Damage Cost Methods

	Travel Cost	Hedonic Price	Contingent Valuation	Econometric Simulation and Programming Approaches
General Description	Uses travel costs to a site as a proxy for the price of visiting the site.	Uses prices of market goods to impute values for natural resources. The most common marketed good used is residential property.	Uses survey techniques and hypothetical markets to directly elicit individuals' willingness-to-pay for different levels of natural resources.	Simulates the behavior of economic agents using empirically estimated relationships or optimization algorithms with and without the hazardous substance release. The change in "well-being" between these two states is then assessed.
Applicable Damage Categories	use values - recreational fishing, boating, swimming, hiking, hunting and aesthetic appreciation. non-use values - not applicable.	use values - urban area human health effects from drinking water, air, food or direct contact. Aesthetics at the property including odor, soiling, and visibility. non-use values - not applicable.	use values - * Human health effects from drinking water, air, food and direct contact. * recreational uses - all * aesthetic effects - all non-use values - both option and preservation values.	use values - * commercial damages to agriculture, fisheries, range land and other industries. * bio-economic or ecosystem simulation models for use values. Requires estimates of unit resource values from one of the other methods. non-use values - not applicable.
Most Appropriate Application	* Travel cost methods will be most appropriate for estimating use values for recreational sites that can be viewed as "destination" sites.	* The hedonic property value methods will be most appropriate for analyzing resource injuries in areas where there are to capitalize the resource damage in the sales price of property.	* CV is the only method available to estimate option and preservation values. * CV will be the most appropriate technique values when the data required for other methods is not available.	* Econometric - Simulation and Programming techniques will be most appropriate in circumstances when resource injuries have influenced commercial markets such as agriculture, commercial fishing, range land, and forest products.

Table 1 (continued - pg 2)

	Travel Cost	Hedonic Price	Contingent Valuation	Econometric Simulation and Programming Approaches
Data Requirements	Requires data on individuals' trips to the affected site and other potential substitute sites. These data include purpose of the trip, travel time, time spent at site, expenditures, income, wages and other socio-economic information. Site attribute data are required for some applications.	Requires property values, property attributes, distance from site of hazardous substance release, and proximity to other exposure pathways (e.g., downwind or downstream).	Requires careful characterization of the injury to natural resources in a survey format. Considerable information must be developed in survey question pretests on the effects of different hypothetical markets on respondent bids before a final questionnaire can be developed.	Requires data on the options available to economic agents, the decision rules that determine their actions, and the constraints that limit their options. Can be very data-intensive. For example, evaluating the response of farmers/growers to air pollution requires information on the yields of crops that could be grown with different input mixes of land, labor, fertilizer, irrigation and varying air pollution levels. Often, data on the values of public goods and resources are needed.
Data Sources and Collection Methods	* Surveys of visitors to different sites * A mail survey to the general population * Surveys of specific subgroups such as licensed fishermen or hunters * site characteristics can be self-assessed by the individuals surveyed e.g., scenic beauty, catch rate etc. ranked on a scale of 1 to 10. * Site characteristics an be obtained by researcher visits to the sites or from records maintained by organizations such as the U.S. Forest Service or Park Service.	* Realtor multiple property listings * County records * Survey or property sites	* In-person, telephone, or mail surveys of users and non-users of the natural resource	* Scientific research * Published industry data * Empirically estimated demand and supply functions using price and production data. * Injury functions relating the hazardous substance to changing resource levels from environmental science research. * Prices or values of resources and public goods may be needed from a travel cost, hedonic, or CV study.

Table 1 (continued - pg 3)

	Travel Cost	Hedonic Price	Contingent Valuation	Econometric Simulation and Programming Approaches
Strengths	• Based on actual decisions of individuals and, therefore, not subject to hypothetical effects. • TCM has a well developed literature. • New techniques have been developed to value changes in a site's characteristics including aesthetic amenities.	• Based on actual decisions of individuals, and therefore, not subject to hypothetical effects. • Able to estimate values for aesthetic amenities of property. • HPM has a well developed literature.	• Primary strength is flexibility. Since it uses hypothetical markets, it can be applied to the entire range of potential resource injuries. • It is the only technique available for estimating option and preservation values.	• Able to incorporate the actions of individuals taken to mitigate resource injury. • Able to address large-scale impacts that could influence the market equilibrium price price of commodities. • Can be used to address complex interactions between ecosystem and economic/value variables.
Weaknesses	• The correct opportunity cost of time in transit for use in calculating total travel costs is uncertain. • Multiple purpose trips, selection of functional form, and proper treatment of time spent on site are potential confounding factors. • Variation in the selected model may affect results.	• The HPM is best suited to valuing small changes in resource levels since only one point on the demand curve is estimated. • Assumes the market used in the HPM (usually the housing market) is economically efficient, i.e., all individuals have full information, the market is in equilibrium, and that all combinations of housing attributes are available. These assumptions never hold absolutely. • Multicollinearity can be present among the site attributes which makes precise statistical estimation difficult.	• The most significant weakness is the potential for hypothetical effects, i.e., the actions that individuals say they will take in the hypothetical market may not predict actual decisions very well. • The accurate portrayal of the change in resource levels that are to be valued can be difficult. Subtle changes in the framing of the valuation question may have an influence on the resulting bids.	• They can require large amounts of data. • The models can be very complex. • Programming models are based on postulated relationships rather than on actual empirically estimated behavioral relationships. The postulated economic/optimization behavior may not be appropriate.

REFERENCES

Bernow, Stephen and Donald Marron. 1990. "The Treatment of Environmental Impacts in Electric Resource Evaluation: A Case Study in Vermont", Tellus Institute, Boston, MA, January 22, 1990.

Brick, Steve and George Edgar. 1990. "Blunting Risk with Caution: the Next Step for Least-Cost Planning", The Electricity Journal, Volume 3, Number 6, July 1990.

Chernick, Paul and Emily Caverhill. 1989. "The Valuation of Externalities from Energy Production, Delivery, and Use", from a Report to the Boston Gas Company, PLC, Inc., December 22, 1989.

Cohen, S.D.; Eto, J.H.; Goldman, C.A.; Beldock, J.; Crandall, G. 1990. "Environmental Externalities: What State Regulators are Doing", The Electricity Journal, Volume 3, Number 6, July 1990.

Cropper, Maureen L. and Wallace E. Oates. 1990. "Environmental Economics: A Survey", Discussion Paper QE90-12, Resources for the Future, Washington, D.C., January 1990.

Destribats, Alan F.; Lowell, Jonathan B.; White, Dean S. 1990. "Dispatches from the Front: New Concepts in Integrated Planning", presented at EPRI Innovations in Pricing and Planning Conference, Milwaukee, Wisconsin, May 3, 1990.

Hazilla, Michael and Raymond J. Kopp. 1990. "Social Cost of Environmental Quality Regulations: A General Equilibrium Analysis", Journal of Political Economy, Volume 98, Number 4, August 1990.

Ottinger, Richard L. 1990. "Getting at the True Cost of Electric Power". The Electricity Journal, Volume 3, Number 6, July 1990.

Violette, Daniel M. and Donald C. Peterson, Jr. 1990. "Utility Planning and Evaluating Environmental Externalities", presented at Decision Support Methods for the Electric Power Industry, Cambridge, Massachusetts, May 29-31, 1990.

Environmental Costs and Resource Planning Consequences: New England Electric's Rating and Weighting Approach

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Abstract

In mid 1989, the New England Electric System ("NEES" or "Company") began an effort to reflect the potential environmental externalities of new resources in its long range planning process. Having examined several methods for incorporating externalities, including cost of control, the Company adopted a rating and weighting approach. Not strictly quantitative nor qualitative, the rating and weighting approach provided a means to apply an environmental score to all new resources considered for the Company's long range resource plan, NEESPLAN 1990. A maximum environmental cost penalty of fifteen percent was applied to the resource considered for inclusion in the plan that posed the highest amount of potential environmental degradation. All other resources received a smaller penalty that was based on the ratio of their environmental score to the highest score. Application of this penalty tended to improve the cost-effectiveness of demand-side programs and worsen some supply-side options' cost-effectiveness.

Both the rating and weighting approach employed by NEES and its application in the long range planning process have been the subject of several critical reviews. Having stated that the advantages of the rating and weighting approach include its easy reviewability and flexibility to be modified as better information becomes available, the Company has subsequently revised the approach to address the comments made by reviewers. The purpose of this paper is to describe the rating and weighting approach, its recent revisions, and the effect of the revised methodology on the Company's long range resource plan.

Introduction

"...Evaluations of the cost-effectiveness of resource options should include costs and benefits external to the transaction, most notably environmental externalities." With these words the Massachusetts Department of Public Utilities joined a growing chorus of

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regulators encouraging utilities to reflect explicitly the costs of environmental externalities, such as SO2 and NOx emissions, in their planning processes. Utility resource cost-effectiveness was now to be examined from a broader, societal perspective. The Company accepted this challenge and launched itself on a comprehensive long-term effort to develop a useful, balanced approach for incorporating environmental externalities in its planning process.

Working with Temple, Barker, and Sloane, Inc., the Company explored several methods for evaluating environmental externalities. Both quantitative approaches (such as cost of damage and cost of control) and qualitative methods (such as a simple list of potential environmental externalities) were examined. After careful consideration, the Company adopted a hybrid rating and weighting approach that was felt to best achieve the objectives the Company established, and still maintains, for an environmental externalities method. These objectives are 1) consistency with the state-of-the-art in both level of detail and precision; 2) ease of integration with the long range planning process; 3) objectivity in its application to all supply and demand-side resource options; and, 4) flexibility to be refined as the current knowledge about environmental externalities improves and as the Company's resource planning process further evolves.

Approaches to Estimating the Costs of Environmental Externalities

Qualitative Approaches

The benefits of qualitative approaches are flexibility and adaptability. In a truly qualitative approach, resource options or portfolios of options are described in terms of their environmental attributes, such as emissions types and rates, water and land use and solid waste production. Decision-makers review the list of environmental attributes and other decision criteria (e.g., prices and risk) and develop a strategy for ranking resource options based on the qualitative assessment of their externalities. However, since any tradeoffs among attributes and criteria of different resources are implicit to the decision-maker, the disadvantage of this approach is its complete subjectivity. Qualitative approaches should be thought of as a starting point in the development of an externalities methodology.

Quantitative Approaches

Shifting away from the subjectivity of the qualitative approaches and towards more objectivity and transparency is the stated goal of those advocating quantitative approaches. In these approaches, attempts are made to completely monetize environmental externalities.

Two paths are commonly used for this monetization: cost of environmental damage and cost of control.

The cost of damage, or direct costing, approach attempts to monetize the societal impacts associated with different resource options by examining the actual damages inflicted upon the environment and the loss of social welfare associated with those damages. Clearly, this is the ideal approach to address the costs of environmental externalities. To do so, all externalities would be identified and the costs, or benefits, of each externality would be determined. There are numerous ways to estimate these costs. One could examine the value of the timber in a forest and calculate the reduced production caused by pollution. One could quantify the cost of having to paint houses more often due to the detrimental effects of acid rain. One could set up elaborate studies to estimate the increased health costs associated with ozone smog. However, even if these calculations were possible how would one calculate the value of diminished biodiversity in the damaged forest, the degradation of limestone tombstones due to acid rain, or the value individuals place on being healthy? Unfortunately, even quantitative approaches require considerable subjectivity.

Although recognizing that much work has been undertaken by various parties to direct cost specific externalities, the tremendous variance one witnesses in the estimates does not provide confidence in the usefulness of the estimates at this time. For instance, a state study concluded that the annual value of fish loss in Lake Michigan due to acid rain was $6.2 million. Another evaluation indicated the loss was $50,000 per year, less than one percent of the state estimate. In addition to the large variation in estimates, much of the research at direct costing is area-specific and may not be directly transferable to another region. Hence, although a direct costing approach is preferable, at present, the data simply does not allow for such an approach.

Another quantitative approach is cost of control. Advocates of this approach suggest that by examining decisions made by regulators and legislators implicit societal willingness to pay estimates can be derived. For example, if New Source Performance Standards (NSPS) in the Clean Air Act require certain controls then the cost of complying with those controls would be used as a proxy for the environmental damage associated with the remaining emissions. This is an appealing proposal in that the decision about the costs has already been made and there is ample documentation.

However, there are complications with these assumptions. With the new Clean Air Act[2] there will be a market for certain emissions. The market clearing price for those

[2] Not passed at the time this paper was completed.

emissions may be significantly lower than what NSPS and other regulations imply. Which price is the correct price? What if control costs for certain technologies are significantly lower than others? A pound of nitrogen oxides from one source imposes similar environmental damages as a pound from another source but the control costs may be significantly different. The cost of control should be the next most cost effective reduction available and not the highest cost society has ever been willing to pay. Even if this premise is accepted, defining the next most cost-effective reduction would be very difficult for many issues.

New England Electric's Rating and Weighting Approach

After reviewing the different approaches to incorporating environmental externalities in its resource planning process, New England Electric chose to pursue the development of a hybrid approach. This decision was based on the fact that the approach would best meet the goals stated above and would allow immediate incorporation of environmental externalities in the Company's long range resource plan, NEESPLAN 1990, that was currently under development. The Company recognized that this approach would be geared towards providing usable results in the short run but would be followed by increasing levels of quantitative sophistication as additional data on actual social damages became available.

Overview of Original Matrix

As the basis for a hybrid approach, the Company developed the rating and weighting scheme shown in Figure 1. This matrix is a relatively simple tool that allows all resource options to be scored based on the magnitude and severity of their potential environmental impacts (NEES 1990).

The lefthand column, Column B, of the matrix lists the ten externality issues for which each option is evaluated. Each issue receives a weight (Column A) reflecting the relative significance of its environmental impacts. Column D lists the contributing factors (environmental agents or subissues) for each issue. Weights for the contributing factors, shown in Column C, reflect the relative importance of each factor within the issue to which it is assigned. Columns E through I provide the ratings from zero to four for each contributing factor. After the contributing factors are weighted for each resource option, weights are applied to the ratings thereby giving a weighted impact score (Column J). For some of the environmental issues, several "contributing factors" are separately rated, weighted, and then summed to form the issue score. These scores are added to yield a composite score for each resource option (Column K). A brief description of the process by which issues, factors, weights, and rates were determined is provided below.

Selection of Issues

The first step in developing the matrix was the compilation of a list of major environmental externalities for which each demand and supply-side resource option would be evaluated. The externalities were then grouped into issues (Figure 1, Column B), such as global warming and acid rain, to allow them to be described in a fashion similar to the way the public views them. For example, while the public may not have an opinion on the importance of mitigating SO2 or CO2, they may have opinions on the importance of controlling acid rain or global warming.

Weighting of Issues

The issue weights in the matrix were determined through a blend of three different types of information including: studies and reports on individual issues and combinations of issues; polling of experts; and weights assigned in previously developed rating and weighting schemes. While a strictly quantitative approach to defining weights would have been preferred, the current lack of reliable quantitative studies, as discussed above, does not allow for complete quantification.

Selection of Contributing Factors

Contributing factors are the individual components of issues. Some issues have only a single contributing factor while others have several. These factors are selected on the basis of their contribution to the issues. For example, sulfur dioxide and nitrogen oxides are the contributing factors that are used to assess a resource option's effects on acid rain. These two factors have been chosen from the list of acidic precursors from man-made and natural sources because they are most closely linked to utility sources. Figure 1 shows the contributing factors for each issue.

In some cases proxies for the true environmental agents have been chosen as contributing factors. For example, under the "Emissions to Air" issue, fuel type is used as a proxy for air toxics. Rather than listing the many specific air toxics that can be emitted in minute quantities, the framework takes advantage of their correlation to fuel type.

Rating of Contributing Factors

In rating contributing factors, a sensible measurement scale for differentiating between resources must be determined. The range of the scale should accommodate most potential resource options so the upper limit may often be set by the greatest effect that would reasonably be proposed in a qualifying facility bid (e.g. NSPS limits for air emissions

for a pulverized coal unit). The lower limit may be set at zero effect, or lower, where environmental improvements are achievable.

Weighting of Contributing Factors

Weights for each contributing factor represent the factor's contribution to an issue. Within an issue, contributing factor weights must sum to 100%. As with factor rating, several approaches may contribute to the estimation of factor weights.

Use of the Rating and Weighting Approach in NEESPLAN 1990

As part of the development of New England Electric's long range resource plan, NEESPLAN 1990, resource options from both New England and Canada were examined using the rating and weighting approach. Project-specific environmental scores can be found in Table 1. As one would expect, coal-fired resources received the highest environmental scores, thus indicating a higher level of potential environmental degradation. Conservation programs and distribution system upgrades received the lowest scores, reflecting little, if any, potential for environmental harm.

To include the environmental score for a resource in the determination of its cost-effectiveness, it was necessary to monetize the score. The chosen method assigned the project with the highest environmental score, and hence, the highest level of potential environmental degradation, a cost penalty of fifteen percent. The present value of all direct costs associated with the project (capital, O&M, fuel, and any other costs) was increased by fifteen percent to reflect environmental externalities. Other options received an adder that was based on the ratio of their score to the highest score. For instance, one option considered in the development of the Company's long range plan was a twenty-year power purchase from a yet-to-be constructed coal-fired unit. This option, when examined using the using the rating and weighting approach, received the highest environmental score at 2.66 and hence was assigned an adder of fifteen percent. If another project received a score of 1.33, the present value of its direct costs were increased by 7.5% (calculated as 1.33/2.66 * 15%). Therefore, the environmental cost penalty received by a project was directly related to its environmental score and direct costs. If two projects received similar environmental scores but one was more costly than another, the project with higher costs received a higher environmental cost penalty. A list of the externality percent adders are shown in Table 1.

Choice of Fifteen Percent Adder

A maximum fifteen percent penalty was arbitrarily adopted, not analytically estimated. The Company chose a fifteen percent penalty for several reasons. First, it is large enough to lead to changes in the resource plan. The fifteen percent penalty improves conservation program cost-effectiveness and degrades the cost-effectiveness of some supply-side options. At the same time, the fifteen percent penalty is not so large than unforeseen problems with the method might irreversably distort resource plans in the short term. Secondly, fifteen percent is an initial estimate that can be revised as the Company gains more experience with environmental externalities, more research becomes available, and feedback from regulators, customers, and interested parties is received. Finally, fifteen percent is within the range of adders adopted in other jurisdictions, including Wisconsin, Vermont, and New York (Wisconsin Public Service Commission, 1989; Vermont Public Service Board, 1988; Putta, 1989).

Effect on Resource Cost-Effectiveness and the Long Range Plan

Including environmental externalities using the rating and weighting approach tended to improve demand-side and worsen supply-side cost-effectiveness. In particular, the cost-effectiveness of new coal-fired resources was jeopardized by the environmental cost penalty. Before the environmental penalty was applied to a purchase from a third-party coal-fired unit, the cost-benefit ratio for the resource was 0.83. After the penalty, the resource's cost-benefit ratio climbed to 1.01, indicating that the resource was not cost-effective. The results for an atmospheric fluidized bed coal unit were similar; 0.94 before and 1.11 after. All other supply-side options retained their cost-effectiveness after the penalty was applied. Natural gas-fired units, in particular, remained cost-effective.

All demand-side programs examined during the planning process remained cost-effective and are included in the long range resource plan. At present, the resource plan shows one-third of incremental capacity needs being met by demand-side programs. Because the inclusion of environmental externalities tended to improve demand-side cost-effectiveness, the Company expects to find more cost-effective opportunities than previously. Previously marginal, or slightly non-cost-effective opportunities when examined using a revenue-requirements-only perspective are now cost-effective when externalities are considered. Effort is on-going to identify these resources so that future plans can reflect their improved attractiveness.

For the long range plan, a small amount of new coal-fired resources have been included even though their cost-effectiveness appears jeopardized by the consideration of environmental externalities. Less than ten percent of incremental needs are expected to be

met by new coal-fired generation from third party suppliers. No new Company-owned coal-fired generation is planned.

One of the reasons new coal-fired generation has been kept in the resource plan even though it appears not to be cost-effective is for fuel diversity considerations. The Company's fuel mix is expected to become dependent on natural gas-fired generation within the next ten years. Natural gas is expected to climb from essentially zero percent of the Company's fuel mix at present to twenty-five percent by 1999, and to thirty-six percent by 2009. If new coal-fired resources were excluded entirely from the long range plan, some of coal's contribution to incremental needs may have to be replaced with additional gas-fired resources. In this case, lack of fuel diversity, which is not uncommon in New England's energy history, could prove to once again be a serious threat. The problem with excluding all coal-fired generation from the resource plan is that the Company expects coal prices to be more stable than other fuels. Price stability and protection against rate volatility are worthy goals and at this time, excluding coal entirely from the resource plan may place these goals in jeopardy.

Another reason coal has been kept in the resource plan is that societal costs include more than just environmental externalities. There are other externalities, such as economic or social, that should also be considered. This is not to imply that these additional considerations will necessarily work to the advantage of coal-fired generation. It is merely to indicate that moving towards a societal perspective for resource selection raises many difficult issues that should be considered before entirely ruling out any resource.

The Revised Matrix

In using the original matrix its limitations became apparent. Some of the problems found with the approach included the need for the following: (1) unlimited bounds in all externality issue categories; (2) reexamination of the weightings given to all externalities; (3) the incorporation of additional externalities into the matrix and the deletion of others already included; and (4) the inclusion of positive credits or offsets. These limitations have been addressed and a new rating and weighting approach has been developed. The following is a summary of the major changes to the matrix:

- The scales are now unbounded, continuous, and multiplicative. A plant that emits 3 lbs of sulfur dioxide/MWh will receive a worse score than a similar plant that emits 2.9 lbs. This allows better discrimination among projects while not artificially bounding the scales.

- Some of the contributing factor weights were changed to reflect the Company's revised understanding of the impacts certain emissions have on the environment. For example, the weighting of nitrogen oxides (NOx) to sulphur dioxide (SO2) was changed to reflect the assumptions inherent in the acid rain emissions trading provisions of the proposed Clean Air Acts.

- Offsets are allowed. For example, a cogenerator is permitted to plant trees and subtract the CO2 uptake of the trees from the output of the project. However, a project is not allowed to have a negative adder.

- All units are per kWh, MWh, or in the case of land, per MW. This change from lbs/mmBTU rewards efficient plants and penalizes inefficient ones. It also facilitates comparability between different size plants. A large plant occupying few acres per MW will score better than a small plant occupying a large land area.

- "Fuel Issues", "Indoor Air Quality", and "Aesthetics" were removed from the matrix. The concerns reflected in "Fuel Issues" were addressed in other categories. "Indoor Air Quality" was removed because indoor air quality problems are addressed in the Company's demand-side program planning and implementation. "Aesthetics" was removed because it appeared to be more of a siting issue rather than an environmental issue.

A copy of the revised version of the matrix can be found in Figure 2. To score the new matrix, project-specific emissions, land, and water use information are entered. This is a simplified method compared to the original matrix where all emissions were fit into distinct categories and the score for that category was used. Under the new method the actual emission rates are used in the multiplicative formula. The emissions and characteristics scores are multiplied by the environmental concern and contributing factor percentage weights to develop a total environmental score for a resource option.

These changes do not represent a significant restructuring of the matrix. However, by fine tuning the matrix the Company is better able to discriminate among options that otherwise would not have shown differences. This ability to discriminate helps in planning and encourages developers to reduce their impact on the environment as much as possible. With the new matrix every incremental reduction in environmental impact that developers make will benefit them in the resource selection process.

Effect of the New Rating and Weighting Approach on the Resource Plan

For the update of the long range resource plan, NEESPLAN 1991, now underway, the new rating and weighting approach will be used to estimate the environmental costs of new resources. Although too early to say with absolute certainty what the effects may be on the resource plan, it appears that the new approach will increase further the cost-effectiveness gap between new gas-fired and new coal-fired resources. Repowering of an existing unit will probably appear quite attractive given that the repowered unit will provide lower total emissions and may claim offsets. For coal-fired generation, the new approach will probably provide greater environmental differentiation between more traditional pulverized coal plants and new fluidized bed units. Unlike the prior version of the approach, the new method will, in most instances, provide no environmental penalty for demand-side programs. Demand-side programs can be expected to maintain their cost-effectiveness and to play a very significant role in the new resource plan.

Conclusion

Although recognizing that the long-term objective of the environmental externalities effort at the Company is to quantify the cost of damage associated with new resources, the data at present does not support explicit quantification of environmental externalities for NEES-specific resource options. The rating and weighting approach bridges this significant gap by providing a useful short-term method for evaluating environmental externalities. It is an approach that can be used immediately by utilities and reflects reasoned judgements about the amount of environmental degradation potentially posed by any new resource. As better information on actual cost of damage becomes available, the approach can be easily adapted.

The rating and weighting approach presented in this paper accounts for a broad range of environmental externalities in a manner which is simple, explainable, and reasonable. One of the main advantages of the approach that other methods lack is that it is quite simple to review the assumptions behind the approach. This ease of reviewability encourages useful discussion between all parties. Given the nature of the subject, discussion can only be helpful, not harmful. To the extent that New England Electric's approach encourages and adds to the discussion of the important environmental issues facing this industry, the method will have been a success. Hopefully, other utilities and commissions will view New England Electric's approach as a reasonable and significant first-step at moving towards the ultimate, difficult objective of accurate estimation and integration of environmental costs.

Figure 1
Environmental Externality Matrix
Version 1.0

A	B	C	D	E	F	G	H	I	J	K
ENVIRONMENTAL CONCERN		CONTRIBUTING FACTOR		LEAST ----------> IMPACT ----------> MOST					Impact	Issue Score
Weight	Issue	Weight	Factor	0	1	2	3	4		
9%	Global Warming	100%	Carbon Dioxide (lb/kWh)	0	0.63	1.25	1.88	2.5		
14%	Acid Rain	50%	Sulphur Dioxide (lb/mmbtu)	0	0.3	0.6	0.9	1.2		
		50%	Nitrogen Oxides (lb/mmbtu)	0	0.15	0.3	0.45	0.6		
7%	Land Use	*	Amount (acres)	0	2000	4000	* multiply "amount" score by "character" score to calculate impact			
			Character	Industrial	res/com/farm	pristine				
14%	Solid Waste	100%	Overall Assessment (lbs/kWh)	0	0.05	0.1	.015	0.2		
			Adjustment							
16%	Water Use/Quality	20%	Amount (gallons/MWh)	0	150	300	450	600		
		40%	Attributes of Input Water	no water used	minor loss of recreational area	minor loss of habitat	major loss of recreational area	major loss of habitat		
		30%	Thermal Attributes of Receiving Water	no change		receiving water with minor thermal change		receiving water with major thermal change		
		10%	Chemical Attributes of Receiving Water	no change		receiving water with minor chemical change		recieving water with major chemical change		
16%	Emissions to Air	25%	Air Toxics (fuel type)	no fuel		natural gas		coal or oil		
		25%	Particulates (lb/mmbtu)	0	0.0075	0.015	0.0225	0.03		
		25%	Sulphur Dioxide (lb/mmbtu)	0	0.3	0.6	0.9	1.2		
		25%	Nitrogen Oxides (lb/mmbtu)	0	0.15	0.3	0.45	0.6		
2%	Aesthetics	40%	Visual Effects	not visible or obtrusive	seasonally visible	visible from major roads	visible from recreation areas	visible from sensitive areas		
		40%	Noise	no noise	below nighttime ambient	below daytime above nighttime	above daytime ambient	meets property line limit		
		20%	Signal Interference (households affected)	0	10	20	30	40		
2%	Indoor Air Quality	10%	Creation	reduces production		no effect		Increases production		
		90%	Retention (air changes)	increases number		no effect		reduces number		
4%	Fuel Issues	100%	Overall Assessment	no fuel		natural gas		coal/oil		
16%	Ozone	45%	VOCs (lb/mmbtu)	0	0.0015	0.003	0.0045	0.006		
		45%	Nitrogen Oxides (lb/mmbtu)	0	0.15	0.3	0.45	0.6		
		10%	CFCs	no release				CFCs released		

Table 1
Environmental Externality Scores, Cost Adders, and Cost-Effectiveness Results

Demand-Side Options	Environmental Scores (0=no impact; 4=maximum impact)	% Cost Adder	Cost-Benefit Ratio Excl. Externalities	Cost-Benefit Ratio Incl. Externalities
Commercial and Industrial Programs				
- Retrofit Conservation	0.04	0.2%	0.35	0.35
- Retrofit Load Management	0.07	0.4%	0.32	0.32
- New Construction Conservation	0.04	0.2%	0.25	0.25
- New Construction Load Management	0.07	0.4%	0.32	0.32
- Interruptible Rates	0.68	3.8%	0.57	0.59
- Standby Generation	1.68	9.5%	0.57	0.63
Residential Programs				
- Low Income	0.04	0.2%	0.69	0.70
- New Construction	0.09	0.5%	0.93	0.93
- Electric Space Heat Retrofit	0.08	0.5%	0.56	0.57
Supply-Side Options				
Power Purchase from an Unscrubbed Coal Unit	2.66	15.0%	0.83	1.01
Atmospheric Fluidized Bed Coal	2.57	14.5%	0.94	1.11
Natural Gas-Fired Combined Cycle	1.07	6.1%	0.75	0.79
15 MW #2 Oil-Fired Peaking Unit	1.44	8.1%	0.87	0.92
Purchase from a Biomass Unit	2.05	11.6%	0.78	0.89
Pumped Storage	0.61	3.5%	0.56	0.54
Canadian Hydro (Hydro Quebec Phase III)	0.66	3.7%	1.04	1.09

Figure 2
Environmental Externality Matrix
Version 2.0

ENVIRONMENTAL CONCERN		CONTRIBUTING FACTOR		EMISSIONS & CHARACTERISTICS									
				Raw Scoring					Issue Scoring				
Wgt	Issue	Wgt	Factor	Option 1	Option 2	Option 3	Option 4	Option 5	Option 1	Option 2	Option 3	Option 4	Option 5
11%	Global Climate	60%	Carbon Dioxide (lb/KWh)										
		25%	Methane (lbs/MWh)										
		15%	CFCs (lbs/MWh)										
15%	Acid Rain	40%	Sulfur Dioxide (lbs/MWh)										
		60%	Nitrogen Oxides (lbs/MWh)										
10%	Land Use	*	Amount (Acres/MW Capacity) Zoning:0.0=Industrial 0.5=Aquifer Protection Character: 0.5=Significant Environ attributes 0.0=Heavy industrial use.										
13%	Solid Waste	*	Amount Generated (lbs/KWh) Character 1=LF,0=100% Recycle										
16%	Water Use/ Quality	*	Amount (Gallons/kWh) Attributes of Input Water 0.5=Major Loss (wetlands) 0=No Net Water Loss Source 0.5=Tight Supply Aquifer -0.2=2nd Sewage effluent Net Thermal Attributes of Receiving Water 0.5=Major Thermal (Affects aquatic life) 0=No output water Net Chemical Effects of Receiving Water 0.5=Major Chemical (Affects aquatic life) 0=No output water										
17%	Emissions to Air	25%	Air Toxics (2=Oil/Coal,0=None)										
		25%	Particulates (lbs/MWh)										
		25%	Sulfur Dioxide (lbs/MWh)										
		25%	Nitrogen Oxides (lbs/MWh)										
18%	Ozone (Smog)	50%	VOCs (lbs/MWh)										
		50%	Nitrogen Oxides (lbs/MWh)										

Total Score:

BIBLIOGRAPHY

Bernow, Stephen S. Marron, Donald B. 1990. Valuation of Environmental Externalities for Energy Planning and Operations. Tellus Institute. Boston, MA.

Destribats, Alan F., Jonathan B. Lowell, Dean S. White. 1990. Dispatches from the Front: New Concepts in Integrated Planning. Paper presented at the Electric Power Research Institute Innovations in Pricing and Planning Conference, Milwaukee, WI.

Energy System Emissions and Material Requirements. 1989. Prepared for the Deputy Assistant Secretary for Renewable Energy. U.S. DOE, Washington, D.C.

Environmental Protection Agency. 1987. Unfinished Business: A Comparative Assessment of Environmental Problems Overview Report. Washington, D.C..

ECO Northwest, Shapiro and Associates, and Seton, Johnson, and Odell. 1984. Economic Analysis of the Environmental Effects of a Combustion-Turbine Generating Station at Frederickson Industrial Park, Pierce County, Washington, Final Report submitted to the Bonneville Power Administration under contract with United States Department of Energy, Portland, OR.

ECO Northwest, Shapiro and Associates, and Seton, Johnson, and Odell. 1986. Estimating Environmental Costs and Benefits for Five Generating Resources, Final Report and Technical Appendices submitted to the Bonneville Power Administration under contract with United States Department of Energy, Portland, OR.

Krupnick, Alan. 1989. The Environmental Costs of Energy Supply: A Framework for Estimation. Resources for the Future. Washington, D.C.

Massachusetts Department of Public Utilities. 1988. Docket No. 86-36-F. Boston, MA.

New England Electric System. 1989. Integrating Environmental Externalities into Resource Planning at New England Electric. Study prepared by Temple, Barker and Sloane. Lexington, MA.

New York State Public Service Commission. Cases 88-E-240 through 88-E-245. Albany, NY.

Putta, Sury N. 1990. "Need and a Method for Valuing Environmental Costs in Deregulated Power Generation." Paper presented at the Eastern Regional Business and Economics Utilities Conference.

Putta, Sury N. 1989. "Consideration of Environmental Externalities in New York State Utilities' Bidding Programs for Acquiring Future Electricity Capacity." New York Public Service Commission.

Shimshak, Rachel, Bruce Biewald, Harvey Salgo, Donald Marron, and Steve Bernow. 1990. "Comments of the Division of Energy Resources on Environmental Externalities", presented before the Massachussetts Department of Public Utilities, Case No. DPU 86-36-G and DPU 89-239, March 2, 1990.

State of Vermont Public Service Board. 1988. Investigation into Least Cost Investments, Energy Efficiency, Conservation and Load Management of Demand for Energy. Hearing Officer's Report and Proposal for Decision. Docket No. 5270. Montpelier, Vermont.

State of Wisconsin Public Service Commission. 1989. Advance Plan 5 Order. Docket No. 05-EP 5. Madison, WI.

White, Dean S., Timothy M. Stout, and Mary Sharpe Hayes. 1990. Incorporating Environmental Externalities in an Integrated Resource Planning Process: One Utility's Experience. Paper presented at the American Council for an Energy Efficient Economy Summer Study, Asilomar, CA.

NATIONAL ASSOCIATION OF
REGULATORY UTILITY COMMISSIONERS

NATIONAL CONFERENCE ON ENVIRONMENTAL EXTERNALITIES

Panel on
"Regulatory Processes: Legal & Institutional Barriers"

Presentation by
Richard L. Ottinger
Pace University Center for
Environmental Legal Studies

1. Introduction[1]

Internalizing the environmental costs imposed on society by polluters is the wave of the future in addressing environmental degradation. By signalling to industry the true societal costs of their operations, inclusion of environmental costs in the price of goods produced gives an economic incentive to industry to reduce pollution. This can be an important supplement to regulation.

Government regulation of pollution has proved to be generally inadequate to address the severe threats to the planet posed by global warming, acid rain, urban smog and toxic contamination of our air, water and food supplies. While some improvements have resulted from regulation in the United States, particularly where contaminants have been totally prohibited as with asbestos, lead in gasoline and DDT, generally pollution increases stay well ahead of mandated regulatory controls. Inevitably economic growth, in both developing and industrialized countries, receives higher government priority than environmental protection and outpaces governmental efforts to control pollution or require switching to less polluting industrial resources.

Governments are just starting to consider supplementing pollution regulation with pollution taxes or fees that will introduce into the marketplace prices that reflect the damages to society inflicted by polluting resources. The OECD has just published a review of pollution levies indicating a total of 85 pollution taxing regimens in six of its principal countries.

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[1] This paper is based on a study performed by the Pace University Center for Environmental Legal Studies (Center) for the New York State Energy Research and Development Authority (NYSERDA) and the U.S. Department of Energy (DOE), Environmental Costs of Electricity, Oceana Publications, Inc., Dobbs Ferry, N.Y., September, 1990, also distributed by the American Council for an Energy-Efficient Economy, Washington, D.C. [hereafter referred to as "Pace 1990"]. The study was performed by Center staff, Pace University Law School students, and consultants, Shepard C. Buchanan of Bonneville Power Administration, Paul Chernick and Emily Caverhill of PLC, Inc., and Alan Krupnick of Resources for the Future.

Thus, Germany, France and Holland have imposed waste water effluent charges ($2, $9 & $39 per capita respectively); Switzerland has imposed extra landing fees on noisy aircraft; Sweden and Norway have required returnable deposits on automobile bodies to prevent their being dumped. West Germany is considering an auto tax based on tailpipe exhausts.[2] And the U.S. House of Representatives' Ways & Means Committee recently held hearings on pollution taxes (March 6, 7 & 14, 1990).

The environmental organizations, which historically have resisted pricing environmental impacts on grounds that it would constitute a licence to pollute, have now embraced the idea. Daniel Dudek of the Environmental Defense Fund has been a leading advocate of marketplace treatment of pollution; he helped draft the Administration's Clean Air Act proposal to create emissions trading rights.

It is remarkable that the conservative electric utility industry and its usually equally cautious utility regulatory commissions have pioneered in applying marketplace principles to valuation of environmental externalities. In twenty-nine jurisdictions, utility regulatory commissions have started formal consideration of incorporating these externalities into utility planning, bidding and other resource selection procedures.

2. Significance of Utility Consideration of Environmental Externality Costs

United States electric utilities are a major contributor to the damages imposed on the global environment. They account for about two-thirds of United States sulphur dioxide emissions and one-third of United States nitrogen oxide emissions, both of which cause acid deposition. They contribute one-third of the national emissions and eleven percent of the global emissions of carbon dioxide, the principal greenhouse gas.[3] Thus, United States electric power production produces a significant environmental impact on the United States and the world, the cost of which is not included in the price of electric power.

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[2] "Money from Greenery." The Economist, October 21, 1989, pp. 16, 17.

[3] Electric utilities contributed in 1985 68% of national SO_2 emissions (16,204,000 tons of 23,699,000 tons nationally), and 33% of national NO_x emissions (6,989,000 tons of 21,054,000 tons nationally). National Acid Precipitation Assessment Program (NAPAP), Interim Assessment, Vol. I (1987).

U.S. electric utilities accounted for 33% of U.S. CO_2 emissions in 1988. CO_2 accounted for 66% of the global warming from 1880 to 1980. U.S. E.P.A., Office of Policy, Planning and Evaluation, Policy Options for Stabilizing Global Change, Draft Report to Congress, February, 1989 [EPA Report]. It has been predicted that CO_2 will account for 80% of future warming because of its long duration in the atmosphere. Lashof and Ahuja, Relative Contributions of Greenhouse Gas Emissions to Global Warming, 344 Nature 529, April 5, 1990. The remaining greenhouse gases, CH_4, CFC 11 & 12, N_2O and others, contributed the balance of global warming. EPA Report, id.

Until recently, most utilities throughout the country have selected their supply and demand side resources on a least economic cost basis, without regard to the very real environmental costs imposed on society. The utilities and regulatory commissions have proceeded on the basis that full compliance with all applicable environmental laws and regulations is sufficient.

However, government-imposed standards and regulations do not purport to eliminate pollution. Rather, they merely limit emissions to levels established by a combination of legislative compromise and regulatory feasibility.[4] The environmental impacts that remain after regulation are significant. Not all emissions are regulated, and even those emissions that are regulated are not eliminated. To the extent that power producers price and select resources solely on the basis of complying with government standards, the effect is to assign the very substantial residual environmental externality costs a value of zero.

As difficult as it is to fix exact dollar figures on environmental damages, one always has to come back to the basic tenet that "A crude approximation, made as exact as possible and changed over time to reflect new information, would be preferable to the manifestly unjust approximation caused by ignoring these costs,"[5] and thus valuing environmental damages at zero.

Incorporation of the dollar values of environmental externalities in utility resource selection procedures will enable utilities and regulators to take environmental costs into account in making resource acquisition decisions. In practical terms, the result will be to encourage utilities to invest in less polluting resources.

3. Why Utilities Should Incorporate Environmental Costs

It could be argued that consideration of environmental externalities should be addressed solely by pollution controls, taxes or fees enacted by Congress and state legislatures, rather than by utility actions and regulatory commission orders affecting resource selection. Indeed, currently, environmental costs for other industries such as automobile and chemical

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[4] The political nature of standards is well demonstrated by the political compromises now being made in the U.S. Congress over the extent of additional air pollution regulation in the Clean Air Act.

[5] Bland, Paul F. 1986. "Problems of Price and Transportation: Two Proposals to Encourage Competition from Alternative Energy Resources." Harv. L. Rev. 10:2.

manufacturing, smelting, etc. are addressed only through legislated controls.

National pollution fees could internalize environmental externality costs for all polluting sources, thus sending universally improved price signals to the marketplace.[6] Of course, complete regulation, eliminating all pollution that poses a threat to human health and the environment would also internalize environmental externality costs universally. Neither appears to be politically feasible at present, however.

In the absence of legislative internalization, utilities nevertheless will continue selecting resources which, after regulation, will still impose significant environmental costs on society. If utilities and their regulatory commissions continue to assign only traditional direct costs to these resources as a principal basis for their selection, these environmental costs still will be ignored. For a full accounting of costs in this continuing resource selection process, it is important that the environmental costs be counted.

There are two principal reasons why utilities and regulatory commissions should consider environmental externalities in their resource selection processes: (1) utilities are franchised monopolies vested with a duty to serve the public interest, a responsibility that includes environmental protection[7]; and (2) foreseeable international, federal and state environmental laws and regulations are likely to impose more stringent environmental controls over the thirty to forty-year life span of electric power plants, making it imprudent for utilities to invest in resources which will have to be abandoned or which will require expensive environmentally-required retrofits.[8] It is within the traditional role of utility regulatory commissions to oversee

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[6] Another way to place pollution values in the marketplace is by setting stricter standards and allocating emission trading rights to facilitate pollution reduction at least cost. This has been proposed legislatively for the first time on a large scale in the Administration's submission for Clean Air Act amendments now pending before Congress; these provisions have recently been adopted by both the House of Representatives and Senate.

[7] See, for example, the New York Environmental Quality Review Act (SEQRA), New York Environmental Conservation Law, Section 8-0107 and its implementing regulation, 6 NYCRR, Part 617.9(c)(3), which require all state agencies to assess and minimize or avoid environmental impacts "to the maximum extent practicable." As noted above, however, these regulations do not eliminate substantial environmental impacts and costs to society.

[8] Tighter national controls are already in prospect, such as the revision being considered in Congress of the law which governs disposal of solid wastes. Resource Conservation and Recovery Act, 42 U.S.C. 6901 et. seq. International negotiations for accords that would affect electric utilities are also in progress such as those before the Intergovernmental Panel on Climate Change, Working Group III, considering a 20% reduction in carbon dioxide by 2020 and 50% thereafter. If and when these national laws and treaties are enacted, however, there will still be large residual environmental impacts and damages requiring valuation.

utility public interest obligations and to prevent imprudent investments.[9]

It should be noted that when commissions require consideration of environmental externalities in utility planning and resource selection, they are not internalizing these costs in the existing rate structure, but are using them as a means of making prudent selection of new resources.

Accounting for environmental externalities in utility decision making will not only help to avoid the economic costs of future environmental controls, it will also reduce the level of uncertainty associated with utility resource plans and increase system reliability.

4. Magnitude of Environmental Costs

The following values are presented as "starting point" figures from the Pace 1990 study. "Starting point" values, as used in that study, are those that seem to most reasonably represent the range of values in the studies reviewed, considering the locations at which the studies were performed, their documentation and thoroughness. The term "starting point" is used because the figures do not pretend to be cost estimates -- too many relevant costs were excluded from this study[10] and the studies reviewed are often of too uneven quality and documentation -- but the "starting point" figures do give the order-of-magnitude of the values in the studies reviewed, and they should provide a good starting point for further research.

a. Fossil Fuel-Fired Plants

Emissions from electric power plants are generally available on a plant specific basis. However, it is difficult to estimate a "typical" set of emissions for any resource type. Emissions depend on several factors other than simply the plant type, including: the age and type of the plant; fuel type, grade and sulfur content; installed emissions control technology; plant operations, including heat rate, combustion temperature, and steam or limestone injection. Finally, the estimate of emissions per unit of energy output can be further complicated by the

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[9] Many utility regulatory commissions still do not require least cost planning or rule in advance on the prudence of utility investments. However, utilities in these jurisdictions still are subject to prudency reviews after they have invested, in their next rate-setting proceedings.

[10] The Pace 1990 study was restricted to the costs of damages to human health and the environment (generally excluding control and mitigation costs) of the operations of electric service facilities through waste disposal (excluding all front end costs such as mining, fuel processing, equipment manufacturing and transportation of fuels, equipment and materials to the generation site).

allocation of emissions to joint products, such as steam and electricity. In the examples presented, all of the externalities have been allocated to electricity output.

The externality values are estimated for three coal-fired technologies, two oil-fired technologies with three different sulfur content assumptions, and two natural gas-fired technologies with differing control equipment. These examples are illustrative of the relative externalities of different fossil-fired resource options, both existing and new, but are not meant to represent average externalities of these technologies.

The reports reviewed estimate the following "starting-point" values, in dollars per pound of emissions: \$2.03/lb SO_2, influenced primarily by the estimated health effects; \$0.82/lb NO_x, also dominated by health effects; and \$1.19/lb particulates, based primarily on visibility effects (\$0.83/lb.), with a strong contribution from health effects (\$0.36/lb.).[11] The value of reducing CO_2 emissions was estimated to be 2.5 cents/lb carbon (or 0.68 cents/lb CO_2) using a mitigation cost estimate for tree planting from the middle of the range found in the studies. These ranges vary from \$17.08/T of carbon to \$80/T, depending on fixation rates, discount rates and other assumptions.

For coal-fired facilities, dollar per pound figures are converted into a cent per kilowatt hour cost. See Table A. No pollution control equipment is used for any of the example plants for SO_2, NO_x or CO_2. This assumption applies for many older coal-fired boilers in most of the country, and it provides a base-line for comparing plants with control technologies. The absence of control could also apply to newer facilities built in the 1970's because they may be able to meet the standards by controlling emissions through improved operating procedures.[12] For particulates, some pollution control equipment (e.g. bag-houses) is assumed to be installed on each plant. The "starting point" externalities from the older coal-fired boiler burning 1.2% sulfur coal are on the order of 5.7 cents/kWh generated, or 6.7 cents/kWh delivered. For an Atmospheric Fluidized Bed Combustion (AFBC) plant with the same heat rate and burning 1.1% sulfur coal, these externalities are on the order of 2.8 cents/kWh (generated). For an Integrated Gas Combined Cycle (IGCC) plant

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[11] Sulfates (SO_4), which are very small particulates, are believed to contribute significantly to particulate-related health effects. Sulfates can be emitted from a power plant either as particulates or as SO_2, which is then converted to SO_4 in the atmosphere.

[12] This would not be true for coal-fired plants built after promulgation of the most recent New Source Performance Standards, however. These plants are required to have scrubbers regardless of sulphur content of fuels. This may change, however, in the Clean Air Act Amendments of 1990, presently being considered by Congress, which may modify the requirement for scrubbers on some newly constructed plants. A cost figure for a NSPS-controlled plant is provided in Table A.

with the same heat rate and sulfur content of 0.45% sulfur these externalities are on the order of 2.5 cents/kWh (generated).

For oil-fired facilities, the results are shown in, Table B. Again, and for the same reasons as for coal-fired plants, no pollution control equipment is used on any of the example plants for SO_2, NO_x or CO_2. This is typical for many older residual oil-fired boilers, and controls are not generally necessary for a distillate oil-fired combustion turbine to meet NSPS standards. The SO_2 and particulate emissions are strongly dependent on the sulfur content of the oil. Table B shows "starting point" estimates of the externalities from two different oil-fired technologies: boilers burning residual oil with three different sulfur contents and a combustion turbine burning distillate oil. The "starting point" externalities from the residual oil-fired boiler burning 0.5% sulfur oil are on the order of 2.7 cents/kWh (generated). For the same boiler burning 1% sulfur oil these externalities are 3.8 cents/kWh (generated), and for the same boiler burning 2.2% sulfur oil these externalities are 6.7 cents/kWh (generated). The "starting point" externalities of a combustion turbine burning distillate oil, and having lower efficiency than the boilers, are on the order of 2.5 cents/kWh (generated).

For natural gas-fired facilities, the results are shown in, Table C. No special NO_x control equipment is assumed to be used on the gas-fired boiler or the combined cycle unit. However, selective catalytic reduction (SCR) and steam water injection (SWI) are applied on the BACT unit, which is a combined cycle unit fitted with best available control technology. SO_2 emissions from natural gas combustion are shown to be negligible. The "starting point" externalities from a natural gas-fired steam plant are on the order of 1.0 cent/kWh (generated). For a combined cycle unit these externalities are estimated to be on the order of 1.0 cent/kWh (generated). For a combined cycle unit fitted with SCR and SWI, these externalities drop to 0.7 cents/kWh (generated).

These results show that the externalities of older coal- and oil-fired boilers are dominated by SO_2 and NO_x emissions. For newer coal and oil-fired technologies, and for gas-fired plants, the externalities are largely dominated by CO_2 emissions. This shift in the emphasis of the externalities is shown by the studies reviewed to be largely due to improved boiler design and efficiency, improved control equipment efficiency, and increasing use of control equipment and emissions-reducing operating procedures in response to ever-tightening emissions regulations.

Finally, these externality estimates leave out so many potential external effects that they are likely to be conservative rather than overstated. To derive more complete cost estimates, other externalities should be incorporated into future environmental cost estimates for fossil fuel-fired power plants, including: air emissions from combustion not included in the studies reviewed, such as the greenhouse gases methane and N_2O; air toxics including heavy metals, ozone precursors, VOCs; and other externalities related to fossil-fuel combustion for which valuation studies could not be found, such as water use, land use, and solid waste disposal; and externalities related to the front end of the fuel cycle, such as extraction, transportation and processing, which were excluded from the Pace 1990 report.

Tables A-C below summarize the environmental costs for fossil fuel plants from the studies received and "starting point" cost for them.

TABLE A: EXTERNALITY COST FOR COAL-FIRED UNITS

		EMISSIONS (lbs/MMBTU)			
EXTERNALITY	$/lb	Existing Boiler (1.2%S)	AFBC (1.1%S)	IGCC (.45%S)	NSPS (N/A)
	[A]	[B]	[C]	[D]	[E]
[1] SO2	$2.03	1.80	0.55	0.48	1.2
[2] NOX	$0.82	0.607	0.3	0.06	0.006
[3] PARTICULATES	$1.19	0.15	0.01	0.01	0.03
[4] CO2	$0.0068	209	209	209	209
TOTALS:					
[5] $/MMBTU INPUT		$5.76	$2.80	$2.46	$3.90
[6] HEAT RATE (BTU/kWh)		10,000	10,000	10,000	10,000
[7] $/kwh GENERATED		$0.058	$0.028	$0.025	$0.039
[8] $/kwh DELIVERED		$0.068	$0.033	$0.028	$0.045

NOTES:

[A]: Unit values derived in Section V.

[B][C][D][E]: Emissions are from PLC (1989); SO2 and CO2 emissions have been restated as lbs SO2 and lbs CO2. All emissions are expressed as lbs/MMBTU fuel input.

[E]: NSPS regulations require 1.2 lbs/MMBTU and 90% reduction for plants with emissions greater than 0.6 lb/MMBTU; for plants with emissions less than 0.6 lb/MMBTU, NSPS requires 70% reduction in emissions.

[1]: No SO2 scrubbers are installed on the first three plants.

[2]: NOx emissions are uncontrolled in each case.

[3]: Particulates emissions vary widely and are extremely dependent on the ash content and sulfur content of the coal. NSPS requires 0.03lbs/MMBTU and 90% reduction.

[4]: CO2 emissions are derived in PLC (1989).

[5]: Sum of (value x emissions for each externality) for each plant.

[6]: Assumed heat rates for each plant.

[7]: [5]*[6]/1,000,000

[8]: Assumes 15% marginal energy losses.

TABLE B: EXTERNALITY COST FOR OIL-FIRED UNITS

		EMISSIONS (lbs/ MMBTU)			
EXTERNALITY	$/lb	BOILER #6 Oil (.5%S)	BOILER #6 Oil (1%S)	BOILER #6 Oil (2.2%S)	COMBUSTION TURBINE #2 Oil (1%S)
	[A]	[B]	[C]	[D]	[E]
[1] SO2	$2.03	0.54	1.08	2.38	0.16
[2] NOX	$0.82	0.357	0.287	0.357	0.498
[3] PARTICULATES	$1.19	0.055	0.09	0.174	0.036
[4] CO2	$0.0068	169	169	169	161
TOTALS:					
[5] $/MMBTU INPUT		$2.60	$3.68	$6.48	$1.87
[6] HEAT RATE (BTU/kWh)		10,400	10,400	10,400	13,600
[7] $/kwh GENERATED		$0.027	$0.038	$0.067	$0.025
[8] $/kwh DELIVERED		$0.032	$0.045	$0.079	$0.030

NOTES:

[A]: Unit values derived in Section V.
[B][C][D]: Emissions are from PLC (1989); SO2 and CO2 emissions have been restated as lbs SO2 and lbs CO2; All emissions are expressed as lbs/MMBTU fuel input.
[1]: SO2 emissions are uncontrolled in each case.
[2]: NOx emissions are uncontrolled in each case.
[3]: Particulates emissions are calculated from EPA AP-42 using the formula: 0.02 + 0.07xS, where S is the sulfur content in percent.
[4]: CO2 emissions are derived in PLC (1989).
[5]: Sum of (value x emissions for each externality) for each plant.
[6]: Assumed heat rates for each plant.
[7]: [5]*[6]/1,000,000
[8]: Assumes 15% marginal energy losses.

TABLE C: EXTERNALITY COST FOR NATURAL GAS-FIRED UNITS

EXTERNALITY	$/lb	EMISSIONS (lbs/ MMBTU) EXISTING STEAM PLANT	COMBINED CYCLE	BACT (SCR, SWI)
	[A]	[B]	[C]	[D]
[1] SO2	$2.03	0	0	0
[2] NOX	$0.82	0.248	0.42	0.042
[3] PARTICULATES	$1.19	0.003	0.003	0.0002
[4] CO2	$0.0068	110	110	110
TOTALS:				
[5] $/MMBTU INPUT		$0.95	$1.10	$0.78
[6] HEAT RATE (BTU/kWh)		10,400	9,000	9,000
[7] $/kwh GENERATED		$0.010	$0.010	$0.007
[8] $/kwh DELIVERED		$0.012	$0.011	$0.008

NOTES:

[A]: Unit values derived in Section V.
[B][C][D]: Emissions are from PLC (1989); CO2 emissions have been restated as lbs CO2;
All emissions are expressed as lbs/MMBTU fuel input.
[1]: SO2 emissions are zero from gas combustion.
[2]: NOx emissions are uncontrolled in the first two cases; For the BACT case,
Selective Catalytic Reduction and Steam Water injection are assumed.
[3]: Particulates emissions are estimated from CEC (1989). BACT assumes fabric filter control.
[4]: CO2 emissions are derived in PLC (1989).
[5]: Sum of (value x emissions for each externality) for each plant.
[6]: Assumed heat rates for each plant.
[7]: [5]*[6]/1,000,000
[8]: Assumes 15% marginal energy losses.

b. Nuclear Plants

The external costs of nuclear power have been divided into a number of categories including: (1) the health, property value and wildlife costs caused by routine radiation emissions; (2) the costs caused by non-routine emissions, for which no studies were found; (3) the health and property damage costs associated with accidental emissions; and (4) decommissioning costs that are not internalized.

The "starting point" environmental costs from nuclear operations are estimated to be 2.91 cents/kWh, which is the sum of: (1) 0.11 cents/kWh for routine and non-routine operations, (2) 2.3 cents/kWh for accidents, and (3) 0.5 cents/kWh for decommissioning costs. This analysis omits all front-end costs from extraction and transportation of uranium, excluded from the Pace 1990 study.

Table D below represents the nuclear plant's "starting point" values.

TABLE D

STARTING POINT VALUES FOR NUCLEAR POWER EXTERNALITIES

	Cents/kWh	
Routine operations		0.11
Accidents	2.30	
Decommissioning	0.50	
TOTAL	2.91	

c. Waste-to Energy Plants

The only study located estimated the externalities of waste-to-energy plant emissions at 11.14 cents/kWh. If half of this value were allocated to the energy production function of the plant, then the environmental externality costs would be approximately 5.5 cents/kWh. The study did not appear to take into account the risks from exposure to toxic substances in the incinerator ash and may have undervalued the risks from toxic emissions.

Since the types of emissions from garbage incinerators are similar to those from coal-fired plants, one costing approach is to apply the dollar-per-pound values for coal plant emissions to incinerators. This provides a lower value of approximately 2.8 cents/kWh solely for SO_2, NO_x, HCL and particulate emissions, excluding a value for human health effects from HCL, for which no social costs were found.

Table E below displays the environmental externality costs of waste-to-energy plants from the studies reviewed.

TABLE E

CALCULATION OF CONVENTIONAL WASTE-TO-ENERGY PLANT EMISSION EXTERNALITIES

Pollutant	Cost Per Pound	Pounds Per Kilowatt Hour	Externality Cost in Cents/Kilowatt
SO_2	$1.72	.014	2.4
NO_x	.98	.002	.2
HCL	.14	.077	.1
Particulate	$1.18 - 2.36	.00075	.09 - .18
Carbon Monoxide	-	.00085	-
Volatile Organic Hydrocarbons	-	.00015	-
CO2	-	-	-
		TOTAL	2.79 - 2.88

d. Solar, Wind and Biomass

"Starting point" costs are given in Table F below from the environmental externalities of solar, wind, and biomass power generating systems. These costs cannot be directly compared, however, because the figures were developed using different methodologies for each technology.

TABLE F

SUMMARY OF ENVIRONMENTAL COSTS FOR VARIOUS RENEWABLE ENERGY TECHNOLOGIES

Technology Type	Cents/kWh
Solar	0 to 0.4
Wind	0 to 0.1
Biomass	0 to 0.7

5. Federal Incorporation

The studies reviewed in Pace 1990 indicate that FERC has taken no action to incorporate environmental externalities in the wholesale and interstate markets that it regulates. Indeed, the recent Notices of Proposed Rulemaking it has issued on PURPA bidding guidelines don't even address DSM options, to say nothing of environmental costs. Federal consideration of environmental costs has been primarily through environmental regulation, which by reducing pollutants, internalizes some of their costs.

Present federal subsidies and tax credits, on the other hand, are found to benefit fossil and nuclear electricity which bear high environmental costs much more than less polluting electricity options such as renewables and DSM. All subsidies are found to distort marketplace pricing of energy resources.

6. Incorporation by Utilities and Regulatory Commissions

A surprising number of states, twenty-nine, have required or are actively considering requiring, their utilities to include environmental externality costs in some manner in planning, bidding or other resource acquisition procedures.[13] Nine states

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[13] Orders: AZ, CA, ID, KA, MA, MICH, MN, NJ, NY, OH, OR, TX, VA, VT, WI
Statutes: ALSK, NV
Pending: CT, IA, MN
Consideration: DC*, HW, ME, MD, MONT, RI, UT
No Consideration: ALA, ARK, DL, FL, GA, IL, IND, KY, LA, MISS, MO, NB, NH, NM, MD, NC, OK SC, SD, TN, WA, WVA, WYO

* The District of Columbia (DC) is considered as a state for the purposes of this analysis

plus the Bonneville Power Administration and the Northwest Power Planning Council have sought to quantify environmental costs or have quantification measures pending; three other states have such measures under active consideration.[14] Those entities are approaching incorporation in several ways:

Quantitative. Some utility commissions either increase the cost of a proposed new resource by a specific amount/kWh, reflecting the environmental consequences of using the resources (e.g. New York) or allow a credit to reduce the effective kWh cost of what are deemed to be less-polluting resources (e.g. Wisconsin). The adder or credit is based on quantified costs.

Qualitative. Several utility commissions require utilities to consider environmental impacts without specifying how the costs are to be calculated or incorporated (e.g. Arizona).

Rate of return. A number of utility commissions award an increased rate of return on specific non-polluting resource investments (e.g. demand-side management in Washington) or an increased rate of return based on over-all performance in utilizing non-polluting resources (e.g. Idaho).[15]

Avoided cost. Some utility commissions increase avoided costs in order to take into account environmental costs (e.g. Virginia).

Ranking. A few utility commissions permit a utility to be guided in selecting resources by a commission-imposed or commission-approved ranking system that weights resources by their environmental impacts or by other criteria, not their environmental costs (e.g. New England Electric System (NEES) in Massachusetts was allowed to use a ranking based on a customer survey[16]).

Pace 1990, Chapter X discusses these incorporation issues and Chapter X, Section G, summarizes state-by-state, with citations, the treatment of environmental externalities. At the end of this section, Table G shows the status of state actions incorporating environmental externality costs and Table H shows the type of action taken by states that have acted to incorporate environmental externality costs.

[14] Orders: CA, CO, NJ, NY, OR, WI, VT
Pending: CT, MA, CA (limited order; more extensive order pending)
Consideration: DC, MD, MI

[15] The New York PSC was recently upheld in providing utility rate incentives for engaging in DSM programs. Multiple Intervenors v. New York State Public Service Commission, No. 249-90 (N.Y. Sup. Ct., June 7, 1990. The Pace Center for Environmental Legal Studies filed a brief in the case in support of the PSC.

[16] Investigation by the Department of Public Utilities on Its Own Motion Into Proposed Rules to Implement Integrated Resource Management Practices for Electric Companies in the Commonwealth, Mass. D.P.U. No. 89-239, Comments by Massachusetts Electric Co. (a NEES subsidiary) at pp. 17-21 and Attachment 2, February 23, 1990.

Collaborative. Several utility commissions authorize utilities to determine environmental costs and their treatment through a collaborative negotiating process involving regulators, state agencies and public interest intervenors. Outside experts are usually hired to design programs, evaluation procedures and incentives rates to utilities, and to determine how environmental costs will be calculated and incorporated. The process is sanctioned and subject to oversight by the commission.

Several innovative incorporation methodologies have not yet been applied in any state. These include **"Environmental LCUP,"** in which pollution reduction targets are set for particular pollutants and the utilities are required to meet these targets at least cost; **environmental dispatch**, in which utilities or a power pool are required to include environmental costs in least cost dispatch of existing resources; **cost-charging**, in which quantified environmental costs are charged to the resource-owner and the proceeds used to establish a pollution mitigation fund; and **set-asides**, in which utilities are required to set aside a specified portion of their capacity needs for designated resources considered to be relatively environmentally benign.

Table G below shows graphically the status of state actions incorporating environmental externality costs, and Table H shows the type of action taken by states which have acted to incorporate these costs.[17]

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[17] These tables are based largely on a 50-state survey of state regulatory commissions in November, 1989, recently updated, on state treatment of environmental externalities. The survey was done for the National Association of Regulatory Utility Commissioners (NARUC) by Lawrence Berkeley Laboratory (LBL), to be published shortly. Cohen, S.D., J.H. Eto, J. Beldock, and G. Crandall., A Survey of State Regulatory Commission Activities to Incorporate Environmental Externalities into Electric Utility Planning and Regulation, draft of May, 1990. For the other sources, see Pace 1990, the State-by-State Survey Sources at the end of Chapter X, Section G.

TABLE G

STATUS OF STATE ACTIONS INCORPORATING ENVIRONMENTAL EXTERNALITY COSTS

Legend

O - Incorporation Ordered
P - Incorporation Order Pending
U - Under Consideration
N - No Action

STATE	O	P	U	N		STATE	O	P	U	N	
ALABAMA				X		NEBRASKA				X	
ALASKA	X				1	NEVADA	X				1
ARIZONA	X					NEW HAMPSHIRE				X	
ARKANSAS				X		NEW JERSEY	X				
CALIFORNIA	X				2	NEW MEXICO				X	
COLORADO	X					NEW YORK	X				
CONNECTICUT		X				NORTH CAROLINA			X		
DELAWARE				X		NORTH DAKOTA				X	
DISTRICT OF COLUMBIA			X			OHIO	X				
FLORIDA				X		OKLAHOMA				X	
GEORGIA				X		OREGON	X				
HAWAII			X			PENNSYLVANIA	X				
IDAHO	X					RHODE ISLAND			X		
ILLINOIS				X		SOUTH CAROLINA				X	
INDIANA				X		SOUTH DAKOTA				X	
IOWA		X				TENNESSEE				X	
KANSAS	X					TEXAS	X				
KENTUCKY				X		UTAH			X		
LOUISIANA				X		VERMONT	X				
MAINE			X			VIRGINIA	X				
MARYLAND			X			WASHINGTON				X	
MASSACHUSETTS	X				2	WEST VIRGINIA				X	
MICHIGAN	X				2	WISCONSIN	X				
MINNESOTA	X				2	WYOMING				X	
MISSISSIPPI				X							
MISSOURI				X	3	BPA	X				1
MONTANA			X			NWPPC	X				1

Source: Pace 1990, Chapter X, Section G.

1. Established by legislation.
2. Order issued to consider externalities; implementation pending.
3. Commission has stated that it may consider externalities.

TABLE H

TYPE OF ACTION BY STATES ACTING TO INCORPORATE ENVIRONMENTAL EXTERNALITY COSTS

Legend

O - Incorp. Ordered	AC - Avoided Cost Consid.
P - Incorp. Order Pending	ED - Environmental Dispatch
U - Under Consideration	C - Collaborative Action
QN- Quantitative Consid.	PL - Planning Consideration
QL- Qualitative Consid.	B - Bidding Consideration
ROR- Rate Consideration	L - Legislative Action

State	QN	QL	ROR	AC	ED	C	PL	B	Comment
ALSK				O			L		
AZ		O					O		
CA	OP				U	C*	O		*Collab. ended
CO	O*							O*	*by fuel type
CT	P		L*			C	P	P	*5% ROR adder
DC							U		
HW							U		
ID			O	O					
IA				P		C			
KA	P		O						
ME		U					U		
MD	U					C		U	
MA	P*					C	P	P	*DSM Evaluations
MICH	U			O			U		
MN*		O					P		*Law caps SO2
MT		U	L*				U		*2% adder for DSM
NV		L					L		
NH							L*		*Law under consid.
NJ	O			O				O	
NY	O		O	L		C	O	O	
OH		O					O		
OK			O*						*ROR, trash only
OR*	O	O					O		*Law caps CO_2
PA		O*					O*		*Not implemented
RI							U		
UT							U		
TX		L					L		
VT	O*					C	O*	O*	*15% on DSM
VA				O*					*15% DSM adder to AC
WA			L*						*2% ROR law for DSM
WI	O		O		U		O		
BPA	L						L	U	
NWPPC	L						L		

Source: Pace 1990, Chapter X, Section G

7. Barriers to Incorporation

Despite this heartening progress on the part of utilities and regulatory commissions to incorporate environmental externalities in planning and resource selection, a number of barriers exist to more widespread adoption.

First, many commissions have not yet adopted least cost planning procedures, leaving it to their utilities to determine the selection of resources. Since inclusion of externalities is a societal function not reflected in utility profits, it is unlikely that utilities will on their own act to incorporate externality costs in their selection procedures and none have done so.

Second and related to the first barrier, only a very few utility commissions have provided ratemaking revisions that reward utilities for considering environmental externalities in their resource selection determinations. Just nine states give rate of return consideration to environmentally benign DSM measures, citing environmental externality cost rationales, for example.[18] No commission has adopted rate incentives specifically tied to avoidance of environmental costs or rewarding investment in environmentally benign resources other than DSM resources. It is unrealistic to expect utilities to take environmental costs into account unless they are rewarded for doing so (or penalized for failure to do so).

Third, there are a number of rate impact and equity issues which derive from utility consideration of environmental externalities.

Requiring incorporation of environmental costs could have a significant impact on rates and the competitive position of electric utilities. So far, rate impacts have not been a significant problem because the environmental adders (or credits to non-combustion sources) have not been large enough to have a significant effect on rates, and the costs have been applied only to selection of new resources, rather than to more highly polluting existing resources.

If, however, the full environmental damage costs are ascertained and used, and particularly if application is made to existing resources, the impact on rates could be considerable. On the other hand, if consideration of environmental costs causes utilities to invest more in energy efficiency resources, which

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[18] Commission Orders: ID, KA, NJ, NY, OK, WI
Statutes: CT, MONT, WA

The Oklahoma commission gives an incentive rate of return on environmental grounds solely to resource recovery plants.

generally have economic and social costs lower than traditional supply alternatives, then the electric bills of participating customers may be reduced (even though utility rates charged to consumers will increase).

Another equitable issue that must be addressed is whether these rate impacts should be borne by all ratepayers or only the class of customers eligible to participate in the utility DSM investment. All customers will benefit by environmental enhancement, and to the extent that DSM is undertaken, all will benefit from avoidance of more expensive supply resource costs. However, if all ratepayers are required to pay for DSM investments, the ineligible classes of customers will pay for DSM without being able to enjoy any of its direct benefits. New York has permitted utilities to experiment with both treatments with respect to allocation of DSM rate impacts.

In this respect, making DSM programs available to low income customers has particularly urgent equity considerations. Unless utilities mount aggressive programs to enable low income customers to participate, they will end up paying higher electricity rates for programs from which they cannot benefit in terms of energy and bill savings. The result will be subsidization by low income ratepayers of more affluent customers.

There also may be competitive problems arising from rate impacts. If the impact of consideration of environmental costs is sufficiently great, it may overprice electricity in relationship to resources that are not incorporating environmental costs. Thus, it may promote more direct use of polluting fuels (such as oil or gas heating rather than electric heating, for example), or self-generation of electricity by major customers who do not have to consider environmental costs.

Fuel switching may take place as a result of utilizing environmental externality costs. This may result in higher rates even though environmental improvements result. If significant environmental costs are incorporated, natural gas, which is cleaner than oil and coal, may be preferred to an extent that will drive up gas prices. The much-debated role of nuclear fuels as an environmentally preferable substitute for fossil fuels will probably not be affected because nuclear plants bear large environmental externality costs in addition to their heavy capital costs and long lead times. Solar electricity, wind generation, biomass and DSM measures, however, should be considerably advantaged by incorporation of externalities, because their environmental costs are small.

These rate impact and equity issues should be taken into account in devising programs for utility incorporation of externalities.

8. Conclusion

Incorporation of environmental externality costs in electric utility planning and resource selection is an important first step towards internalizing these costs. It is remarkable that twenty-nine states have taken some action to require utilities to take these costs into account and eighteen have actually issued orders to do so. The commissions in these states are wrestling innovatively with how to value these costs.

While damage costs are by far the best to use because it is the environmental damages to society that are sought to be avoided, it is apparent from the damage cost literature that much research on damage costs remains to be done. All commissions to date have used control costs as a proxy.[19] Most commissions that have acted have either had their staffs estimate the damages as in New York, used a proxy adder or credit as in Wisconsin, given some kind of rate of return consideration or merely ordered their utilities to consider the costs without specifying how they should do so.

Despite the uncertainties, environmental costing studies demonstrate that the environmental externality costs of most electricity-related environmental impacts can be valued. The studies also show the means of valuing them. But the literature also shows that a great deal of research is still needed to quantify many of the externalities. Electricity is found to have substantial environmental costs, not presently included in most utility resource selection. While many of the cost studies are incomplete and of varying adequacy, they do indicate the order of magnitude of these costs.

If environmental costs are to be internalized universally in the future through pollution taxes or fees, reliable damage figures are as important to their accurate determination as they are to the incorporation of accurate externality costs in utility resource selections.

The barriers to adoption of environmental costs are considerable. Adoption of least cost planning is required and rate consideration for utilities that consider environmental costs. Important rate impacts and equity issues must be resolved.

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[19] The Oregon Commission, however, has ordered its utilities to seek to quantify damage costs in evaluating resource selections, Re Least Cost Planning, UM 180, OR PSC Order No. 89-507 (April 20, 1989), and the New York Commission has ordered a pooled study by its utilities on their environmental externality damage costs, NY PSC Case 28223, Electric Utility Conservation Programs, Opinion and Order 89-15 (May 23, 1989).

That more than half of the utility commissions have started to consider environmental externality costs is encouraging, although only a handful (nine) have actually attempted to quantify those costs and use quantified environmental costs in utility resource selection procedures.

The studies reviewed in Pace 1990 indicate that many utilities are reluctant to incorporate environmental externality costs. Progress has been most pronounced when commissions have required quantification of environmental costs and when rate of return consideration is given for investment in less polluting resources.

Despite the reluctance of many utilities, the electric utility industry (including independent power producers and demand-side energy service companies) is pioneering in consideration of environmental costs in resource selection. The results for improvement of the environment could be of great significance.

Externalities: The Legal and Institutional Barriers

Presented at the NARUC National Conference
on Environmental Externalities

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Introduction

Environmental externalities are the outward effects of people on the environment around them. For our purposes, externalities are the effects produced by electrical power plants. Typically, these include No_x and So_x pollutants, fly ash and other particulates. They can also include thermal impacts on cooling water supply systems, visual impairment and other such impacts. One problem in defining externalities is that there is virtually no limit to what can be included. For example, one could include the effects of the plant construction, the effect of the removal of raw materials to build the plant, the mining of fuel for the plant, the effects of building the equipment to build the plant, the effects of building the plant that builds the equipment to build the plant, and so on, ad infinitum. Fortunately, researchers have focused the question of externalities to the immediate products of power plants. This greatly reduces the amount of work needed to quantify the costs of externalities.

Our purpose here is to discuss the institutional and legal barriers to incorporating the costs to society of environmental externalities in regulatory proceedings by public service commissions. Presently, commissions are divided on whether externality costs should be included in evaluating utility plant options. For example, in 1985, the Virginia State Corporation Commission discussed including environmental externality costs in avoided costs in an Order involving Virginia Electric and Power Company (VEPCO):

> It is thus important that factors such as...[a reduction in the use of fossil fuel, saving money, conservation of resources and a lessening of environmental pollution]...be considered in developing avoided cost rates. It is not expected, however, that such intangible benefits can be priced with mathematical precision and, therefore, it is not surprising that no attempt was made by the parties...to quantify their value. This fact does not relieve the commission of its responsibility under the law to give reasonable weight to these matters. *This task requires the exercise of our judgment and discretion,*

> *bearing in mind the mandate of PURPA that cogeneration and small power production is to be encouraged.* We believe that the best way to accomplish this in the present case is to increase the avoided energy cost payments...by 15%.[1] (emphasis added)

Next, consider an excerpt from a 1986 Order of the Montana Public Service Commission discussing its version of avoided cost:

> 131. The irrigation districts [an intervenor] requested the commission to give the same considerations to alternative power producers as it does to coal-fired generation and to account for the environmental externalities of alternative energy sources in avoided cost prices.
>
> 132. For clarification purposes, the commission would note that its charge is to set avoided cost prices to reflect the costs that utilities avoid. The request to account for externalities *goes beyond the commission's regulatory role.* For example, the Montana department of health and environmental sciences may issue water and air permits to QF's....The Montana department of natural resources and conservation may issue certificates of public convenience and necessity to some relatively large QF projects.
>
> 133. Aside from the specific roles of these state agencies, there is no certainty that externalities are always positive. For example, plans for a 10 mw wood-fired cogeneration plant...were dropped because of negative public input...[concerning] [a]ir and water pollution....[2] (emphasis added)

These two positions illustrate the extremes in dealing with externality costs. There are commissions that include externality costs because excluding these costs, even though

they cannot be precisely calculated, would skew planning decisions toward plants that have high environmental costs. Other commissions, however, while acknowledging the existence of externalities, have determined that such an evaluation is either beyond the regulator's scope of authority, or may not be accurate because the costs are difficult to determine, and, therefore, the result may be skewed in the wrong direction.

These diametrically opposed decisions highlight the crux of this problem. These positions lead to primary questions: first, are externality costs something that should properly be examined by a public service commission? Second, if so, how are such unquantifiable costs to be determined in the context of regulatory proceedings?

The Challenge

Currently, the majority of states do not include externality costs[3]. If externality costs exist and should be accounted for, what mechanisms can be developed to allow all states to uniformly apply them?

These questions cannot be answered by any simplistic analysis. It will take perhaps years of debate and review before externality costs are fully considered across the nation. The reason for this is simple: the traditional rate-making formulae and the conservative nature of most commissions act as institutional barriers that slow implementation of new costing methodologies. Similarly, legal barriers to examining and including externalities exist. These include the level of proof required to establish the amount of externality costs and jurisdictional hurdles that prevent commissions from even considering these issues.

Briefly, these barriers include:

1. Lack of awareness by commissions of externalities, their impact, and their costs.

2. Commission reluctance to aggressively exercise authority over what might be considered a social problem.

3. Utility opposition.

4. Legislative issues.

5. Jurisdictional issues.

6. Burden of Proof issues in Determining costs.

Items 1-4 are perhaps best characterized as institutional barriers, while items 5-6 are usually viewed as legal barriers. The legislative issues might fall into either category. However, here we are primarily referring to lack of knowledge of the issue by the legislature or sympathy with the concerns of industry, which may produce changes in specific statutory provisions.

Institutional Barriers

1. Lack of Commission Awareness

The utility industry is in a constant state of flux. As a result, commissioners are faced with a barrage of information, not only from the electric utilities, but from telecommunications, gas, and water utilities. In the past twenty years, commissions have dealt with a complete revolution in electric utility planning. The environmental externalities issue is only the latest in a series of major policy decisions that must be examined by commissions. Although these issues require considerable technical expertise, many commissions, due to budget limitations, among other things, are not well equipped to engage in rigorous technical analyses of issues like externalities. Thus, many commissions necessarily will follow the lead of larger commissions. For example, the District of Columbia Public Service Commission (DCPSC) recently stated that it would not include externalities at this time, preferring to see what happens in Wisconsin and New York PSC externality proceedings.[5]

The first step, obviously, is the development of a dialogue on externalities so that a threshold level of awareness on the subject can be developed among all public service commissions. This exploratory conference is a significant step in that direction. It follows that as externality

issues are resolved in larger jurisdictions and conferences are held to explain them, knowledge of the subject will increase, allowing a uniform approach to incorporation of externalities to be developed.

2. Commission Reluctance

This barrier has two components. The first is the inherently conservative nature of public service commissions. Traditionally, commissions balance many factors in setting rates and making policy, including the principle that rates should be stable. Because of this, commissions rarely make radical policy changes on a wholesale basis. Rather, such changes come either through legislative mandates (e.g. PURPA) or over time, through cumulative decisions in adjudicatory proceedings. Consequently, the incorporation of externalities will occur gradually, with adoption in the "better equipped" states first.

Secondly, many commissions have fully understood and appreciated externalities but do not believe it is something that they should be examining. The Montana Order cited above gives a clear statement of such reluctance. Often this type of reluctance stems from a commission's interpretation of two legal considerations: jurisdiction and standard of proof (both are discussed below). However, commissions also have an understandable desire to obtain as much information as possible before making any firm decisions, as indicated in the DCPSC decision discussed above.

The solution for overcoming commission reluctance is to first discern what the problem really is, and then address that problem directly. For example, if the reluctance stems from insufficient awareness of the issues, commissioner education on the subject would be the most productive solution. Time and persistence, on the other hand, are the best tools when dealing with a conservative commission. Until the commissioners are convinced that the concept of incorporating externalities is in the public interest and that in doing so, utility rates will not be changed drastically, no real movement will occur. Even then, the commission may incorporate externalities gradually to prevent severe rate changes.

3. Utility Opposition

Although there are a number of forward thinking electric utilities, most utilities are resistant to increasing their costs for any reason. Many companies, especially those with excess capacity (as is the case in Alaska), do not like making their "product" less competitive. Adding externality costs to encourage demand side programs, for example, reduces opportunities for the utility to use its excess capacity.

Companies that are generally held to a high standard of proof in rate proceedings may not fully appreciate a commission's finding of an externality cost that is indeterminate. In some jurisdictions, this will result in judicial appeals and, undoubtedly, some reversals.

Utility opposition can be addressed in two ways. First, the commission can recognize that many aspects of regulation are not warmly received by industry and that externalities are simply another aspect of regulation. This is not always the best political solution, however. A better approach is to work with the utilities to introduce them to the issues. Perhaps workshops can be held or a task force can be established to help the process along. You may not fully convert them, but you may reduce their opposition to the point where meaningful dialogue can be maintained.

4. Legislative Issues

These problems track those of commissions, only on a broader scale. In states desiring to develop new industry, a preference for demand side measures may not be fully appreciated. Some states have a tendency to support existing industry to the point of protectionism. This does not suggest that legislatures ignore environmental concerns. However, they may be unwilling to permit commissions to tip the scales in favor of "soft path" solutions if the data underpinning externality costs are tenuous and the internalization of them may involve loss of jobs and industry shut-downs or contraction.

While legislatures have the power to create or expand PSC jurisdiction to incorporate externalities, they also have

the power to restrict such reviews. It is important, therefore, to be sensitive to the political climate in considering externalities when the local economy is involved. Here, again, education and information should be used not only to promote legislative understanding of the purpose behind incorporating externalities, but also to enable the public and industry to appreciate the resultant benefits.

Legal Barriers

5. Jurisdictional Issues

The question here is whether or not a commission has the statutory authorization to examine externalities as part of its ratemaking or certification authority and, if not, what alternatives exist to enable such reviews? A survey in a report by Pace University[3], indicates that the majority of the states have not adopted any formal environmental code, while a considerable minority have either a statute or an executive order that requires environmental reviews. The study also shows that many of the commissions in the states that have no specific statutory authority are implementing some form of environmental review via general oversight powers or as an extension of PURPA regulation. Thus, jurisdiction need not be solely circumscribed by explicit statutory authority.

6. Burden of Proof Issues and Determination of Cost

We concur that the critical impediment to including externalities is a realistic (i.e., legally sustainable) determination of their costs. Despite excellent work by researchers at Pace University and Lawrence Berkeley Labs, to name only two, currently available cost data consists of broad estimates or ranges of possible costs. Many argue that since this is the best that we have, we should use it in view of the known environmental impacts caused by energy utility plants.

The problem arises when these estimates are examined in the regulatory context. Traditional ratemaking requires a utility that requests a change to its rates, to provide quantifiable evidence of the need for that change. For example, the "known and measurable" standard is used in many jurisdictions to evaluate future costs that are known, but have not yet occurred. If a cost is not "known and

measurable", it is not included. Even jurisdictions relying on future test years and/or marginal cost analysis require some type of tangible, calculable proof. In the VEPCO Order quoted above, for example, the Virginia Commission rejected use of rates based on a program called PROMOD. The commission stated:

> [i]t is a well-established principle that a utility carries the burden of proving that the relief it requests in regulatory proceedings is reasonable and justified. In this case, VEPCO's proposed rates were based to a large extent on the use of PROMOD, and we agree with the protestants that such a computer program must be shown to be appropriate for the use to which it is put. *The program should also be shown to produce valid results, based on suitable and reasonable inputs and assumptions before it can form the basis of proof in a proceeding such as this.*[4] (emphasis added)

Therefore, it would appear incumbent on a party that petitions a commission to include externality costs to satisfy the same burden of proof. There must be sound evidence on the record to substantiate any commission decision. In administrative law, the standard of review for commission decisions on factual questions is the substantial evidence test[7]. Under this test, the findings will be upheld if the commission bases its findings on substantial evidence[8]. Substantial evidence has been defined as "such relevant evidence as a reasonable mind might accept as adequate to support a conclusion"[9]. This type of standard does not lend itself to mechanical application. Rather, it requires a detailed analysis, to determine whether the facts presented were adequate to support those conclusions drawn for the specific case at hand.

However, public service commissions are generally recognized as having special expertise in utility-related economic matters. Accordingly, they are given proper deference by appellate courts with respect to findings of fact and conclusions of law based upon this expertise. Agency decisions involving fundamental policy formulation, or assessment of technical data related to complex subject matter within the particularized knowledge of the agency, need only have a "reasonable basis." Courts will generally not substitute their judgment for that of a commission in those

instances.[10] Because of this deference, there are opportunities to expand the scope of externalities in both planning and rate making proceedings, notwithstanding imprecise cost data.

Conclusion

We have discussed the major barriers to including externalities in utility planning and rate making. Institutional and legal barriers are not insurmountable, however. The more commissions, legislators, industry leaders and consumers know about the importance of making decisions that are based, in part, on environmental costs, the more widely accepted this process will become. The 1990's have been unofficially declared the "decade of the environment". It is fitting, therefore, that at this point in time externality costs are being addressed. The challenge is to render the term "externalities" obsolete. The benefits of our efforts will redound to our present communities and future generations.

Endnotes

1. *RE: Virginia Electric and Power Company*, Case no. PUE830067, 71 PUR4th 160, 168, Virginia State Corporation Commission, 1985.

2. *RE: Electric Avoided Cost Rates*, Docket No. 84.10.64, Order No. 5091c, 73 PUR4th 138, 163, Montana Public Service Commission, 1986.

3. *Environmental Externalities: A Survey of State Commission Actions*, NARUC, Washington, D.C. July 11, 1990.

4. *In the Matter of Application of Potomac Electric Power Company*, Case No. 834, Order No. 9417, Public Service Commission of the District of Columbia, January 16, 1990.

5. R. Ottinger, N. Robinson, S. Babb, D. Wooley and D. Hodas. September, 1990. "Environmental Costs of Electricity", Chapter X, section G, final report, Pace University Center for Environmental Legal Studies.

6. *RE: Virginia Electric, Supra*, at 165.

7. See, e.g., Jager v. State, 537 P.2d 1100, 1107, fn. 23. (Alaska 1975). See, also, City of Fairbanks v. Alaska Public Utilities Commission, 611 P.2d 493, 495 (Alaska 1980)

8. See, e.g., Kiner v. City of Anchorage, 378 P.2d 406, 411 (Alaska 1963).

9. Id. at 411.

10. See e.g., U. S. v. RCA Alaska Communications, Inc., 597 P.2d 489, 507 (Alaska 1979)

NARUC

ENVIRONMENTAL EXTERNALITIES

JACKSON HOLE, WYOMING

OCTOBER 1-3, 1990

GERALD R. BROWNE

DIRECTOR EXTERNAL COORDINATION

NEW ENGLAND POWER POOL

NARUC Conference on
Environmental Externalities
Jackson Hole, Wyoming
October 1-3, 1990

The Electric Utility industry, has in the past, is today, and will in the future, comply with all State and Federal environmental laws and regulations. For the past 20 years our companies have complied with these regulations and our electric customers have paid the added price to meet these environmental requirements. We believe in being a responsible corporate citizen. The production of electricity should minimize the environmental impact and as an industry, we have spent hundreds of millions of dollars to mitigate the impact of our power plants. If we use the preliminary data from the Department of Energy Report[1] published this Spring, between the years 1973 and 1987, our industry has increased the burning of coal by more than 75%. Yet, on a pounds per BTU basis, SO_2 is down 10%, particulates are down a dramatic 83%, and NOX is down by 7%. This has had a major impact upon improving the environment. We will be facing additional requirements under new State and Federal Legislation within the next several years. This industry will again comply with these regulations.

In Exhibit I we have summarized the Federal and Commonwealth of Massachusetts changes for the past 20 years in regulations dealing with Air Quality. These regulations were first implemented in 1970 and have been revised every few years. New requirements both at the Federal and State level will be implemented in the 1990's.

One of the more dramatic impacts that my company experienced was in 1971 when we were required to burn low-sulphur oil in our power plants. At that point in time these requirements were applicable primarily in Massachusetts and were stricter than Federal law. Just prior to the enactment of these requirements our company had entered into a contract to purchase oil for five years at $1.67 per barrel. The impact of new regulations were to increase that price immediately to $3.75 per barrel. That dramatic increase in fuel price had a major impact upon our customers of $15 million to $20 million. We communicated this dramatic increase to our customers on their electric bill with a statement that this added cost was "YOUR FAIR SHARE OF CLEAN AIR". Repercussions of that communication were very dramatic. Customers did not understand the relationship between these environmental requirements imposed by the State and our cost of delivering electricity to their premises. In fact, many of our customers did not understand why electricity delivered to their homes by wires had any impact on the environment whatsoever.

Over the years, a need to educate the public concerning the use of our product and its impact on the environment has been a constant challenge to this industry. There is no doubt that today citizens are willing to pay an additional price to minimize the impact on the environment of all energy resources. However, I'm not certain that it is clear that these consumers are willing to pay <u>any</u> price for their energy consumption to meet all environmental requirements that may be proposed through the Environmental Externalities process.

Let us now turn to the proposal made by the states that there is a societal cost being borne by the public in general associated with energy that is not reflected in the price of that energy. Most of us can agree that there probably are some costs that are not borne by the energy consumer. It may not be an easy process to measure those additional costs, however, that process of evaluation is the subject matter of another panel. My question addresses whether or not these additional costs should be transferred from society in general, to the consumer of the Electric Utility industry. Some will argue that the proposal is to use Environmental Externalities only in the planning process and not to add these costs to the piece of electricity. There is no possible way that we can add 15% or 1.5¢ per KWH to the cost of a coal plant and not have an increase in the costs we pay for all resources. This added costs has to be reflected in the price of our product.

What is particularly troublesome to this industry is that these costs be borne by the Electric Utility consumers. They are not being added to gas consumers. In addition, they will not be added to oil consumers. This may drive consumers from the use of electricity to gas and oil without the benefit of evaluation to determine if it is environmentally positive or negative. It may well undo what is intended by the Environmental Externalities movement. Studies[2] during the past two years at the M.I.T. Energy Lab indicate that an expansion for New England of only conservation and load management would <u>not</u> minimize the environmental impact. As a region we should be building some new resources that will use the cleaner technologies. It is the combination of conservation and load management with new generators that will create the least environmental impact for our region.

As stated at the outset, this industry stands ready to comply with all laws passed by either our State or Federal government. But, we raise the question of adding costs to our consumers that go beyond these laws. To have Regulators require the inclusion of Environmental Externalities be added to our costs seems to exceed the authority of State Regulators. If it is in the public interest to internalize these social costs, then the legislative branch of government should consider additional laws. If these costs should be borne by the electric consumers through their rates, then this should be instituted by the Federal or State government instead of by Regulatory Fiat.

What is the bottom-line that we are trying to accomplish by the process of Environmental Externalities? It would appear that the intent is to increase the costs of all energy that is consumed to reflect the additional environmental costs that go beyond the law. The result of that process should be to encourage conservation and load management. Certainly, as a New England utility, our industry understands the importance of the efficient use of this premium product called electricity. Our companies are and will in the future dedicate major dollars to a very aggressive program of conservation and load management.

If we do not have enough resources in conservation and load management the next impact of Environmental Externalities would be to install gas fired generation. The New England region is still struggling to get sufficient gas pipelines to accomplish all of the expanded use of gas for new generation. Without this pipeline capacity we will not be able to meet our current environmental requirements. If we use the data from the Department of Energy's Preliminary Report[3] (the chart on page 40) Exhibit 2, makes it abundantly clear that this nation cannot survive into the turn of the next century without a major and continuing use of coal as a basic energy resource. The events during the Summer of 1990 in the Middle East would indicate an urgent need to move further in the direction of coal resources. Gas will play a role, but we must have coal somewhere in the energy policy of this nation. The use of Environmental Externalities would price coal out of the market place.

If this is the process, then what is the role of the Regulators in dealing with the environmental issues? The Federal government and most, if not all states, have an environmental regulatory body within their jurisdictions. The State Regulators certainly have a responsibility to see that their electric utilities are in compliance with those laws. They are not the enforcing agent, but they certainly do play a major role on the recovery of the expenses associated with meeting State and Federal requirements. There is a serious question however, whether Regulators at the State level have the authority or the responsibility to be setting social policy for this nation. If it truly is the desire of our government to have a cost transferred from one group of citizens to another group of citizens, we have the legislative processes which have the authority and the responsibility of carrying out this obligation.

This particular issue becomes extremely complex when we look at a tight regional area such as New England operating under the NEPOOL organization. We operate as a six-state unit. If one state is to require the inclusion of Environmental Externalities and others do not, how will this fit into our Regional planning? Worse yet, if we have six different state rules to comply with, we may never make any sense out of the planning process. Many of our 93 member companies purchase short and long-term power from generation located in various New England states. What will be the criteria in setting the costs for these transfers? We, the Electric Utility industry, stand ready to meet the requirements of the Clean Air Act. But we cannot afford to be isolated, either as a region or as a nation, leaving our customers in an unacceptable non-competitive position. As stated by William Ellis, CEO of Northeast Utilities, in testimony before the Department of Energy in Providence, R.I. on December 1, 1989, "internalization of such costs is truly only appropriate on a National or International scale. If left to only a regional basis it would create undo financial hardships and competitive disadvantages. Such has been historically the case in New England."

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1 Department of Energy "Interim Report - National Energy Strategy" (April 1990), pp. 69

2 Connors and Andrews, "System-Wide Evaluation of Efficiency Improvement. Replacing Local, Regional and Global Environmental Impacts" Energy Lab M.I.T., Cambridge, Mass., March 27, 1990

3 Department of Energy, pp. 40

HISTORY OF

AIR QUALITY REGULATIONS

1970 - Federal Clean Air Act, directs EPA to set NAAQS, NSPS

1971 - EPA sets NAAQS for various pollutants including SO_2

1971 - EPA sets NSPS for fossil units beginning construction after 8/07/71 - limit SO_2, NO_x, particulate emissions

1972 - Mass. DPH sets ambient standards stricter than Federal NAAQS

1972 - Mass. DPH sets emission limits for new in-state sources

1974 - Mass. Legislature passes Chapter 494, requiring state ambient air standards to be no stricter than NAAQS

1975 - EPS issues "Reconstruction" rule, making existing units undergoing extensive renovations subject to NSPS

1977 - EPA sets NSPS for combustion turbines

1977 - Congress amends Clean Air Act, mandating scrubbers, PSD permits, BACT, etc.

1978 - EPS sets revised NSPS for coal and residual oil units

HISTORY OF

AIR QUALITY REGULATIONS

1978 - Mass. approves BP Coal Regulation (then approved by EPA in 1979)

1980 - Mass. clarifies Sulfur Regulation for Salem Harbor

1982 - Mass. DEQE issues rule requiring BACT on even small projects

1985 - Mass. Legislature passes Chapter 590 - State Acid Rain Law - requiring "Cap" and "Rollback" on SO_2 emissions

1988 - NESCAUM adopts "Top-Down" BACT policy and Gas Turbine guideline

1988 - Mass. issues "Cap" SO_2 Regulation, limiting statewide emissions

1989 - Mass. issues "Rollback" SO_2 regulation under Acid Rain law

1989 - EPA issues initial WEPCO decision

1990 - Court overturns part of WEPCO decision

1990 - EPA issues revised WEPCO decision

1990 - NESCAUM issues simple cycle guideline

DEPARTMENT OF ENERGY "INTERIM REPORT
NATIONAL ENERGY STRATEGY (April 1990)

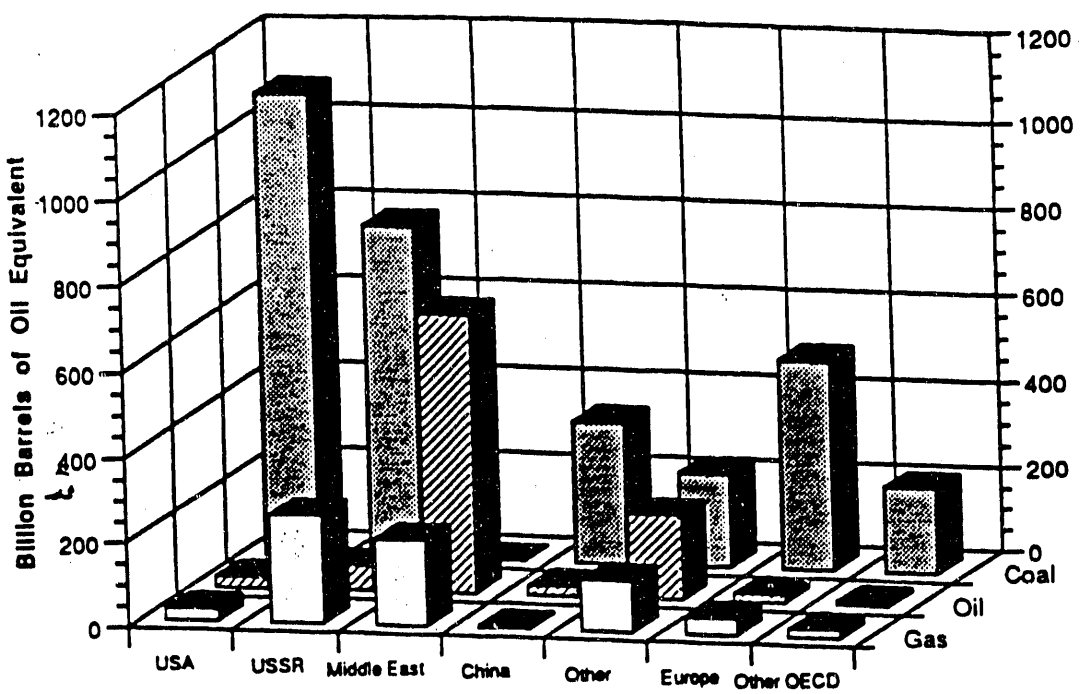
SECURING FUTURE ENERGY SUPPLIES

Global and U.S. Energy Resources

Both the United States and the world are endowed with large reserves of energy resources. Figure 10 shows, by region of the world, how much economically producible oil, natural gas, and coal are known to exist, assuming technologies now available. Crude oil is concentrated in the Middle East; in the less developed countries, located mainly along the equatorial belt; and in the Soviet Union. Natural gas is similarly distributed, but with the largest share concentrated in the Soviet Union, *not* the Middle East. And coal reserves overwhelm those of oil and natural gas, with the United States possessing the largest share. Annual world energy consumption now is equivalent to considerably less than 1 percent of the combined reserves shown.

Beyond the "proved" reserves, there are likely to be significant additions of yet undiscovered reserves. Even larger hydrocarbon deposits of tar sands, heavy oil, shale oil, and other forms would likely become available if prices were to rise. Coupled with nuclear power, solar energy, and geothermal energy, the world's energy resources, in theory, could support even the most rapid increases in global energy demand for many years to come. Access to these resources, however, may be constrained by a number of economic, geopolitical, and environmental factors.

Figure 10. Proved World Energy Reserves



Source: Energy Information Administration, *International Energy Annual 1988*

Academy Award Winning
Environmental Externalities Documentary Film

The Four Corners:
A National Sacrifice Area?

Millions of Americans have experienced the majesty of the Colorado Plateau: the Golden Circle of National Parks, the rugged canyonlands of the West's most powerful rivers, the largest population of traditional Native Americans in the United States.

Buried beneath the silent beauty of the Plateau lie billions of tons of coal and oil shale, and half of America's uranium reserves -- a potential part of the supply-side solution to the present energy security crisis, but at what costs?

The Four Corners: A National Sacrifice Area? documents the "hidden costs," or externalities, of energy development in Utah, Colorado, New Mexico, and Arizona. The hidden costs include:

- radioactive uranium tailings, creating land, air, and water impacts throughout the Southwest and beyond,
- potential health effects in the Hopi and Navajo country
- impacts on National Parks of coal strip mining, power plants, and radioactive waste,
- water use and contamination throughout the Colorado River Basin, which supplies Los Angeles, Phoenix, and much of the Southwest with water for drinking and irrigation.

The Four Corners: A National Sacrifice Area? takes its title from a National Academy of Sciences report which concludes that strip mining and other energy development activities in the arid Southwest could permanently damage the land, requiring a rezoning of the region to justify its development as a "National Sacrifice Area" for energy.

Governors, Presidents, uranium miners, Indian leaders, ranchers, energy company spokesman, government officials, and others, bring home the powerful conflicts which surround the issues of energy's environmental externalities in the remote and fragile Southwest.

The film points to a number of the as yet unsolved issues associated with environmental externalities and the methods presently in use to account for effects of energy development, generation, delivery, and use. These issues include: water and land effects, regional priorities, and the enormous uncertainties as to how to account for health effects. "The Four Corners..." provides problem definition, identifies critical research opportunities, and perhaps most importantly serves as a call to action. It's not to be missed.

CONTINGENT VALUATION STUDY OF THE ENVIRONMENTAL COSTS OF ELECTRICITY GENERATING TECHNOLOGIES*

SHEPARD C. BUCHANAN

Introduction

The environmental costs of electricity generation technologies are the total value of risks imposed on society by the environmental effects of those technologies. The economic value of environmental risks is the amount that society would be willing to pay to avoid those risks or the amount society would require as compensation to accept those risks voluntarily.[1]

The usual approach to determining society's willingness to pay to avoid environmental risks of electricity generating technologies is to establish the significant environmental effects, measure them, and then apply economic valuation techniques to each of the effects.[2] For example, one might determine that sulfur emissions create health risks, reduce visibility, and damage materials. Then, each of those risks would be quantified in units that can be valued in monetary terms. Next, economic values for those risks would be determined and summed to yield an estimate of the economic value of the risks associated with sulfur emissions. The process would be repeated for other emissions and other environmental intrusions with all costs totalled to obtain a complete estimate of the environmental cost of a particular electric power resource.

There are many advantages to this approach but I will mention just three. First, it provides for an objective analysis of each component of the electric power resource's environmental costs. Such an analysis provides meaningful and replicable information for weighing the costs and benefits of alternative resources. It displays the data, logic, and assumptions used, permitting other parties to confirm or refute the analysis while avoiding the unresolvable philosophical disagreements which are typical of subjective processes.

Second, by estimating the environmental costs of each environmental effect associated with an electric power plant, a utility can focus mitigation efforts efficiently. Controls can be implemented where gains in economic efficiency would be the greatest. Or, pollution offsets could be purchased elsewhere as envisioned by pending versions of the Clean Air Act.

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* Presented to NARUC LCUP Externalities conference, Jackson Hole, Wyoming, October 1990

Third, identification of significant elements of environmental costs can guide future research. Future research would be of particular value for those effects that appear to be costly to society as well as for effects that are highly uncertain and need further refinement. Uncertainty could be reduced whether it lies in the physical quantification of the effects or in the economic valuation of the risks.

There are, however, some disadvantages to a segmented approach to estimating environmental costs. Two general difficulties are worth noting. First, it is sometimes difficult to obtain reasonably certain estimates of the actual environmental risks posed by a power plant. I don't want to overemphasize this phenomenon because uncertainty is a fact of life for resource planners. Who, for example, can claim to foretell future rates of load growth or future fuel prices? Despite the impossibility of forecasting accurate values for these and other variables, we nevertheless have little choice but to try to do so, coping with uncertainty as well as we can. The same is no less true for environmental cost estimates. (I might also note that, in my opinion, environmental costs are likely to be underestimated because one can be reasonably sure that some environmental effects will be either overlooked or just plain unknown.)

Second, the use of expected values based on "expert" or scientific assessments of risk can be problematic under some circumstances. Expected values are typically used in economic analyses because they are unbiased estimators. Unfortunately, expected values do not represent the variability of possible outcomes. In the extreme, the use of expected values masks the potential for low probability, high cost outcomes, or catastrophes.[3] Some argue that if probabilities are low enough, such costs should be coded as zero and dismissed.[4] Others argue that risks of large scale catastrophes, no matter how improbable, are risks not worth taking and therefore must be treated as having infinite costs. The resulting dilemma of whether to use near-zero or near-infinite costs makes for fascinating philosophical discussions but frustrates analysts who must finally choose some value.[5]

Recognition of these difficulties led Bonneville Power Administration (BPA) to seek a different method for estimating the environmental costs of certain generating technologies. The remainder of this paper describes the method and the results of its initial application.

The Contingent Valuation Study

Perhaps the most important goal of an environmental cost study is to obtain an estimate of a resource's total environmental cost which, when added to its internal costs, results in an estimate of the resource's total cost. The utility can then select the resource(s) with the lowest total cost. As I mentioned at the outset, the environmental cost of a resource is society's willingness to pay to avoid the resource's environmental risks, or the compensation society would demand to incur those risks voluntarily. The contingent valuation method can estimate either of those values using a question phrased something like, "How much would you pay to avoid [some resource]?"

In a study sponsored by BPA, Hinman et. al. of Washington State University conducted a survey of public attitudes about various risks. The study included contingent valuation questions about ratepayers' willingness to pay to avoid specific generating technologies.[6]

The survey was conducted by mail in January, 1990. Questionnaires were mailed to a random sample of 1600 households in the BPA service territory which includes all of Washington, Oregon, and Idaho, and a portion of Montana. The response rate for the survey was 52 percent.

Before discussing the contingent valuation portion of the survey, let me briefly summarize the other findings. The survey asked about levels of concern for ten environmental issues, levels of environmental activism, general opinions about risk, comparisons of 30 items involving various risks, and the contingent valuation questions. Among the ten environmental issues, air pollution from coal-fired plants, water pollution, storage of nuclear wastes, transportation of radioactive materials, and ozone depletion in the upper atmosphere were of most concern to people. The greenhouse effect, new nuclear plants, fish losses, radon in homes, and additional dams were of less concern.

The respondents, especially women and those most concerned about the ten environmental issues, collectively think the world is riskier than it was ten years ago. They also believe, however, that it is possible for individuals to take actions to reduce and control the risks they face.

When comparing concerns about energy related items involving risks, respondents indicated the most dread for risks associated with transporting nuclear materials, radioactive waste disposal, and nuclear accidents, although nuclear power plants, themselves, were not especially dreaded. Similar expressions of dread were given for AIDS, crime, and alcohol-related accidents. Low levels of concern were expressed for hydropower and solar electric power. Additional questions regarding people's attitudes about these and other risks were also asked. A list of the 30 technologies, substances, and activities involving risk is included as Appendix A.

The contingent valuation questions are reproduced as Appendix B. Approximately half of the respondents (49 percent) indicated they would pay an additional charge on their electric bills to avoid the addition of one or more of the three types of generating facilities in the region. Of those who would not pay an additional charge, about one-fourth were not concerned about the environmental consequences of the three technologies while the rest were unwilling to pay because of other reasons.

The average amount respondents would be willing to pay to avoid the three technologies, including those who gave responses of zero, was $3.11 per month or $37.32 per year. The total number of residential customers in the region in 1988--the last year for which such information is available--was 3.58 million. Therefore, the total amount the region's residential customers would be willing to pay to avoid the three technologies, assuming the sample is representative, is $133.6 million per year. This figure could be interpreted as the amount the region[7] would be willing to pay each year to meet future load growth with energy conservation measures and non-hydro renewable resources.

The respondents were also asked to indicate the amount they would pay to avoid each of the technologies. The average annual willingness to pay to avoid new hydro was $6.24; for fossil fuel it was $14.16; and, for nuclear it was $14.76. Expressed as regional annual willingness to pay values, the totals were $22.3 million to avoid hydro, $50.7 million to avoid fossil fuel, and $52.8 million to avoid nuclear. (These do not add to the overall total of $133.6 million because some respondents failed to preserve the equality in their individual answers on the questionnaires.)

Regression analyses were conducted to test whether the demographic backgrounds of respondents were predictive of the additional charge on the utility bill respondents were willing to pay.[8] The regression analyses were conducted for a group (A) consisting of all respondents and for a group (B) consisting of only the respondents who indicated a positive willingness to pay.

The regression equation was:

(1) $Y = A_0 + A_1 * AGE + A_2 * SEX + A_3 * INCOME + A_4 * EDUCATION$

Where

Y = Willingness to pay to avoid one or more generating technologies
AGE = Respondent's age in years
SEX = Respondent's sex (1 if female; 0 if male)
INCOME = Family income in thousands of dollars per year
EDUCATION = Highest grade completed

The results for each of the two groups were:

Group A: Only those respondents willing to pay a positive amount

(2) $Y = 8.33 - .07 * AGE - 1.00 * SEX + .09 * INCOME + .82 * EDUCATION$
$(-3.16)^* \quad (-1.34) \quad (0.28) \quad (2.74)^*$

$R^2 = .07 \qquad F = 6.3^*$

(t values shown in parentheses; * indicates significant at 99% confidence level or better.)

Group B: All respondents

(3) $Y = 3.32 - .05 * AGE - 0.19 * SEX + .12 * INCOME + .89 * EDUCATION$
$(-3.82)^* \quad (-0.42) \quad (0.67) \quad (4.82)^*$

$R^2 = .08 \qquad F = 14.0^*$

(t values shown in parentheses; * indicates significant at 99% confidence level or better.)

The results indicate that younger people and those with more education are more likely to pay higher amounts to avoid the three technologies. The coefficients on income and sex are not significant, implying that neither variable can be shown to be related to the willingness to pay value. These results held true for both groups. The demographic variables, while collectively significant as predictors of willingness to pay as evidenced by the significant F values, do not explain much of the variation in willingness to pay. Together, the four variables explain only eight percent, or less, of the variation in willingness to pay.[9]

Discussion

The results of the study show that it is feasible to use the contingent valuation method to derive estimates of society's willingness to pay to avoid the risks of various energy resources. The application of environmental cost estimates we typically envision is for a specific resource consideration; for example, a utility needs to add 200 MW of capacity and has a menu of resources from which to choose. Whether the utility engages in a bidding process, a negotiating process, or simply builds its own resources, least-cost planning principles would lead the utility to select the resource or combination of resources capable of meeting need while having the lowest total social costs. In such a process, the environmental cost of each plant or project would be added to its costs to produce an estimate of its total social cost.

The nature of the BPA study was somewhat different. It did not examine the cost of different projects or plants. Instead, it required respondents to evaluate their willingness to pay to avoid entire technologies. Respondents were not provided any information about the technologies, where such plants might be located, or what the effects of the plants might be; they had to rely on their own knowledge to make judgments regarding their willingness to pay additional amounts on their utility bills to avoid the technologies.

Consequently, the elicited values can not be used to determine resource environmental costs on a cents-per-kilowatt-hour basis. (Such was not the intent of the survey.) The estimates could be used, however, in the planning context to evaluate the cost-effectiveness of different resource strategies. For example, a resource strategy based on the lowest internal costs could be formulated first. (This would be the strategy that would emerge from a least-cost planning process that did not include environmental costs or other externality costs.) Then, an alternative resource strategy could be formulated relying only on resources other than the resource technologies which people indicated a willingness to pay to avoid. In the case of the BPA study, such a strategy would consist of energy conservation measures and non-hydro renewables such as geothermal, wind, and cogeneration using waste fuels, for example. If such a strategy could be implemented for less than the $136 million annual willingness to pay value, it would be a cost-effective investment. Thus, although the BPA study does not result in levelized cost estimates by resource, it does provide information that could be of use in developing resource strategies.

Despite the lack of levelized cost estimates, the BPA study could be modified easily to examine specific electric power plants or projects. The principal advantage of the approach is that one does not need to develop separate cost estimates for all of the different environmental risks that may be associated with a power resource. People are asked to determine the amount they would pay to avoid the entire plant or project; each individual is free to consider any combination of attributes they wish. Moreover, the analyst does not need to decide on expected values or how to treat catastrophic risks. The amount that people are willing to pay to avoid such risks are included in their expressed payment amounts. Those who deem catastrophic risks to be unacceptable may provide high bids, while those who treat them as zero cost risks may give bids of zero.

It would, of course, be desirable for people to make informed choices about electric power resources to meet their future needs. Information regarding the characteristics of different power resources, including the environmental and other risks associated with those resources, could be provided to potential respondents. A balance needs to be struck to avoid overloading respondents with information, providing information that may bias responses, and not providing sufficient information. A discussion

of bias, which is a significant issue for contingent valuation studies, is beyond the scope of this paper, but the reader is referred to Mitchell and Carson[10] for a thorough review of not only bias, but all issues related to contingent valuation methodologies.

Conclusion

Environmental costs are measured by the amount that society would be willing to pay to avoid environmental risks or the amount society would require as compensation to incur the risks voluntarily. The usual approach to measuring society's willingness to pay is to quantify and price each of the environmental risks associated with an electric power resource. This approach has significant advantages.

Two disadvantages, however, are the uncertainty of physical estimates and the potential for catastrophic risks. Both present difficulties to the analyst attempting to quantify environmental costs.

To overcome those difficulties, BPA sponsored a contingent valuation study to query the public directly as to its willingness to pay to avoid different generation technologies. The study found that the region's households would be willing to pay $133.6 million each year in additions to their utility bills to avoid nuclear, fossil fuel, and hydroelectric power plants.

This result may have implications for resource strategies in that the estimated amount would be an additional system benefit of strategies that meet future load growth without recourse to any of the three resources.

Finally, the methodology could be adapted to estimating costs of specific resource plants or projects. Such studies would result in environmental cost estimates on a levelized cost basis. Bonneville Power Administration and the author seek comment on this approach and its appropriateness for use in the resource planning process.

FOOTNOTES

[1] Pace University, Environmental Costs of Electricity, Oceana Publications, Dobbs Ferry, New York, 1990.

[2] See, for example, ECO Northwest, Generic Coal Study, for Bonneville Power Administration, DE-AM79-86BP62884, Portland, Oregon, 1987.

[3] Pace, supra.

[4] Rescher, Nicholas, Risk: A Philosophical Introduction to the Theory of Risk Evaluation and Management, University Press of America, Lanham, Maryland, 1983.

[5] While the analyst could perform a sensitivity analysis using both a zero cost and some extremely high cost, the result would not be particularly illuminating nor would it be of any real help to a decisionmaker.

[6] Hinman, George, Eugene rosa, and Randall Kleinhesselink of Washington State University, Public Attitudes Toward Risks Associated with Various Activities, Substances, and Technologies, for Bonneville Power Administration, DE-AI79-89BP98129, Portland, Oregon, July 1990.

[7] Actually, the region could be willing to pay a higher amount after accounting for business and industry. Firms, like households, benefit from clean environments.

[8] Regression analyses were also conducted for the willingness to pay value for each of the three technologies using the same explanatory variables. To avoid overwhelming the reader with numbers, those results are not presented but are similar to those shown here.

[9] While other variables could have been regressed against the willingness to pay values, and in the study some were, the study was not designed to test hypotheses of the relationship between potential explanatory variables and respondents' willingness to pay to avoid certain generating technologies.

[10] Mitchell, Robert and Richard Carson, Using Surveys to Value Public Goods: The Contingent Valuation Method, Resources for the Future, Washington, D.C., 1989.

APPENDIX A

Prescription Drugs
Food Preservatives
Hydroelectric Power
Diagnostic X-Rays
Leaded Gasoline
Transporting Nuclear Materials
Nuclear Power (routine operation radiation)
Solar Electric Power
Radioactive Waste Disposal
Nuclear Reactor Accidents (radiation)
DNA Research
Asbestos
Mercury
Crime
Fossil Fuel Electric Power (coal, oil)
Smoking Tobacco
Alcoholic Diseases
Greenhouse Effect (fossil fuel combustion)
Electric Household Appliances
Nuclear Power Production
Motorcycles
Auto Exhaust Fumes
Liquid Natural Gas (transport)
Dams (construction and use)
Nuclear War (weapons)
Alcohol Related Accidents
Non-Nuclear Electric Power
Commercial Aviation
Motor Vehicle Accidents (cars, buses, trucks)
Acquired Immune Deficiency Syndrome (AIDS)

APPENDIX B

In order to meet the future electricity needs of the Pacific Norhwest, the region will soon have to step up its conservation efforts and probably add new generating facilities. When a new generating facility is added, it is usually the kind that provides the least expensive power. However, some citizens in the region would like to prohibit certain kinds of facilities for a variey of reasons such as environmental threats, safety, and health related problems. Other citizens do not object to these facilities. Nuclear plants, fossil fuel power plants, and/or hydro-electric dams are the facilities towards which objections are most often mentioned. If any of these facilities are prohibited there may be greater increases in the future cost of electricity.

Q11. Would you pay an additional charge on each monthly utility bill to avoid using any one or more of these electrical generating facilities? (The money collected would be used to offset the higher costs of alternative facilities.) PLEASE CIRCLE 1 FOR YES OR 2 FOR NO.

1. YES ——→

Q12. If yes, please circle the amount that you would have charged to your utility bill each month.

.50 $1 $2 $3 $4 $5 $6 $7

$8 $9 $10 $12 $15 $20 $25

PLEASE WRITE OTHER PREFERRED AMOUNT HERE: $ _____

Of the amount you selected above, how much should be used to AVOID each of the following facilities? (Please make sure the total adds up to the amount you selected above.)

Q13. HYDRO-ELECTRIC POWER: _____

Q14. FOSSIL FUEL POWER: _____

Q15. NUCLEAR POWER: _____

SKIP TO QUESTION # 17 ON THE NEXT PAGE.

2. NO ——→

Q16. If not, why not? (Circle the number of your response.)

1. YOU SIMPLY DO NOT WISH TO PAY ANYTHING BECAUSE AVOIDING THESE FACILITIES IS NOT IMPORTANT TO YOU.
2. YOU THINK ENOUGH MONEY IS ALREADY BEING SPENT ON ELECTRIC POWER FACILITIES.
3. YOU ARE UNABLE TO PAY.
4. OTHER, PLEASE SPECIFY: _____

_____

Full Cost Economic Dispatch: Recognizing Environmental Externalities in Electric Utility System Operation

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Abstract

In this paper, "full cost economic dispatching" is proposed as a means of operating an electric utility system to the maximum benefit of society. Environmental and societal costs of generation can be estimated, and then considered along with fuel costs in determining the most economical dispatch order of power supply resources. A simplified example of full cost dispatch is presented both to illustrate the concept and to indicate the rough magnitudes of its costs and benefits. Issues which must be addressed in implementing full cost dispatching are discussed.

Introduction

The generation of electricity from power plants imposes a variety of burdens on the environment (e.g., emissions of atmospheric pollutants) which, through a variety of pathways and interactions, can cause damage to human health, ecosystems, economic productivity, and cultures. While these impacts often occur far from the actual sources of pollution, both spatially and temporally, they are a genuine cost of electricity production and use. Whether through the damages themselves, later remediation efforts, or belated attempts to reduce pollutant loadings, these costs are ultimately borne by society, even if that burden is not distributed equally over geography or generations.

Electricity planners have begun to recognize such environmental externalities in *long-range planning* and resource procurement decisions. To be consistent and economically efficient, however, it is now necessary that *short-run operating* decisions also incorporate these externalities. Despite the current momentum towards energy efficiency and the use of less-polluting resources, the major sources of utility pollution, for the foreseeable future, will continue to be existing power plants; this situation will only gradually change as newer, more efficient plants are brought into service. Thus, while least-cost energy/environmental planning will help secure a more socially rational *future* energy system, *current* energy production will continue to impose unnecessary environmental burdens on society. To avoid this consequence, the *dispatching* of electric utility system resources should also attempt to minimize the societal costs of power generation.

While this approach breaks with traditional economic dispatching practices, it is a natural extension of the recognition currently being given to environmental and other externalities in electric utility planning. The difference is essentially a matter of time-frame. System planners make resource commitments for periods of many years, while system operators work in fractions of hours. In both cases, however, the objective should be the same: to provide electricity at the lowest possible cost, where "cost" includes both the direct and indirect costs of electricity production to society. If planners and operators seek to achieve different objectives, they will tend to undermine each other's efforts; as a result, optimum use of society's energy resources will not be achieved.

Electric Generating Resource Externalities

Economists refer to the cost implications of a decision that are not borne by the decision-maker as "externalities."[1] A typical externality is the cost of pollution, or more accurately, its cost impact in terms of damage to structures, ecosystems, productivity, and human health.

Among the most widely recognized externalities resulting from electricity generation are the air emissions of power plants. These include carbon dioxide (CO_2 -- a principal greenhouse gas), sulfur dioxide and nitrogen oxides (SO_2 and NO_x, respectively, -- the precursors of "acid rain"), and other air pollutants such as carbon monoxide, particulates, and volatile organic compounds, among others. Power plants also pollute water and create substantial volumes of solid waste. Nuclear plants create radioactive wastes: high-level waste consisting of irradiated fuel rods and assemblies and low-level waste consisting of contaminated equipment and supplies; they also routinely release radioactive air emissions, as do some fossil plants.

In addition to such pollutant loadings on the environment, the operation of power plants can also have other direct external costs. For example, the operation of hydro-electric plants can kill vast quantities of fish (a problem, e.g., at the Ludington plant in Michigan) and/or alter river habitats (a problem, e.g., in the Platte River Basin in Nebraska)[2]. Since these resources have substantial commercial, recreational, and intrinsic values to society, such environmental damages can be very costly.

While emissions of air toxics and fish kills are important *direct* externalities of electric

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[1] *As such, an externality can involve impacts on a different segment of the population or a different geographical or political region (e.g., acid gas emissions and impacts, or the import of hydropower from James Bay to New England). It can also involve impacts on later generations. Finally, even within a given spatial and temporal boundary, externalities can be said to exist where the decision calculus ignores important impacts (whether on society directly or on other species or habitats).*

[2] *In a report to the National Audubon Society (Tellus Institute 1989), we analyzed the potential for improving the Platte River Basin habitat through modifications to the operating practices and dispatch at a hydro-electric facility.*

generation, it must be noted that important externalities may also be *indirect*, as in the case of oil spills. In general, oil spills occur far from a power plant site and do not directly result from electric generation. They do, however, result indirectly from the consumption of oil for electric generation; the use of oil increases the need to transport oil, and thus increases the probability of oil spills and their associated damages to the environment. This increase in oil spill probabilities is an indirect externality of electric generation at oil plants. Similar indirect impacts of electricity generation and use occur throughout the electric fuel cycle, from extraction, processing, and transport of fuels to plant construction to energy conversion at the plant to decommissioning and waste disposal.

While each of these stages of the fuel cycle is involved in planning decisions, only some are affected by operating protocols. Thus, while planning protocols for including externalities will, in principle, need to consider all these stages, operating protocols can be more focused. For the purposes of incorporating externalities in operating decisions, it is likely that it will be sufficient to concentrate on those impacts that, like fuel costs, increase or decrease with plant output.

Internalizing Environmental Costs

Regulation can internalize externalities by ensuring that they are included in the decision calculus and by requiring those responsible for the costs to bear them. The traditional approach is through *environmental regulations* that establish restrictions with which utilities must comply, leaving utilities and utility regulators to focus on costs already deemed internal.[3] Such requirements delimit the amount of pollution that may be generated at certain facilities. The result is that some of the pollution cost has now been internalized in the decision process.

Significant external costs remain, however, either because the environmental restrictions do not set limits at zero for certain pollutants and facilities or because they do not address certain pollutants or facilities at all. For example, CO_2 is not yet controlled through environmental regulations affecting power plants. Moreover, as environmental restrictions are developed they generally apply only to new sources.[4] Those externalities that remain are receiving increasing attention by utility planners and regulators. In utility planning studies, the environmental impacts of various resource plans are often cited as important in deciding among plans (see, for example, Florida Power and Light Company, 1989).

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[3] *For example, the EPA currently requires that new coal-fired power stations have flue-gas desulfurization equipment (scrubbers) in order to limit sulfur dioxide emissions. The costs of installing and operating the scrubbers are then paid by the plant's owner. Electric utility planning studies now include the costs of scrubbers in deciding upon the most economical type of future capacity addition. In addition, the incremental cost of operating the scrubber is considered by system dispatchers in determining the optimal use of the facility.*

[4] *The proposed new amendments to the clean air act will indirectly address existing facilities, since it imposes overall rather than facility-specific limits.*

Note that this goes beyond the impact of environmental considerations upon direct utility costs. That is, the utility might chose a resource plan with higher direct costs, if it were less environmentally damaging.

Regulators in a range of states have begun to address the issue of externalities in resource planning and acquisition by a variety of means. In some states, e.g. Wisconsin, non-polluting resources are given a specific cost advantage over polluting resources. In other states, e.g., New York, Massachusetts, and California, regulators have determined that the environmental costs of air emissions, expressed in dollars, should be included in overall resource planning just as are the costs of fuel and plant construction. In this way, the costs of air emissions are internalized to the resource selection process. Other states, e.g., Vermont and Nevada, are considering similar approaches.

In each of these states, the focus has been on new resources and not on the enormous levels of pollution produced at existing facilities. Thus, despite their increasing recognition by planners, environmental externalities are not reflected in the decision protocols of utility system operators.

Conventional Economic Dispatch

Electric utility system operators use economic dispatching principles in order to employ optimally a set of available resources to serve customer loads. Typically, a computer system loaded with information about the costs and operating efficiencies of these resources determines the mix to be dispatched on an hourly or shorter basis. Conventional economic dispatch dictates that resources be operated to serve customer loads in a priority order based upon their incremental operating costs. These are the costs to produce the next unit of output from a plant, and so include the incremental cost of fuel and the variable portion of plant operation and maintenance (O&M) costs.

Conventional economic dispatch proceeds from lowest to highest cost resources to ensure overall economies in the production of electricity. Generating units with low variable operating costs, such as hydro and nuclear, are dispatched first. These resources will be operated even during low load periods, and so may be considered "baseload." Coal-fired plants have higher variable costs and so typically are next in the economic dispatch order. As such they may provide baseload service, or, in some cases, cycle to follow variations in customer load. Finally, oil and gas plants have higher variable costs, and so often operate as peaking units, providing generation to serve customer loads only during high load periods.[5] From the standpoint of annual generation related emissions, then, baseload and cycling units are of greatest importance, while peakers can become significant over shorter time periods.

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[5] *New combined-cycle units burning natural gas have recently become attractive options for baseload and cycling service because of their high fuel efficiency (low heat rate) and resulting low variable costs.*

In practice, all of the electric generating units on a system will be ranked by the dispatchers according to their direct incremental costs, and so within each class of units (coal, oil, etc.) there will be a range of incremental costs represented. Sometimes, owing to differences in plant efficiency (i.e., "heat rate") there can be some overlap of plant types in the dispatch order. For example, an efficient oil-fired unit may have a lower incremental cost per unit of electricity production than an inefficient coal-fired plant, even though oil costs more per unit of energy input.

Moreover, the efficiency of a generating unit typically varies with the output of the unit. The heat rate curves, which give the operating efficiency as a function of the operating capacity of the unit, are generally "U" shaped. For this reason, the optimal use of a system of generating units to serve a particular level of demand may have a number of units operating at partial capacity. The dispatch order will thus, in general, reflect different plants at different levels of output, rather than a simple sequence of plants.

A simplified representation of conventional economic dispatch is provided in Figure 1. Customer electricity requirements are represented as a "load duration curve" or cumulative probability distribution. In the diagram, the horizontal dimension represents time, the vertical dimension represents MW of capacity of load, and the areas can thus be interpreted as energy (megawatt-hours).

The typical baseload facilities (hydro, nuclear, coal) are seen to provide most of the system energy requirements, while intermediate units and peakers (gas, residual oil, distillate oil) contribute a smaller share. In this system the dispatch order for the baseload facilities (hydro, nuclear, and coal) based on ascending variable production cost, ensures that hydro and nuclear operate at their maximum availabilities, while coal operates below its full availability. Intermediate resources (inefficient coal or efficient gas and oil units) operate at significantly less than their full availability, but still contribute a substantial amount of energy. The peaking resources (inefficient oil and gas units) provide energy primarily during daily and seasonal peak (high load) periods.

Full Cost Economic Dispatch

The procedure described above, in which electric resources are operated on the basis of direct fuel and variable O&M costs, may be termed "direct cost dispatch", "partial cost economic dispatch," or "utility cost dispatch." It aims for optimal use of resources only from the narrow perspective of the electric utility system and its revenue requirements. A broader outlook would include the costs of plant operation beyond these direct costs. As discussed above, these additional incremental costs to society include the impacts of pollutants from the plant, both on the utility customers who benefit directly from the electricity produced and on other people and natural environments that do not so benefit.

The concept of economic dispatch can be expanded to incorporate these external costs. Electric generating resources could be dispatched in order of increasing incremental cost to society, including the societal costs of incremental pollution (and other externalities), as well as the direct utility costs of fuel and O&M. This expanded concept could be called "*full cost dispatch*" or "*societal cost dispatch.*" The result of full cost dispatch would, in general, be a re-arrangement of the dispatch order and different contributions of resources to meet aggregate and seasonal energy requirements. Lower overall emissions would likely ensue, although tradeoffs between different pollutants according to their relative harm (societal cost) make this a more complex matter. If the pollution costs reflect the likely damage cost or the value society wishes to place on the risk of such damage, then this method will produce socially efficient results.

The term "*least-emissions dispatch*" has been used in various contexts and with various meanings. By recognizing an important category of external costs of electric plant operation (air pollution) this concept goes part way toward full cost dispatching, but stops well short, as it fails to recognize any of the other external costs of electricity generation. Moreover, the phrase "least emissions" is ambiguous with regards to the treatment of multiple pollutants and the relative weights to give them. It could refer to a single pollutant among many, or it could refer to a simple aggregate of pollutant emissions. If, however, society views the impacts of each pollutant differently, the aggregate incremental emissions from a resource could be a weighted sum of the pollutants emitted or, more directly, a sum of the societal costs of the pollutants. Dispatching based on these costs would be a "least-emissions cost dispatch".

If such aggregate environmental costs are added to the direct variable costs of generation in the system dispatch protocols, full cost dispatch would result. Thus, the ***multiple*** environmental attributes of electric generation would naturally be reflected in system dispatch. This would be quite different from dispatch with respect to a single pollutant (e.g., SO_2).

The term "least-emissions" may be misleading, as it often refers to a hybrid approach in which the objective is to minimize a combined function of utility cost and emissions (or emissions cost). A true least-emissions dispatching strategy would load the available resources in a priority order based *solely* upon emissions -- from the lowest emitter (or aggregate emissions cost) to the highest -- with no regard to fuel and O&M cost. Such an approach could produce dramatically altered economic results. Whether such an outcome -- much higher direct costs -- would be acceptable is a matter of social and economic policy. These results would be consistent with those of full cost dispatch if the societal costs of emissions are much larger than the direct costs of the electric generation.[6]

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[6] *Of course, when very high dispatch costs might otherwise be incurred, non-dispatch related options become relatively more attractive.*

Full cost dispatch could be effected by ascribing values to environmental *loadings* (e.g., emissions). It could also be pursued in more site-specific detail by representing loadings, the transport of pollutants, the exposure of sensitive populations and systems, the dose-response relationships, and, finally, the value of damages caused. This could be done either in great detail or approximately by developing factors and algorithms that would effectively capture these relationships at a reasonable level of accuracy for the facilities on the system.

Another approach would be to minimize the incremental utility costs, subject to a set of emissions constraints. A simple example of "*emissions constrained dispatch*" is the operating restriction of the Powerplant and Industrial Fuel Use Act of 1978[7] which specified that natural gas could be used in a new power plant, but only if the annual operation were constrained to 1500 hours or less (subject to certain exemptions). These restrictions were enacted as a means of reducing national dependance upon oil and gas. Emissions constrained dispatch can be viewed as the operating component of an overall strategy for meeting emissions caps such as those for acid gases embodied in the proposed amendments to the Clean Air Act.

Emissions constrained dispatch is an alternative method to full cost dispatch for reflecting society's environmental concerns. These two methods need not be viewed as fundamentally incompatible. Since the societal cost of emissions is a complex matter of science, economics, policy, and values, setting the costs of environmental impacts for full cost dispatch is not a precise exercise. At different levels set for the external costs, different levels of pollutant emissions would be achieved by full cost dispatch. The direct cost of achieving different overall pollutant loadings can thus be examined. Alternatively, setting different target levels of pollutant loadings and determining the direct costs to achieve them comes at the problem from another direction. The two approaches should provide consistent results over a range of pollutant levels and costs.

An Example of Full Cost Dispatch

To explore the potential implications of full cost dispatch we will examine a simplified "hypothetical system." This analysis is intended to illustrate the concept of full-cost dispatching as it compares with conventional economic dispatch and with strict least-emissions dispatch. This idealized example will also provide some indication of the costs and impacts which may be associated with various dispatching methods for a large, diverse system. We will outline the characteristics of the hypothetical system, and then consider the results for this system under three methods of dispatching: 1) conventional economic dispatch, 2) strict least-emissions dispatch, and 3) full cost economic dispatch.

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[7] *PL 95-620, enacted by Congress October 14, 1978 and signed by President Carter November 9, 1978.*

Our hypothetical system is modelled after the fossil fuel portions of the New York Power Pool (NYPP) and New England Power Pool (NEPOOL) systems. Table 1 shows the dispatch order for the hypothetical system, with capacity ratings, energy generation (under conventional economic dispatch), heat rates, fuel costs, and variable O&M costs. The capacity contributions for each major fuel type were selected to resemble the mix of fuel types in the Northeast U.S., while within each fuel type the hypothetical "plant" capacities are arbitrary. We have added some combined cycle gas capacity to represent likely near-term capacity additions. Also, we have assumed that dual-fuel facilities (primarily oil/gas) will burn gas only.

The amounts of energy generation were determined by fitting the resources under a simplified "load duration curve" derived from a probability density function for a normal distribution. The costs and heat rates were based on selected NYPP fossil fuel plants (these data were obtained from dispatch model runs developed for the New York State Energy Plan [New York State Energy Office et al. 1989]). The variable production costs, in the right-hand column, are the sum of the fuel and variable O&M costs, expressed per kwh of generation.

The dispatch simulation method used in our analysis is highly idealized. It employed average heat rates (rather than detailed heat rate curves) and assumed that the outage rates for these fossil units are identical. These sumplifying assumptions permit changes in the dispatch to be determined in a straightforward manner, by "flipping" the order of generators under the load curve. While not entirely accurate, this simplified approach can be implemented in a "spreadsheet model," thus avoiding the use of a complex probabilistic production costing model. This procedure is adequate for our illustrative purposes.

The simplified approach permits quick comparisons of dispatch methods to be made to a level of accuracy acceptable for illustrative purposes. *Detailed* studies of emissions dispatching should be done for specific actual systems to determine how much emissions could be reduced and at what cost. We know of one such study, which explored SO_2 dispatch strategies for the state of Ohio (Heslin and Hobbs, 1990). That analysis employed a probalilistic production costing model to explore SO_2 reducing dispatch strategies, and found that "emissions dispatching appears to be a [*sic*] inexpensive way to quickly achieve substantial emissions reductions, no matter what other strategies it is used in combination with." Each large electric system could conduct a detailed study of alternative dispatch strategies.

Emissions coefficients for the plants in the hypothetical system are shown in Table 2. These coefficients were based upon the NYPP fossil units that were used for the hypothetical system cost and efficiency assumptions.

The first column of numbers in Table 3 shows the summary results for this system dispatched based upon variable production costs only. The total production cost (fuel plus variable O&M) is $3,679 million, and total emissions are 790,075 tons of SO_2, 263,788 tons of NO_x, 119,881,000 tons of CO_2, and smaller amounts of the other air pollutants.

We can estimate the "societal cost" of the air pollution from this dispatch using "emissions values" (cost per pound) for each pollutant. We have developed values for these pollutants using an approach based upon marginal control costs and regulators' revealed preferences. This approach is described in detail in Bernow and Marron (1990). The values resulting from that analysis are listed in Table 4. The Massachusetts Department of Public Utilities recently adopted these costs for use in Massachusetts (Mass DPU 1990).

Multiplying the values in Table 4 by the amounts of pollution in Table 2 yields a societal cost of emissions of $6,133 million. The total societal cost is, therefore, $9,812 million ($3,679 million in direct costs plus $6,133 million in emissions costs).

We can now examine a case in which the same system is dispatched according to the strict "least-emissions" method. Instead of using direct variable production costs (column 1 in Table 5) to determine the loading order, the emissions values (column 2 in Table 5) are used. The emissions value for a plant is determined by multiplying its emissions coefficients (pounds per kwh) by the set of emissions values ($ per pound).[8]

The results for the strict least-emissions dispatch of the hypothetical system are provided in the second column of Table 3. Production costs have increased by $681 million relative to conventional dispatch, but the amounts of air emissions have, in general, gone down substantially. For example, SO_2, NO_x, and CO_2 have decreased by 74%, 28%, and 20%, respectively. Emissions of three of the less important pollutants have increased. The net result, of course, is a large reduction in emissions costs: from $6,133 million for conventional dispatch to $3,949 million for least-emissions dispatch. In this case, moreover, the strict least-emissions approach has lowered total societal cost as well.

There are, of course, intermediate approaches between the two extremes analyzed above. The conventional economic dispatch entirely ignores environmental costs, while the strict least-emissions dispatch entirely ignores direct economic costs of fuel and O&M. Could

[8] *Note that if the least-emissions dispatch were dealing with only one pollutant, the valuing would not be necessary. With one pollutant, we could simply dispatch to minimize emissions of that type. With multiple pollutants, however, we need a means of valuing each relative to the others. The emissions values (in dollars per pound) provide a convenient way to specify relative values. Other ways are possible. For example, we could say simply that one ton of SO_2 emitted is seventy "times as bad" as one ton of CO_2, that one ton of NO_x is four "times as bad" as one ton of SO_2, and so on. This would be equivalent for the least-emissions dispatch case. Using a monetary definition, however, offers a convenient measure of "badness," and also allows easy comparison of direct costs and emissions costs. It also permits aggregation of environmental costs across different pollutants.*

the system be dispatched such that overall costs to society are minimized? We believe that a full cost economic approach to dispatching -- based upon both direct and environmental cost -- is both feasible and desirable.

For our hypothetical system, full cost dispatching was done using the combined costs per kwh shown in the right-hand column of Table 5. The results, in Table 3, are a slightly higher overall pollution cost than for the least-emissions case (by 4 percent) and somewhat higher fossil plant production costs than for the conventional dispatch case (by 9 percent).[9] Overall, however, the full cost dispatch provides the best alternative in that it results in the lowest total societal cost. Compared with the conventional economic dispatch case, full cost dispatch saves $2.0 billion, about 33 percent, of the emissions costs for the hypothetical system, at an additional direct cost of $344 million, about 9 percent of the fossil fuel production costs of the system. The benefit to cost ratio is thus about 5.9 to 1. At the same time, the overall societal (direct plus emissions) costs decrease by about 17 percent, from $9,812 million to $8,130 million. Averaged over the seven pollutants, pollution reduction by full cost dispatch is effected at extra direct costs at about 17 percent of the value of the pollutant (e.g., the average SO_2 reduction cost of $272/ton compared with the reduction value of $1,600/ton, while for NO_x the average reduction cost was $1,156/ton versus the value of $6,800/ton).

This result is not a surprise. Indeed, it is certain that the dispatch which is based upon the objective of minimizing societal costs will result in lower societal cost than dispatches based upon other objectives such as minimizing production costs or emissions. It can also be expected, in general, that the cost of pollution reduction will be lower than the value of the pollution reduced, the degree of course reflecting the particular conditions of the system. Nonetheless, as noted earlier, this is a hypothetical system treated in an approximate manner, without any constraints that could limit the degree of operating flexibility.

The results for the three dispatch methods, summarized in Table 3, show surprisingly little difference between the least emissions dispatch and the full cost dispatch approaches. This is depicted in Figure 3, where "hybrid" dispatch approaches fill out a curve between the three approaches discussed above. As the relative weight given to environmental costs is increased (moving along the x-axis), the direct production costs increase while the emissions costs decrease. The societal cost (production cost plus emissions cost) decreases to an minimum at full cost dispatch, and then increases slowly.

For our hypothetical system, the shape of the societal cost curve indicates that most of the savings are to be realized in the first small steps toward full cost dispatch, and that to go

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[9] *Note that total dispatch costs, which include nuclear and hydro plants, have increased by less than 9 percent, since we assume that the non-fossil generation is unaffected. Further, note that total electricity costs have increased by substantially less than 9 percent, since total costs include fixed costs etc.*

beyond full cost dispatch toward least emissions is not costly. It is not clear, however, that this would be the outcome for any particular real utility system.

Technical Constraints on Full Cost Dispatch

The example above is "idealized" in several respects. It used a hypothetical system, a simplified treatment of outage rates and heat rates, and it ignored "real time" system operating conditions such as ramp rates, minimum loading levels, and minimum down time.

We have no reason to believe that the hypothetical system, or the simplification of outage rates and heat rates results in a bias one way or another in the results provided above. On the other hand, the "real time" considerations could place important constraints on emissions dispatch in practice, and so actual emissions reductions will likely be somewhat lower than those forecast with a system which ignores these system operating issues. For example, the extent to which generation from coal units can be cut back will certainly be limited by the minimum loading levels for those units.

This point was made in an extreme form by a utility vice president quoted in a widely circulated publication:

> It's practically impossible to do 'environmental dispatch'. From an engineering point of view, it just won't work. It would be utter chaos. The system will break down in about 15 minutes and you won't have any more NEPOOL. If you try to turn off a baseload coal plant in the afternoon and expect to turn it on again the next morning, it won't happen. Same goes for gas-fired peaking plants. If you run those for very long they will break down. Environmental dispatch is physically impossible. (Electric Utility Week, 1990)

Although cast in near absolute form, these statements contain an important point of a relative nature -- that there are physical constraints on the operation of generating units. Such constraints should be recognized in dispatching the system. This does not mean, however, that no "environmental dispatch" at all can be performed but, rather, that it will be subject to constraints and will thus realize lower levels of emissions cost reductions. For example, with full cost dispatch, some, especially dirty, coal plants would run at very low capacity factors. This would not be realized by using these coal units for quick start purposes, as are peaking facilities, but would be possible if individual units were run only for short periods, perhaps cycling between 25% and higher capacity levels.[10]

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[10] *It could also imply that retirement (or reserve shutdown status) would be desirable for such units if environmental costs were adopted in system planning and operation.*

It is important to remember that such constraints are not unique to environmental dispatch. Electric systems all over the world are currently dispatched by computer systems programmed to satisfy ramp rates and minimum loading constraints. The addition of environmental variable costs to direct variable costs would not fundamentally alter these considerations. Rather, it would (or could) cause a different set of units in a particular system to run up against the constraints.

It is common and sometimes necessary to make modifications to the system which impact the way in which generating units operate. Coal units were often built to back down expensive oil or gas generation. Nuclear plants were built to modify dispatch. The many nuclear plant additions over the last decade were intended to back down expensive fossil generation to achieve economies in direct variable costs. For example, with the addition of the three Palo Verde nuclear units to its system, the Arizona Public Service Company fossil units capacity factors were expected to drop from an average of about 72 percent to about 54 percent, far below full availability, with some individual units lower still (Bernow 1987).

Of course, the long-run performance of generating units can also depend upon the manner in which they are operated. Coal units are generally expected to operate at high capacity factors, with a minimum of load following, while combustion turbines are expected to operate at low capacity factors, often in a load following mode. However, it is far from clear that combustion turbines would perform poorly if operated in a baseload mode if that were needed to satisfy full cost dispatch protocols. Combined cycle plants, which frequently are used in baseload applications, use combustion turbines to generate electricity and feed the exhaust gas into a heat recovery steam generator. The combustion turbine portion of a combined cycle facility will often be called upon for baseload operation. Modern combustion turbines can (and do) operate at capacity factors of more than 90 percent (EPRI 1986). In a baseload mode of operation, the performance could even be improved, as frequent start ups can cause wear on the plant components (Williams and Larson 1988, and Todd 1990).

With regard to the use of coal facilities for cycling or peaking operation, there will be limitations. Subcritical coal units are designed to be cycled. That is, they can be brought down to minimum load (about 25 percent of total capacity) during nighttime periods and shutdown on weekends. Supercritical units may be more constrained to baseload operation, but in a full cost dispatch protocol might be taken off line entirely during low-load months in the spring or fall. The above example of Arizona Public Service shows that such operation is undertaken by utilities. The best approach to use in backing down coal plants if necessary will depend upon the particular generating unit, and the characteristics of the system in which it is located.

Finally, it should be noted that many of the existing power plants that might be affected

by full cost dispatch are oil and gas steam facilities, originally built for baseload operation but operated late in the loading order in recent years owing to their high fuel costs. If full cost dispatch were to require increased operation of these units, this would be consistent with their original design intent.

Full cost dispatch, and the constraints under which it could operate, can be readily represented in conventional production costing and planning models that simulate system operation and the economics of alternative system plans.

Full Cost Dispatch and Electric Rates

The impact of full cost dispatch on revenue requirements, rates, and customer electricity bills could be substantial in some systems, especially where low cost, high emissions generation resources dominate the overall mix of electricity production. For example, in a system for which coal provides most of the energy, while gas or oil provide peaking capability, switching from coal at 1.5 to 2.0 ¢/kWh to higher cost fuels at 3.5 ¢/kWh could almost double the system energy costs. Overall revenue requirements (which include fixed costs) could increase by as much as 50 percent in such a case. Of course, this is an extreme example. First, the one-for-one switching between high and low cost fuels would be unlikely in most systems. Second, significant emissions benefits could be secured in some instances by switching between fuels closer in cost. Finally, system and unit operating conditions and constraints would restrict dispatch flexibility and, thus, the degree of fuel switching possible.

The actual impact will, therefore, be much less than the 50 percent in this extreme example. Indeed, for the hypothetical system evaluated earlier the impact on production costs alone was found to be less than 9 percent. Nonetheless, electricity cost increases would occur under a regime of full cost dispatch. For those systems that are expected to incur relatively small increases, no specific remediation may be necessary. At the higher end, however, it might be desirable to soften the blow, and permit electricity customers to adjust their expectations and behavior gradually, by using phase-in techniques similar to those that have been used in ratebasing expensive new generating units. With such a technique, transition to complete full cost dispatch could be effected over several years. System specific studies of the revenue requirements impacts, as well as the environmental benefits, of full cost dispatch should be conducted so that opportunities can be seized and appropriate action for dealing with rate impacts, if necessary, can be formulated.

Cost Allocation in Power Pools

The increase in energy costs resulting from use of full cost dispatch not only affects how rates are set for ratepayers; in cases where multiple utility systems are dispatched as part of a central power pool, the increase in costs will affect the allocation of dispatch costs among the utilities.

The implementation of full cost dispatching is best undertaken at the power pool level as is conventional economic dispatch. This would permit the greatest level of flexibility and, thereby, overall economies in providing energy across several utility service territories. The addition of variable environmental costs to variable direct costs could, however, entail some distributional problems, even as it realizes overall societal economies. As noted earlier, the total direct costs of supplying power will tend to increase when shifting to full cost dispatch.

For a single utility, this is a matter between the utility and its ratepayers, mediated by the regulatory process. Both the direct costs and the environmental benefits (or some share thereof) would accrue to the utility's customers. Within a power pool, on the other hand, full cost dispatching could cause the increase in direct costs to be borne disproportionately by the member utilities (and, thus, their ratepayers). This would tend to occur if the lower polluting plants were distributed disproportionately across the utilities in the pool. Thus, a concern for fairness could be seen as in contradiction with the goal of overall societal efficiency.

There are means to deal with these potential transfer problems without abandoning the goal of overall societal efficiency. A sharing of the additional costs on a *pro-rata* basis would be the simplest procedure. However, this approach might provide insufficient incentive for individual utilities to improve their system's emissions characteristics. A more nuanced procedure may be necessary. Such a procedure could follow the basic logic and structure of allocational protocols already in place at power pools.

In the New England Power Pool (NEPOOL), for example, an overall reserve margin target is established for reliability purposes, to which member utilities are expected to contribute their "capability responsibilities". These capacity requirements are based primarily on relative contributions to the pool-wide peak. This *pro-rata* distribution is modified by member system-specific characteristics reflecting the relative reliability (forced outage rates, etc) of their systems. Since capacity shortfalls are paid into a pool fund using this scheme, there is some incentive for members to improve their system reliability. This NEPOOL system is called the Performance Incentive Program (PIP).

NEPOOL also has a system to allocate the benefits of pool-wide, as opposed to individual utility, economic dispatch. As full cost dispatch is a direct extension of direct cost dispatch, the procedures in place for allocating the benefits of pool-wide dispatch could serve as a starting point for a similar system with full cost dispatch at the power pool level. However, it is important that such a system not sharply penalize those utility systems that have relatively cleaner generation but higher direct operating costs. The existing allocation system could be modified to ensure a fair allocation of the extra costs of full cost dispatch on a pool-wide basis.

Finally, it is important to note that there are local environmental impacts of power plant generation that could be affected by full cost dispatch. If global environmental costs (i.e., the costs of loadings) rather than site-specific environmental costs are added to direct operating costs, there could be some increased local impacts even as overall emissions and societal costs are reduced. This could cause new problems of fairness and transfers (on the environmental benefits or costs side) that would need solution by the participants in the pooling arrangements.[11] At the least, local emissions or concentration limits could be followed, thereby constraining somewhat the flexibility at the global emissions level.

Collecting the Environmental Costs

Despite all this concern with allocation and the implementation of a full cost dispatch system, we do ultimately wish to encourage rather than suppress a system that obeys the "polluter pays" principle, both as a matter of assigning responsibility and to affect behavior appropriately. After phase-in, the "full" societal cost of *fuels* for electric energy generation would be seen by electric utility planners and system operators, while the higher direct costs of their planning and operating decisions would be seen by electricity consumers. But, our approach implies more, i.e. that the full cost of electricity production should be borne by electricity consumers.

The question that arises in this context is whether external costs should be merely imputed in the planning process, without actual collection from ratepayers ("phantom" costs) or whether they should actually be collected ("real" costs). Consistent with the traditional notion of economic efficiency, we believe that it may be appropriate to collect external costs from energy consumers. Consumers would then be presented with "correct" price signals, rather than the artificially low prices that result from only imputing external costs to planning and operating decisions.

By collecting actual externalities costs, the energy-related decisions of both electricity consumers (through increased conservation and fuel switching) and utilities (through changed priorities for dispatch and power purchases) could become more efficient from a total cost standpoint, to the degree that these decisions are price elastic. Moreover, modified (i.e., decreased) consumption can, in turn, affect planning decisions. Inclusion of externality costs in rates would thus be a consistent way to incorporate the valuation of external costs and the goals of such valuation in the planning and behavior of utilities and their customers.

The revenues collected from such a system could be placed in a fund that would be used to remediate the very problem that was the source of those revenues: the emissions of pollutants. Such remediation could include investments in pollution control, in

[11] *If full cost dispatch incorporated simulations of transport, exposure, dose-response, and damage valuation, global and local impacts could receive their appropriate relative treatment.*

environmental remediation, in conservation and renewables, in further research on environmental damages, damage costs and control techniques, and in other related options. Of course, the design and administration of such a system would require careful thought, in order to ensure that it meets its objectives. One possible system could be based on competitive bidding for opportunities to pursue the pollution prevention and environmental damage reduction objectives of the fund.

A similar approach that is receiving attention with regard to CO_2 is one ascribing pollution taxes to energy purchase prices. This has the merit of being economy-wide, crossing all sectors in a *prima facie* consistent manner.

Conclusion

Over the past few years, we have been heartened by the increasing attention regulators and, to some extent, utilities have been giving to the inclusion of environmental externalities in electric resource planning. While much work remains to be done on this important issue, we believe that the time is ripe for extending such efforts beyond utility planning to the area of actual utility operations. Planning can only go so far, since it is actual utility operations, including usage of existing facilities, that will determine the level of environmental pollution that will result from electric generation.

In this paper, we have proposed what we believe to be the most reasonable method for including environmental externalities in utility operations: full cost dispatching. We recognize that a range of issues must be addressed before such dispatching can become widely implemented. The technical issues are, we believe, more easily addressed than the allocational issues. Regulators, in conjunction with utilities, environmental groups, consumer advocates, and other interested parties, must determine what costs are to be imputed to which pollutants for dispatch purposes (an issue that must also be addressed with regards to planning), what operational constraints will need to be identified before altering the dispatch, and how additional operating costs will be allocated across customer classes and utilities in power pools.

While the implementation of full cost dispatch will not be a simple matter, the large potential benefits to society make the effort worthwhile. From a societal perspective, it is very expensive to continue to dispatch electric facilities according to traditional economic practice.

References

Bernow, Stephen. 1987. "Excess Capacity and Cost Benefit Analysis of the Palo Verde Generating Station", direct Testimony before the Arizona Corporation Commission in Docket No. U-1345-85-367, February, 1987.

Bernow, Stephen and Donald Marron. 1990. "Valuation of Environmental Externalities for Energy Planning and Operations: May 1990 Update". Tellus Institute, Boston, Massachusetts, May 18, 1990.

Electric Power Research Institute (EPRI). 1986. Technical Assessment Guide, Volume 1: Electricity Supply. Palo Alto, California.

Electric Utility Week. 1990. "Environmental 'Dispatch' Impossible, Says New England Electric Executive". July 2, 1990.

Florida Power and Light Company 1989. Petition to Determine Need for Electric Power Plant 1993-1996.

Heslin, James S. and Hobbs, Benjamin F. 1990. "A State-Level Probabilistic Production Costing Analysis of SO_2 Emissions Reduction Strategies for Ohio; Effectiveness, Costs, and Regional Economic Impacts". Case Western Reserve University, Cleveland, Ohio.

Massachusetts Department of Public Utilities. 1990. "Investigation by the Department of Public Utilities on its own motion into proposed rules to implement integrated resource management practices for electric companies in the Commonwealth", Docket No. DPU 89-239, Final Order, August 31, 1990.

New York State Energy Office, New York State Department of Public Service, and New York State Department of Environmental Conservation. 1989. New York State Energy Plan, Albany, New York.

Tellus Institute. 1989. "Regulating the Kingsley Hydro-Electric Facility and Dam to Provide Scouring Flows on the Platte River". Report to the National Audubon Society, August, 1989.

Todd, Doug. 1990. Phone conversation, G.E. Power Systems, Schenectady, New York.

Williams, Robert H. and Eric D. Larson. 1988. "Expanding Roles for Gas Turbines in Power Generation" in Johannsen, T, B. Boduld, and R. Williams, eds. 1988. Electricity, University of Lund Press, Lund, Sweden.

Table 1: Test System for Emissions Dispatch Analysis

	Capacity (MW)	Generation Under Conventional Economic Dispatch (GWh)	Capacity Factor Under Conventional Dispatch	Fuel Cost ($/MMBTU)	Variable O&M Cost (¢/KWh)	Variable Heat Rate (BTU/KWh)	Prod. Cost (¢/KWh)
Coal with FGD	2000	14,016	80.0%	1.60	0.50	9,500	2.02
Coal, 2.37% sulfur	2000	14,016	80.0%	1.80	0.30	9,900	2.08
Coal, 1.83% sulfur	2000	14,016	80.0%	1.50	0.45	12,100	2.27
Coal, 0.82% sulfur	2000	11,339	64.7%	1.80	0.40	13,000	2.74
Oil steam, 1.5% sulfur	2000	9,763	55.7%	2.75	0.30	9,900	3.02
Oil steam, 1.3% sulfur	2000	12,654	72.2%	2.70	0.20	9,400	2.74
Oil steam, 1.0% sulfur	2000	2,540	14.5%	2.80	0.25	10,200	3.11
Oil steam, 0.75% sulfur	2000	1,721	9.8%	3.05	0.25	10,200	3.36
Oil steam, 0.70% sulfur	2000	1,121	6.4%	2.95	0.35	10,300	3.39
Oil steam, 0.30% sulfur	4000	1,123	3.2%	3.15	0.65	12,900	4.71
Gas steam	8000	23,004	32.8%	2.75	0.20	10,400	3.06
Oil, CT	3000	177	0.7%	4.25	0.65	15,000	7.03
Gas, CT	2000	244	1.4%	3.05	0.30	15,000	4.88
Gas, CC	5000	34,558	78.9%	2.55	0.45	8,200	2.54
TOTAL	40,000	140,292					

Table 2: Emission Coefficients for Test System (lbs/MMBTu in)

	SO2	NOx	CO2	CH4	CO	Partic.	VOC	Emissions "Value" (1990¢/KWh)
Coal with FGD	0.3600	0.5300	220.0000	0.0012	0.0240	0.0300	0.0028	4.4601
Coal, 2.37% sulfur	3.3200	0.4000	220.0000	0.0012	0.0240	0.2400	0.0028	7.0002
Coal, 1.83% sulfur	2.9300	0.8490	220.0000	0.0012	0.0240	0.2200	0.0028	9.9737
Coal, 0.82% sulfur	1.3100	0.1500	220.0000	0.0012	0.0240	0.2600	0.0028	7.0410
Residual steam, 1.5% sulfur	1.6200	0.6250	169.0000	0.0019	0.0330	0.1000	0.0051	5.5752
Residual steam, 1.3% sulfur	1.4200	0.2810	169.0000	0.0019	0.0330	0.0530	0.0051	3.9441
Residual steam, 1.0% sulfur	1.0800	0.2810	169.0000	0.0019	0.0330	0.1000	0.0051	4.0906
Residual steam, 0.75% sulfur	0.8000	0.1900	169.0000	0.0019	0.0330	0.1000	0.0051	3.5274
Residual steam, 0.7% sulfur	0.7600	0.2810	169.0000	0.0019	0.0330	0.1000	0.0051	3.8619
Residual steam, 0.3% sulfur	0.3200	0.3000	169.0000	0.0019	0.0330	0.0919	0.0051	4.4247
Gas steam	0.0000	0.2670	117.0000	0.0003	0.0390	0.0029	0.0014	2.3789
Oil CT	0.2120	0.5110	164.0000	0.0016	0.1160	0.0376	0.0359	10.3307
Gas, CT	0.0006	0.3950	118.0000	0.0123	0.1100	0.0134	0.0120	5.9907
Gas, CC	0.0000	0.2000	117.0000	0.0003	0.0330	0.0014	0.0013	1.6815

Table 3: Costs and Emissions for Various Dispatching Methods

	Conventional Economic Dispatch	Least Emissions Dispatch	Full Cost Dispatch
Costs (millions of 1990$)			
Production Costs	3,679	4,360	4,023
Emission Costs	6,133	3,949	4,107
Societal Costs	9,812	8,309	8,130
Emissions (tons/year)			
SO2	790,075	207,373	257,777
NOx	263,788	187,998	194,026
CO2	119,881,000	95,734,000	97,442,000
CH4	727	1,031	653
CO	21,468	28,275	24,359
Particulates	68,489	23,207	24,258
VOC	1,979	2,457	1,829

Table 4: Values Used for Air Emissions

	1990$/lb
SO_2	0.800
NO_x	3.400
CO_2	0.012
CH_4	0.115
CO	0.455
Particulates	2.100
VOC	2.750

Table 5: Variable Costs of Operating Test System Fossil Plants

	Variable Production Costs (cents/KWh)	Emissions "Value" (cents/KWh)	Full Societal Costs (cents/KWh)
Coal with FGD	2.02	4.47	6.49
Coal, 2.37% sulfur	2.08	7.00	9.08
Coal, 1.83% sulfur	2.27	9.97	12.24
Coal, 0.82% sulfur	2.74	6.05	8.79
Residual steam, 1.5% sulfur	3.02	5.55	8.57
Residual steam, 1.3% sulfur	2.74	3.92	6.66
Residual steam, 1.0% sulfur	3.11	4.08	7.19
Residual steam, 0.75% sulfur	3.36	3.54	6.90
Residual steam, 0.7% sulfur	3.39	3.86	7.25
Residual steam, 0.3% sulfur	4.71	4.44	9.15
Gas steam	3.06	2.37	5.43
Oil CT	7.03	6.04	13.06
Gas, CT	4.88	4.22	9.09
Gas, CC	2.54	1.68	4.22

Figure 1
Simplified Diagram of Economic Dispatch

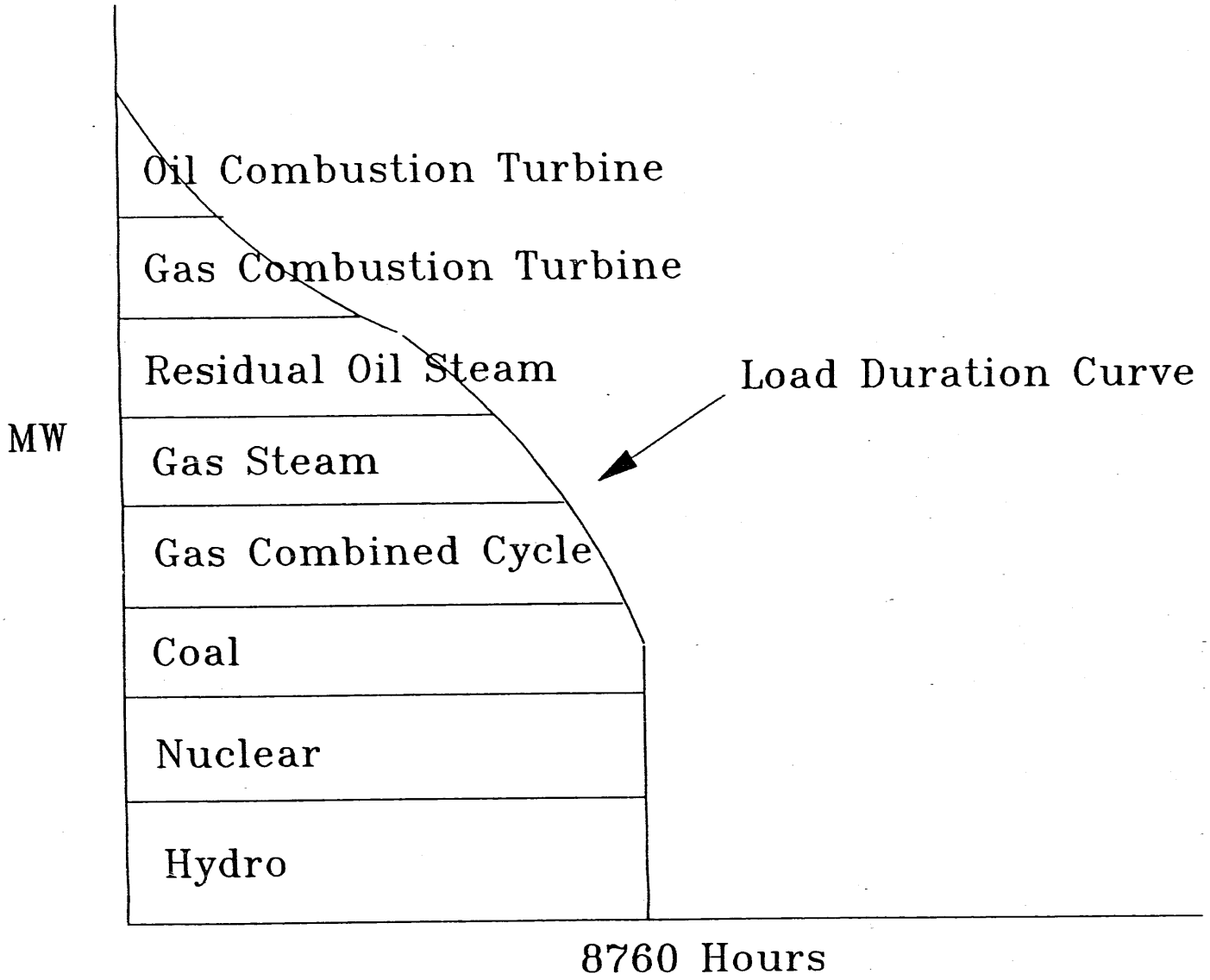
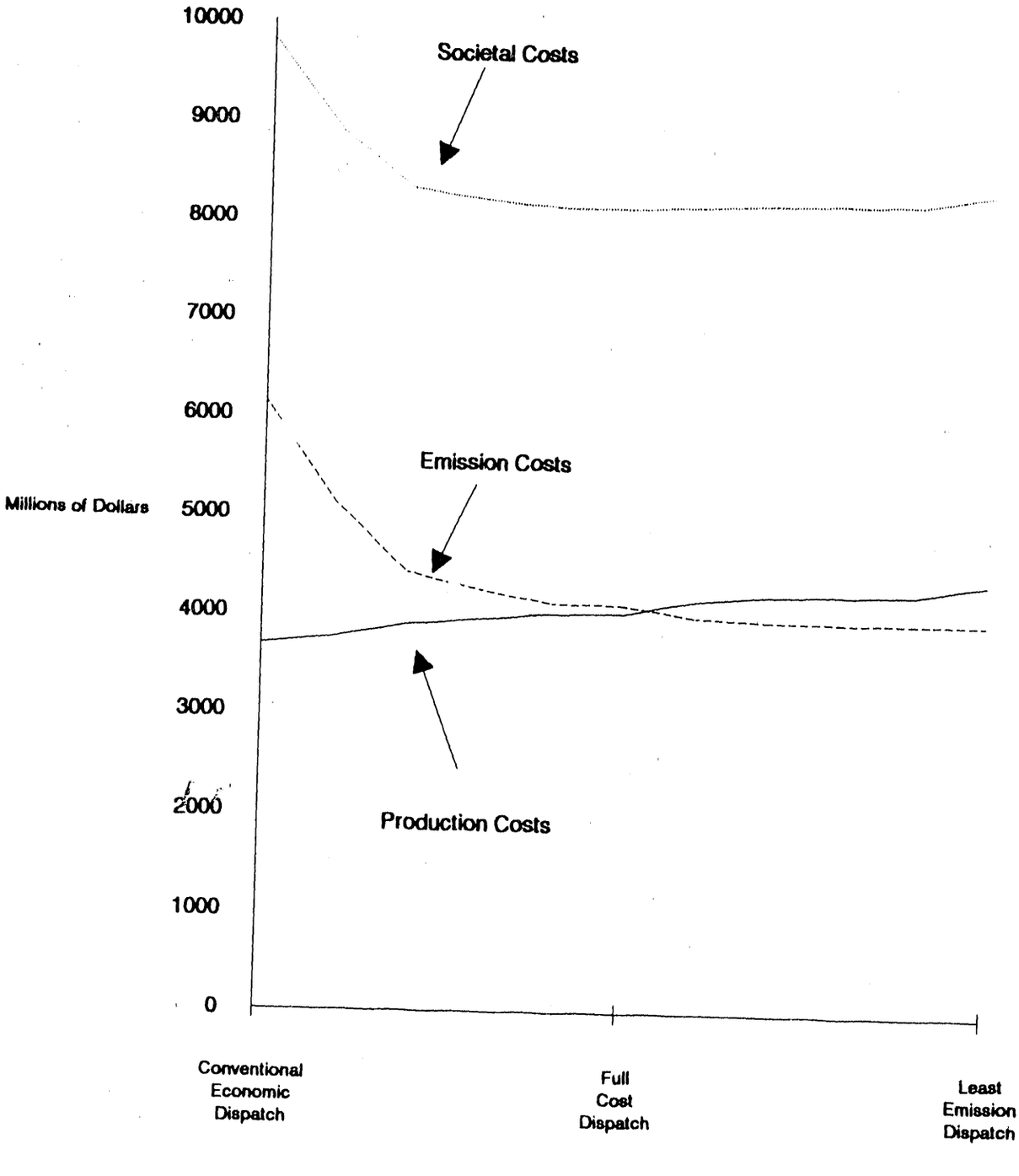


Figure 2
Relationship Between Costs and Dispatch Method for Test System



Bringing Environmental Damage Costs into the Electricity Marketplace: Gains to be Expected and Pitfalls to be Avoided

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National Audubon Society
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Table of Contents

Introduction 1

What are the goals and objectives of internalizing environmental externalities? 3

Why address externalities in the energy sector? 3
Energy production and consumption is the major cause of environmental stress 3

Methods of internalizing externalities 4
Method 1. Augment financial costs with environmental cost estimates when planning for resource acquisition .. 5
Method 2. Add environmental cost estimates to utility bills and return excess revenues to society as a whole. 7

There are huge uncertainties in assessing direct damage costs 7

In some cases, alternatives could introduce environmental problems of comparable significance. 8

Need for consistency 9
Special impacts that need to be recognized 11
Upstream pollution embedded in material 11

Methods of assigning costs 11
Use of damage function 11
Use of control costs 11
Revealed preference 12
Polling 12
Need for updates 12

Assessment of each energy source and appropriate regulatory response 12

Fossil fuels: coal, oil, and gas. 13

Energy efficiency 13
Indoor air pollution 13
Greenhouse gases in insulation 13
Fiberglass health effects 14

Residential solar 14

Waste-to-energy facilities 14

Nuclear 15

Conventional 15
Second generation 16

Solar technologies 16

Solar thermal 16

Photovoltaics 17

Hydropower 17
Assigning costs to hydropower habitat destruction 18
James Bay in Canada, an example of special problems with hydropower 18

Biomass 19

Geothermal 21
Earthquake risk from dry rock geothermal 22

Tables 22

Introduction

Energy, and electricity in particular, are major factors in determining the economic quality of human life. Electricity furthers the production of goods and services, but its production and use seriously impact on the quality of the environment. The vocabulary of environmental damage is virtually synonymous with the vocabulary of energy side effects: acid rain, smog, oil spills, destructive strip-mining, radioactive wastes.

In the past, regulatory agencies have thought of energy impacts as relatively local. Today, with our great technological power, energy impacts are transcending state and national concerns. Energy has given us the power to master the earth. And what are we doing with that power? We are tampering with the planet's climate balance and we are driving more and more species to extinction. In fact, we have reached a critical juncture in environmental history. It is this generation that must halt the emission of greenhouse gases, if future generations are to have any options left to them. It is this generation that must halt the destruction of critical natural regions, or see up to half the world's species lost to human development in the next thirty years.

There has been much discussion recently about the role energy use plays in possible global climate change. Less well recognized is the fact that energy technologies are contributing to the loss of critical areas and their non-human inhabitants. After all, it is energy that powers human development. Utility Commissions already contribute in one way or another to the massive environmental destruction projected for the relatively unspoiled parts of the world.

1) Utility Commissions contribute to the damage directly when they allow the import of energy from sensitive regions (and thereby export extraction damage). This problem will become particularly acute in the next two decades with respect to Northern regions. Our eye for oil, gas, and hydropower has turned in recent years to areas of Canada that are still relatively pristine. God save Canada.

2) Utility Commissions contribute to damage throughout the world indirectly when they set a bad example for other societies to copy, one of disregard for environmental damage costs in electricity planning.

Concern for environmental factors external to the marketplace must not stop at national boundaries, if we are to save what is left of the natural world and preserve the global ecosystem on which we depend.

That human technological power has reached such a destructive scale should lead us all to experience a sense of humility and a sense of mission. We need to learn a new word, "moderation," and account for the costs that we normally leave out of our decision-making. Fortunately, there are signs that a new national attitude of respect towards the environment has developed in the last two years. To nurture this new attitude, each of us must do our part. Utility regulators bear a special responsibility, because so many of a Commission's decision have an impact on the environment. Even those (few) commissioners who are skeptical of the need for increased protection of the environment are going to have to pay attention in the years ahead to environmental externalities. The increased level of public concern about environmental damages makes it inevitable that public utility commissions will get involved in the externality problem.

There are four key contributions that Utility Commissions can make:

1) Assist in protecting the local environment in one's state and the rest of the nation,

2) Assist in protecting the global climate balance,

3) Minimize any direct intrusions that local utilities are making into critical natural areas, and

4) Set an example for the developing world in the management of environmental impacts from electricity use and production.

All four of these contributions can be furthered by accounting for environmental damage costs not normally paid in the marketplace.

I literally breathed a sigh of relief, when I received notice about this conference. (Living in polluted New York City, as I do, that's about the only decent breath I drew in recent months.) It is exciting that utility regulators are finally focusing on the vital task of " internalizing environmental externalities." I can think of no more important environmental initiative than the one being discussed at this conference. The initial efforts taking place around the country must continue and they must be carried out in a consistent and logical manner.

Early attention to externalities has focused on the criteria air pollutants covered in the Clean Air Act. However, concern for energy externalities is taking place today in a new environmental context. There is concern about preserving the ozone layer, biodiversity, and the global climate. This means that the externality analyst must be prepared to cast a rather wide net, assessing the impact of all the energy resources in the utility portfolio.

What are the goals and objectives of internalizing environmental externalities?

Actions taken by utility commissions to deal with environmental externalities, especially those related to market mechanisms, should be viewed as a supplement to traditional effluent limits and technology-based requirements established by environmental agencies.

What can we expect from efforts to internalize environmental externalities? To the extent that dollar values can be assigned to environmental damage, there exists the possibility of using market mechanisms to increase the efficiency with which environmental expenditures are made, as well as compensating society for some percentage of the damage.

Use of market mechanisms to deal with environmental damage makes some environmentalists very queasy, because it can be interpreted as condoning pollution. Nevertheless, there are many strong arguments in favor of such an approach as a supplement to standard methods. It would be nice if all pollution could be ended instantly. Unfortunately, environmental damage will be with us for many years prior to our evolution into a recycling and solar energy society. In the meantime, we can benefit from techniques that economists tell us will be more efficient in an economic sense than total reliance on direct regulation.

Hopefully, including estimates of environmental costs, directly or indirectly, in the price of electricity will lead to a more efficient allocation of total social resources. Electricity resource use will shift, with a resulting reduction in environmental impacts. In particular, it is likely that additional use of energy efficiency, renewables, and natural gas will occur. And, if we set up a consistent process, any shift to these alternatives will be channeled to the best versions of these resources.

Not only can consideration of externalities help to reduce our direct contribution to environmental damage, it can also set an important example. By regularizing consideration of externalities in electricity planning, we are setting an example that developing countries will likely follow when they make the transition to industrialization.

Why address externalities in the energy sector?

Energy production and consumption is the major cause of environmental stress

Environmental damage costs are centered in the energy sector of economy. This is a key justification for attending to externalities in the energy sector alone. If this were not the case, it would be wiser to start elsewhere:

Attention to externalities will inevitably drive direct energy costs higher (although lowering total social costs), so that dollars will shift into other sectors of the economy. Because expenditures in these other sectors are likely to cause less environmental damage per dollar, the society-wide benefits will be positive. The situation is more complicated when it comes to shifts within the energy sector itself. Internalizing environmental costs in the utility sector alone will leave such costs untouched in the residential and industrial fuel markets. This implies a shift away from electricity, some of which will surface in increased fuel use in those sectors. If the environmental impacts of consumption of the substituted fuel, say wood in residential stoves without catalytic converters, are much greater than the consumption of utility fuel, the net impact on the environment could be negative.

Utility commission analysts who are assigning damage costs should make an assessment of likely fuel shifts to wood stoves or any other highly polluting non-utility resource as a result of the externality program. If the shift should appear significant, electricity resources, such as coal plants, should only be penalized for their net contribution to environmental damage. Economic studies of cross-elasticities may be required for this purpose.

Fortunately, there is no rush for such studies. In the early stages of the externality programs being implemented today, those that consider externalities only when choosing new resources, the net impact on overall electricity prices is going to be so small that such concerns are really second order and negligible. Over decades, however, such concerns will become important. I want to emphasize that fuel-shifting out of the electricity sector is a non-trivial problem that must eventually receive serious attention, if we are to meet our goal of improving the environment.

Methods of internalizing externalities

Attention at this conference will focus on addressing externalities through market mechanisms. Of course, it is not always appropriate to deal with externalities in this way. Direct regulatory restrictions in Commission rules may be sufficient, especially, as I shall argue, when it comes to externalities associated with diverse resources such as energy efficiency and renewables. Market mechanisms are appropriate when an externality, such as sulphur emissions, cannot be completely eliminated in a straightforward way by regulation.

I shall discuss two market mechanisms in this paper. Note that, although I shall not do so, direct regulatory restrictions on design or management of a resource could also be considered an extreme form of market mechanism, one where the price of not complying with the restrictions is set very high.

Method 1. Augment financial costs with environmental cost estimates when planning for resource acquisition

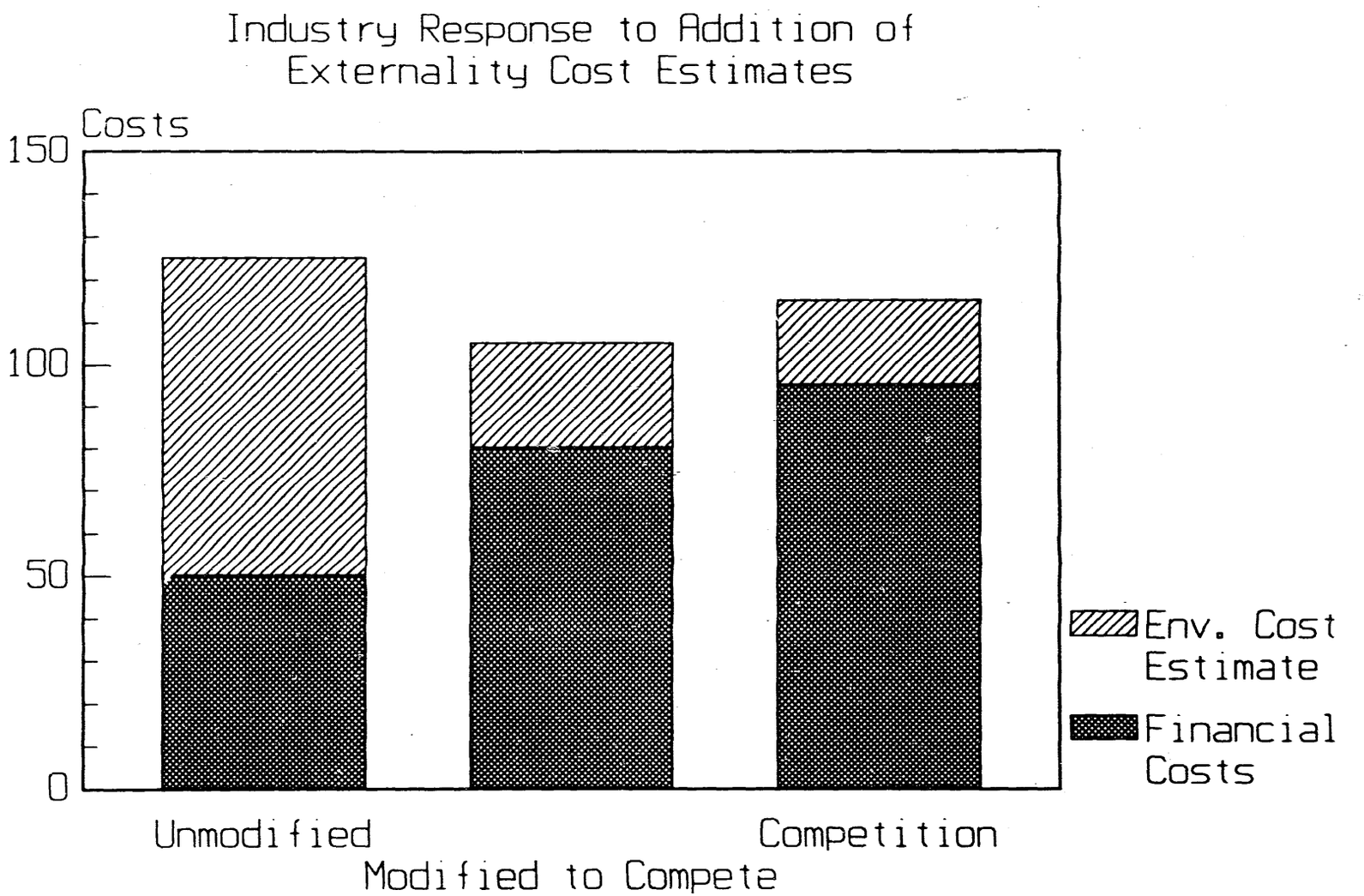
Currently, utility commissions accounting for external costs are making use of damage cost estimates to shift the economic balance between different resources at the resource planning stage. Traditional cost estimates for meeting projected demand are augmented with the assigned external cost and the sum used in meeting least-cost criteria for choosing electricity resources. It is useful to anticipate the impacts of introducing this method:

1) This approach reduces future environmental damage, not current damages. Cost increases will be introduced gradually. Eventually, as older plants are phased out, the full system will be operating with internalized environmental costs.

2) In the short term, if the assigned damage cost is high enough, it might shift the utility's next resource acquisition to a different technology. In case of energy efficiency measures, presumably a larger fraction of the efficiency portfolio would be used prior to building a new generator. In either case, there will be a reduction in the environmental impacts over what would have occurred in the absence of the externality program.

3) If the energy resource mix does shift, the direct price paid by consumers will increase, leading to an overall long-term consumption decline, and reduction in the utility's share of environmental damage. On the assumption that the damage from expenditures in other sectors is less than in the utility sector, the overall environmental burden will be reduced, because a shift in spending to those other sectors will cause less damage.

4) Rather than lead to a shift in resource mix, industry advocates may add greater controls to offset the relative decline in competitiveness of a traditional resource, such as coal. This will lead to a decrease in environmental damage. See Figure 1.


Industry Response to Addition of
Externality Cost Estimates
Costs
150
100
50
0
Unmodified
Competition
Modified to Compete
Env. Cost Estimate
Financial Costs

In summary, then, environmental improvements can result in at least three ways: directly through substitution of cleaner options, through dampening of overall demand as a result of increased utility bills, and through imposition of new controls to meet competition.

Method 2. Add environmental cost estimates to utility bills and return excess revenues to society as a whole.

A more direct approach than using damage cost estimates in choosing resources is assignment of a direct fee to be collected from the utility for each kilowatt hour generated in an amount proportional to the damage. This approach has the advantage that it will lead to immediate changes in the damage mix, as utilities shift towards environmental dispatching to reduce penalties and as consumers reduce demand in response to increased utility bills.

The revenues from such an approach could be used for further environmental protection, to stimulate development of cheaper alternatives, and to pay for the externalities program. Of course, consumer resistance would be higher because costs would rise faster.

Revenues could also be used for compensation to those injured by the damage. Equity considerations indicate that society should be compensated by polluters for the environmental damage they impose. Compensation should flow from those who use electricity to those who are most penalized by externalities.

Although compensation schemes make sense for that share of the damage associated with human illness or other human losses, paying humans for damage to wildlife has a bit of an "Alice-in-Wonderland" quality to it.

And what about compensating people who are damaged, but live outside of the Commission's boundaries? Transfer payments of this kind would no doubt generate intense opposition, certainly as long as neighboring states or countries did not have comparable programs.

There are huge uncertainties in assessing direct damage costs

The uncertainties are so large that the uncertainty range may be much larger than the estimates themselves. As a result, it may be difficult initially to defend estimates against legal challenge. To avoid some legal entanglements, it would be best to refer to these costs in regulations as "damage cost estimates," not "damage costs." On the other hand, the fact that uncertainties exist should not be taken as an excuse to do nothing about externalities. There are also great uncertainties in projecting other aspects of the planning process, such as

future energy prices, growth rates, and so on. As a consistent and reasonable externality methodology is developed, objections to the process should subside.

However, there are cases where the science is so weak that it is difficult to justify internalizing any risk at all. Drawing the line is a subjective judgement that can be made more scientific by polling experts. Experts are not always right, of course. In some cases, the public may be skeptical of experts, and it may make sense to externalize on the basis of stress alone or potential risk.

In some cases, there may be a confusing dispute among experts or there may be a lack of information that could be corrected by further scientific research. There is a dilemma here, however. Who gets the benefit of the doubt, while the research is being done? Does one allow the resource to be used, ignoring the potential externality until further research clarifies the reality of the damage? Or does one disallow the resource access into the portfolio, until more information is attained?. I argue below for the first approach in the case of fiberglass insulation and the second in the case of hydropower in remote wilderness areas. Such decisions are subjective and cannot be justified solely on the basis of technical analysis.

In some cases, alternatives could introduce environmental problems of comparable significance.

New energy sources may become more widely utilized as a result of an externality program. With these new energy sources comes the opportunity to implement them responsibly, i.e. with environmental concerns in mind from their inception. It doesn't matter that their impacts and/or risks will generally be less than that of coal and nuclear power. What matters is that their impacts can be significantly reduced by proper attention to their regulation and externalities. It would be a shame to throw away the full potential of internalization because of a naive belief that some energy sources are inherently benign.

Utility Commission staff seem to be very skeptical of this call for consistency. Part of the reason, no doubt, has to do with the severity of the problems associated with the energy sources we now use to make electricity. How can the alternatives fail to be better? Yet, some of the alternatives have gotten positive reputations solely because they come to attention on a very small scale.

I must confess that I get very blank stares when I bring this subject up with Commission staffers. I used to think I had bad breath or some other socially unacceptable odor problem when this happened, but I have since learned that there are other reasons for staff dismay. Some want to focus externality costing

efforts on criteria pollutants. Some are concerned that any mention of problems with alternatives will drive Commissions from taking any action at all. Nevertheless, those of us who spend our full time trying to protect the environment always end up struggling to control the new panacea, whether it be small hydropower or cattail farms. I know it's difficult to jump two steps ahead at a time, rather than one, but it will save us all a lot of headaches, if we take a consistent approach to externalities from the beginning.

Without some assessment of damage costs of alternatives and their environmental regulation, the large scale use of alternatives could backfire. On the other hand, it would be ridiculous to undertake a complex set of analysis of a technology that might never make it on a large scale and whose final form might not be anticipated.

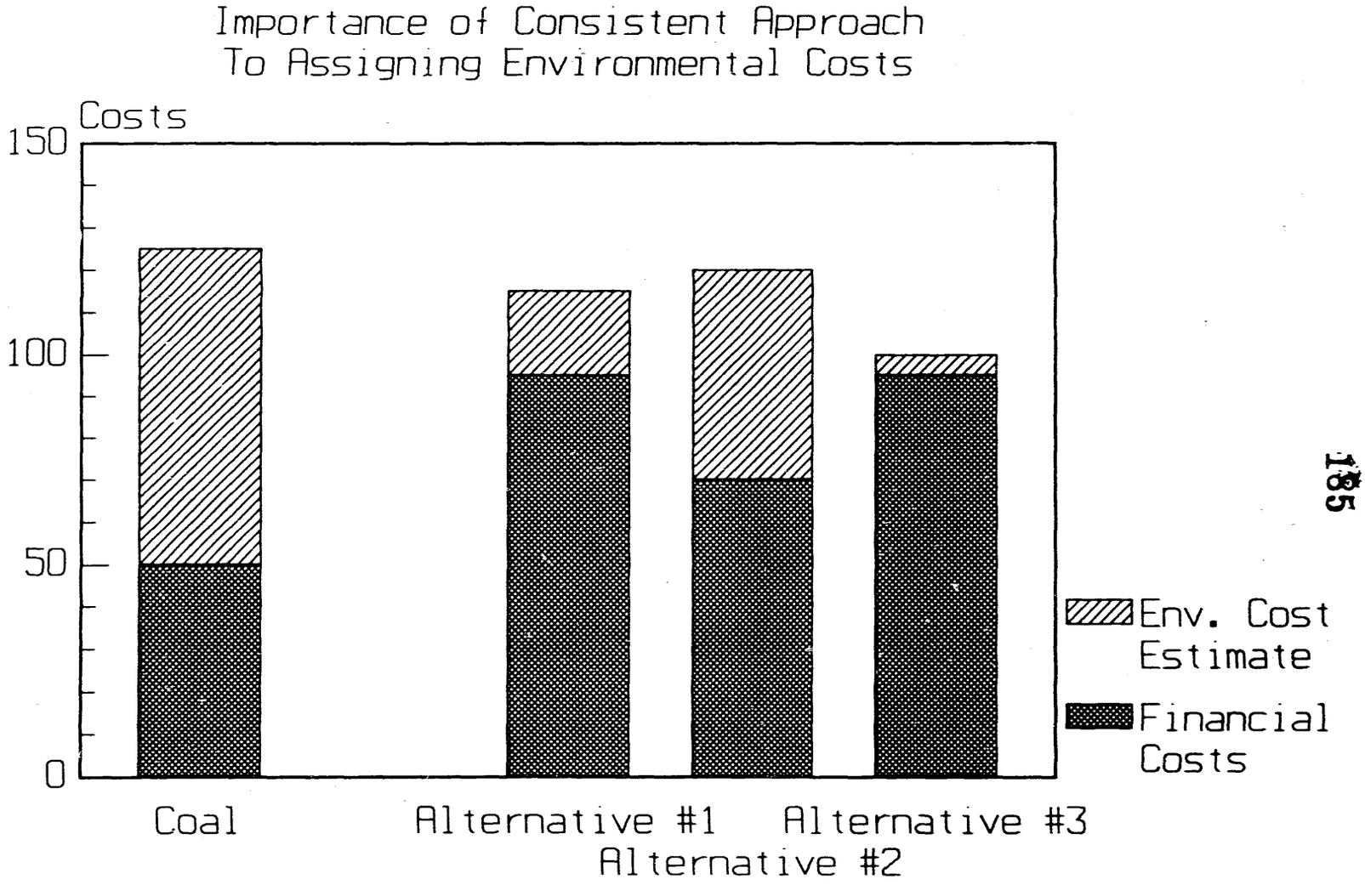
A reasonable way to address this problem is to assign externality damage cost based on present knowledge, energy mix, and estimates of likely alternatives. After the externality program is operating, the resulting resource shift can be assessed and research commissioned as appropriate into new damage assessment and appropriate control requirements.

All damage costs should be re-assessed on a regular basis anyway to incorporate new knowledge.

Need for consistency

Only a consistent approach will bring a real increase in environmental protection efficiency. A consistent approach will not only move us towards a more optimal mix of technologies, e.g., conservation vs. coal, but also move us towards more optimal versions of each technology. (See Figure 2.)

Example: In terms of climate change, consistency considerations suggest that natural gas be penalized for emission of unburned natural gas, a greenhouse gas itself, that occurs during production and transmission.


Importance of Consistent Approach
To Assigning Environmental Costs
Costs
150
100
50
0
Coal
Alternative #1
Alternative #2
Alternative #3
Env. Cost Estimate
Financial Costs

Special impacts that need to be recognized

Habitat destruction and wildlife damage from hydropower and biomass production should not be ignored in externality programs. I highlight these issues, because they have not gotten sufficient attention in past analyses of externalities. Yet, there is a fairly large body of knowledge developed as part of river regulation that could be used to assign damage cost estimates.

Upstream pollution embedded in material

If damage costs are assessed for pollutant emissions, the emissions in the production of materials used in energy facilities (steel in nuclear plants, wind turbines, etc.) should also be assessed. This is particularly important for renewable technologies, where such emissions may dominate the total environmental impact. As computer codes become available for accounting for such upstream emissions (e.g., the German GEMIS code), it will be rather straightforward for Commission staff to determine whether upstream effects are significant and need to be taken into account.

Methods of assigning costs

In this paper, I shall refer to four methods of assigning damage cost estimates.[1]

Use of damage function

In the case of emissions of sulfur dioxide, dioxin, radioactive isotopes, and miscellaneous other carcinogens, it may be possible to extract from the literature a mean estimate of a damage function, along with a reasonable uncertainty estimate. If one has an accompanying value for the damage, e.g., lost wages from sickness or an assigned dollar penalty for each life, it is possible to directly calculate the damage cost.

Use of control costs

Alternatively, one can roughly estimate the value assigned by society to negating emissions by looking at the controls that are implemented on particular pollutants and their costs per unit of controlled pollution. Although this type of assessment does not give one the marginal value of controls, it presumably is in the right ball park.

---

1 See: R. Ottinger, D. Wooley, N. Robinson, D. Hodas, S. Babb, S. Buchannan, P. Chernic, E. Krupnick, Uwe Fritsche, The Environmental Cost of Electricity, Oceana Press, Dobbs Ferry, 1990

Revealed preference

Sometimes it is possible to infer a value from other actions. For instance, if property values are lower around a particular facility, it can be inferred that the damage in the vicinity is assigned a negative value equal to the loss in property values.

Polling

Finally, in particularly difficult cases, it may be appropriate to simply poll a sample of the public, asking them how much each would pay to avoid certain impacts (or how much compensation should be paid for imposing a risk or environmental injury). Although there will clearly be a difference between what people say they will pay, or want in compensation, and what they would actually pay, or want, the average of such polls may be the best method for approximating social benefits in the absence of the previous three methods. Consider the great difficulties involved in estimating dollar costs of nuclear accidents. Uncertainties of accident probabilities is so great that the resulting damage estimates are so broad as to be relatively useless in an externality program. On the other hand, simply asking a sample of people how much more they would be willing to pay on their electricity bill to have no nuclear plants within 100 miles would be rather useful. It would give a reasonable estimate of the disbenefits that are perceived from the stress of living near a facility of such uncertain safety.

Need for updates

Whatever method is chosen, there must be provisions for regular updates to accommodate new knowledge.

Assessment of each energy source and appropriate regulatory response

In the sections below, the major environmental problems associated with a variety of electricity sources and demand side management techniques are listed. Also included are recommendations as to how to address each problem, whether it be to penalize the resource in proportion to its inflicted damage, whether to restrict the versions or management of the technology that will be allowed in the portfolio, or whether to pursue research before further action is taken.

At the end of this material, a Summary Table is presented, which, in addition to tabulating the recommendations on appropriate regulatory responses, lists possible methods to use in estimating environmental costs.

Fossil fuels: coal, oil, and gas.

We are all very familiar with the damage caused by fossil fuels, e.g., oil spills and other forms of water pollution, acid rain, refinery air pollution, land impacts, and potential climate change. Less familiar impacts include the environmental changes wrought by the inland infrastructure associated with exploration, production, and refining.

There is a general hierarchy that is almost always found in terms of environmental impacts: coal is the worst, with oil next, and natural gas least harmful. (Estimates in the literature showing that coal's damage costs equal the normal financial costs do not surprise me.[2])

Energy efficiency

In most cases, energy efficiency is the most environmentally benign way to provide energy services. However, there are certain efficiency strategies where program restrictions should be imposed to eliminate negative impacts, particularly in the area of indoor air pollution.

Indoor air pollution

The biggest potential problem associated with efficiency is the increases in indoor air pollution that can be associated with tighter buildings. However, buildings with reduced air-quality need not be a part of our efficiency strategy. Such conservation measures only contribute to a small part of the overall efficiency potential.

The possibility of using energy efficiency retrofit programs as an opportunity to identify homes with indoor air problems has been recognized by several authors as a way of actually reducing net risks from indoor air pollution.[3] In fact, an energy efficiency program may be the only chance of identifying problem homes on a large scale. Recommendations to home owners and building managers as to how to correct the identified problems could lead to a large reduction in the societal risk from indoor air.

Greenhouse gases in insulation

Some building insulation material contains gases, such as HCFCs, that impact the ozone layer and the global heat balance. If coal plants are being assessed for carbon dioxide

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2 Ottinger et al., op. cit.

3 Many years ago, Anthony Nero of Lawrence Berkeley Laboratory suggested this approach for dealing with Radon. See Also Ottinger et al.

emissions, demand side management programs using such insulation should be assessed at the same rate per unit of CO-2 equivalent. This is likely to turn out to be a small effect, now that insulation manufacturers are moving away from the more serious CFCs, but analysis should be made of the insulation that is to be used in any demand side program.

An alternate response to financially penalizing insulation made with these gases is to simply ban use of such insulation in a utility conservation program.

Fiberglass health effects

There is some concern that fiberglass insulation may pose a risk to the lungs. However, the indications for this are not sufficiently established to justify a halt to the use of fiberglass insulation, nor is the scientific data complete enough to allow a damage cost estimate to be made. Here is an area where further research could be useful in resolving a lingering concern.

Residential solar

It is possible that some utilities may get involved in supporting residential solar hot water heaters as part of their demand side management options. Environmental problems associated with this form of solar technology are very small and would include emissions during production of the collectors. In the future, residential photovoltaics may be an electricity demand management technology supported by utilities. Here the impacts are of greater concern, because the emissions during production can be more severe and because of the risk of fires and subsequent release of toxics. A combination of management restrictions and penalties should be applied to photovoltaic technologies. The risk of fires can be addressed, as can the nature of the materials allowed in the residential collectors in the first place. I am not claiming that the risks of photovoltaics are anywhere near comparable to the risks of generating electricity from coal. In fact, I am a strong advocate of this technology, popping up solar-powered calculators during television interviews at an obnoxious rate. What I am claiming is that attention to the residual risks that do exist will ensure we get the full environmental potential from this promising technology.

Waste-to-energy facilities

Air pollution problems include emissions of criteria pollutants, carbon dioxide, heavy metals, hydrochloric acid, dioxins, and miscellaneous carcinogens. It is also necessary to worry

about near-toxic ash containing heavy metals that are more easily mobilized than if the original trash had been placed into a landfill.

The uncertainty and controversy of the health risks from incinerators leads to stress in populations living near them. Such stress should be accounted for in externality programs in terms of risk.

The management restrictions available for utility commissions to impose on such facilities to eliminate externalities are limited. Only state and federal regulators can keep the material out of the waste stream that causes many of the problems with incineration. A proportional penalty approach seems the most appropriate response at this time.

Nuclear

The litany of risks associated with nuclear power are well known: routine releases, risk of accidents, escape of radioactive waste, risk of faster proliferation of nuclear weapons. The stress of living with the uncertainty from nuclear risks is a real problem and needs to be recognized in externality accounting.

Conventional

Despite the well-known problems of nuclear power, it does have one advantage over coal. It emits no direct greenhouse gases and little is emitted indirectly during the mining and transportation of the fuel, but the current technology has lost so much credibility that it is unlikely to be a viable alternative, even in a world concerned about global warming. Much of the externalities associated with nuclear power have to do with large, low-probability risks. In the current economic and political climate, utility commissions considering externalities for new plants are not going to have to set policy for costing nuclear externalities. No plants will be put forward. If, on the other hand, conventional nuclear does make a come-back, commissions will not be able to avoid a decision on how to assess the externality costs of risks.

Management restrictions to eliminate risks open to a utility regulator are minimal, although there are some significant ones. For instance, the risk of catastrophic accidents at on-site spent fuel storage facilities can be eliminated by requiring dry cement casks, rather than water storage pools. Nevertheless, the major externalities associated with conventional nuclear power are going to have to be dealt with by penalizing nuclear facilities in proportion to a damage cost estimate.

Second generation

There is the possibility of developing new designs of nuclear power that are meltdown free. Research into them should be started, but we must recognize that they do not address other problems and other public concerns. They do not address the transportation of radioactive materials. They do not address their disposal. They do not address the proliferation of weapons grade material. Furthermore, it is questionable that the new designs can compete economically with other methods for avoiding carbon dioxide emissions, especially if they are really built to reassure the public on safety and quality assurance.

It is important to mention that successful demonstration of idiot-proof reactors is decades off, if it should prove possible at all. And then, acceptance is still problematical. The battle ground of the nuclear debate will shift. Local communities will be skeptical that an actual plant will be built to the same standards as the demonstration plants. They will be unhappy with the fact that small releases will still be possible. They will be unhappy that radioactive waste will have to be stored at the reactor, to be transported through the community to waste repositories in which few people will have any confidence.

Thus, the prospects of a Commission having to reach a decision on externality costs associated with second generation reactors in the next decade is vanishingly small.

Solar technologies

Now we will turn to some of the non-residential solar-related technologies. All of them listed in Table 1 derive their potential power at some point from the sun. (Wind, for instance, arises from unequal heating of the earth by solar energy.) The success of technologies like wind turbines has shown that such alternatives can make a real contribution to the U.S. energy supply under the right regulatory climate. However, there is no free lunch when it comes to energy sources, so care must be exercised even with solar technologies.

As discussed under residential solar, a combination of management restrictions and penalties proportional to damage cost estimates should be applied to utility solar in order to shift the technology towards versions with the least social cost.

Solar thermal

On the supply side, one of the most promising options from the environmental perspective is solar electricity. It can be derived from steam produced by high temperature solar heat, assisted by the burning of natural gas.

Photovoltaics

The "hottest" form of solar electricity today is that which is produced directly when sunlight hits photovoltaic cells. The costs of these cells have been dropping dramatically, with the potential for producing electricity at costs well below that of nuclear power. Expanding research into photovoltaics would seem to be the most important energy research step that can be taken for the long term. Replacing electricity fossil fuel units would be a massive job, requiring the laying down of collectors on an area of the U.S., perhaps one-third the size of the interstate highway system, or 2% of U.S. farmland, an equivalent area. We are talking engineering projects so vast that engineers would kill to be a part of them.

Although land use of this magnitude will raise eyebrows, the other advantages of solar will ensure its widespread public acceptance. In fact, development of photovoltaic cells may represent the most politically viable way of solving the bulk of our externality problems and forestalling massive climate change in the next century. If high-quality land is kept off-limits to photovoltaics through regulation by Commissions, the major problem with this technology will have been solved. Emissions from production can be handled by restriction on the nature of the cells that will be acceptable to Commissions as well as by assigning damage cost estimates to the emitted pollutants.

Environmental problems from photovoltaic technology will be significant, but nothing compared to the problems that would arise from use of fossil fuels. Pollution from the production of the solar cells will be a problem, as will use of herbicides to keep solar arrays free of vegetation. Cleaning of the arrays will lead to water pollution.

Hydropower

Hydro in moderation is fine, but too much is a disaster. We have all too few crucial sites left for wildlife and river recreation. The natural flow of rivers is essential to ecosystems. For instance in the spring when ice melts, the resulting rush carries much-needed nutrients for wildlife far and wide. Dams change the natural rhythms by regulating the flow.

By the way, even small hydro can be a problem because it requires so many dams to make the electrical equivalent of a large dam.

There is a hydro option that needs consideration, so-called, "run of the river" turbines - which operate during peak flows only. It is not the turbines themselves that cause environmental problems, but the flooding of land from dams and the smoothing out of the natural flows. Therefore, by generating electricity

in phase with the natural flows (which does not require the construction of a large dam), we can eliminate the greatest problems with hydropower. Although run-of-the-river systems are more expensive, they do offer hope that hydropower can help offset global warming, without causing major damage to natural ecosystems and the creatures that depend on them.

Assigning costs to hydropower habitat destruction

Damage costs can be assigned to flooded lands using the "revealed preference" or polling techniques discussed earlier. Another possibility would be to directly estimate the value of the land lost by multiplying land values in the area with a wildlife density factor and a habitat uniqueness factor.

It is very important to penalize hydropower to the extent it reduces variability of flow. One method might be:

1) assume that total loss of flow variability results in 100% loss of riverine habitat acreage.
2) Multiply acreage by a wildlife density factor to properly value the importance of riverine habitat.
3) Multiply by a factor that takes into account the uniqueness of the habitat for critical species.
4) Finally multiply by typical land values in the area.

Obviously, such a calculation will give appropriate preference to run-of-the-river systems.

James Bay in Canada, an example of special problems with hydropower

Increased imports of electricity from Quebec into the Northeast would mean new dams in the northern Quebec wilderness and potentially disastrous consequences on James Bay, a rich area for wildlife.[4] As I have said, hydropower in moderation is a wonderful energy source. Pushed too far in any one region, it can be ecologically destructive.

Will the ecosystem of James Bay be overloaded? HydroQuebec, the provincially-chartered utility, does not think so. It already generates 10,000 megawatts of power from huge dams and reservoirs. Only full-scale studies of the cumulative impacts of HydroQuebec's long range plans will settle the question.

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4 J. Beyea, J. Rosenthal, J. Hansell, "Long-Term Threats to James Bay from Hydroelectric Development," Information North (Newsletter of the Arctic Institute of North America), University of Calgary, Alberta, Sept. 1990.

The argument made against long-range environmental assessment and planning is that each new dam is only a small fraction of the total built so far, so the latest dam can't be that bad. This refusal to look ahead to the final results is reminiscent of past U.S. approaches to the environment. It allows a society to ignore the gradual deterioration of much of its natural resources. Decades of small losses inevitably lead to disaster. Then the argument becomes, "well, the damage has been done, so the next dam won't make things much worse." I, and other environmentalists, worry that 50 years from now the five out of six rivers entering James Bay will be dammed and the natural timing of water that maintains the ecosystem of plankton, marsh grasses, fish, insects, mammals and birds will be forever altered.

What should be the appropriate regulatory response? Because of the uncertainty that exists about the long-term impact of HydroQuebec's plans, I argue that, we need to look ahead now at all the plans on the drawing board and assess the cumulative impact before going forward with any new U.S. contracts.

In addition to protecting local and migratory wildlife, there are two other issues: the cultural survival of native peoples and the protection of wilderness for its own sake. Although the U.S. can hardly lecture Quebec about any of these issues, we can restrict our own appetite for imports through administrative and legislative action, while these disputes are being resolved. We can join with those in Quebec who are asking for proper studies, so that policy makers will have an idea of whether the area can stand any further development, and if so, how much.

Delaying the purchase of cheaper electricity out of concern for environmental risk is a way of internalizing those environmental risks. Presumably, electricity costs will be higher than they would be otherwise. By gaining more scientific information, the uncertainty in any risk estimates will be narrowed.

Biomass

Biomass refers to biological matter that contains stored energy. Consider trees and plants, which collect sunshine and use it, along with CO-2 extracted from the atmosphere, to build up biological molecules, storing energy in the process. The stored energy can be extracted from these molecules for human use. (Note that biomass also includes living matter that eats plants or other living things. With very rare exceptions, all of the energy in biological systems can be traced back along the food chain to solar energy.)

Biomass externalities include air pollution from combustion, particularly benzo-a-pyrene and similar carcinogens from wood-burning. Land use impacts and habitat loss are also important externalities.

Although biomass produces CO-2 when consumed for energy purposes, the next crop absorbs CO-2 back from the air. Equilibrium results when the next crop stores as much biomass as did the original. In contrast, should a forest be cut down and replaced with corn or short crops, the difference in biomass appears in the atmosphere as CO-2.[5]

Once equilibrium is reached with biomass, it is an energy source that does not contribute to global climate disruption. As a result, some analysts are projecting massive reliance on this energy source, not just for transportation, but for electricity production as well.[6] The problem is that too great reliance on this energy source could have disastrous environmental impacts on land and habitat, unless agricultural and silvicultural practices are radically changed. Suppose, for example, the current U.S. transportation fleet were powered by alcohol. It could take 300 million acres of land to grow the necessary crops and wood.[7] This is an area equivalent to our current crop base and would seriously impinge on our entire agricultural and silvicultural resource. The pressure to build so-called "biomass farms" for both transportation and electricity fuel would be enormous. If not properly designed, biomass farms could eliminate much of the wildlife habitat in the U.S. and put equivalent stress on the environment in other countries. Environmental biomass plantations should be designed to provide biological diversity that will allow wildlife to survive. "New forestry" techniques offer a management response to utility Commissions that can preserve habitat[8]. Believe me when I say that concern about this technology is not an imaginary problem. The prospects for biotechnology

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5 In considering the net climate impacts of changing land practices, it is necessary to consider the changes in surface reflectivity that occur, as well as the changes in stored biomass, above and below ground.

6 Congresswoman Claudine Schneider, letter to the Editor of the New York Times, December 27, 1989.

7 J. Beyea, K. Keeler, "Biotechnological Advances in Biomass Energy and Chemicals Production: Impacts on Wildlife and Habitat", Critical Reviews of Biotechnology, forthcoming.

8 J. Cook, J. Beyea, K. Keeler, "Potential Impacts of Large-Scale Biomass Production on Biodiversity and Wildlife Habitat," in preparation.

lowering biomass costs is so great[9] that more and more utilities are going to have to deal with the environmental externalities from biomass in the decade ahead. No utility should be cutting wood from a forest that does not have a forestry plan that is approved by state wildlife agencies and that is designed to protect biodiversity. Attention should not be restricted to endangered species or game species.

Externality costs can be assigned to biomass habitat destruction, by first establishing guidelines for acceptable forestry practices and assuming the habitat is lost, if guidelines not followed. If assumed lost, the resource would be charged according to the revealed preference or polling method. Alternatively, an approach similar to that discussed above for hydropower could be used.

Standard methods of assigning costs to pollution emissions can be followed for biomass pollutants studied for other energy sources. What about the carcinogenic emissions that are important sources of risk from biomass combustion? Although to my knowledge no analyst has made such calculations for benzo-a-pyrene, there is no reason why techniques used to assess health risks from nuclear or coal pollutants can't be used. (It would be useful to do this as a function of control levels.) This may be an important area for research by the federal government or one of our larger states.

Geothermal

Geothermal energy is obtained from hot waters deep underground. The waters are heated as a result of radioactive decay deep in the earth. The practical potential for long-term replacement of fossil fuels by this technology is not well-known. However, the world's geothermal energy base is very large, comparable to the world's coal resource base.[10] Most U.S. geothermal energy facilities are in California. Its use elsewhere in the United States will depend on the price of competing fuels. To avoid environmental contamination, geothermal water should be reinjected, after the heat has been extracted, into the underground layers from which it was originally pumped. Otherwise, the chemicals in such waters will contaminate surface water systems.

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9 Beyea and Keeler, op. cit.

10 J.W. Tester, D.W. Brown, R.M. Potter, "The Potential for Geothermal Energy," in Proceedings of the Second North American Conference on Preparing for Climate Change, Climate Institute, Washington, 1988, p. 614.

Earthquake risk from dry rock geothermal

This is a risk from an energy source that is speculative, so it can be safely relegated to the research stage.

Tables

The following Table indicates the major environmental problems associated with each energy source and the methods that might be used by a utility Commission to deal with those problems. The listed methods include 1) management or design restrictions on a resource, 2) penalties in proportion to damage cost estimates, and 3) further research. Also included in the Table is a column on possible accounting methods that would be appropriate for estimating the damage cost associated with each impact.

Table 1. Appropriate Regulatory Response to the Environmental Impacts of Individual Energy Sources

Energy Resource	Environmental Impact	Appropriate Regulatory Response	Possible Costing Method
Energy efficiency.	Indoor air pollution.	M[a]	NA
	Climate-changing gases used in foam insulation	P,M[b]	Use equivalence to CO-2
	Fiberglass health effects	R[c]	NA
Natural gas	NOX, CO-2	P	Control costs
	Risks of Accidents at LNG facilities	P	Revealed pref. or polling
	Infrastructure impacts associated with exploration and production	P	"
Oil	SOX, NOX, CO-2	P	Control & "offset" costs
	Toxics from refining	P	Damage function
	Oil spills	P	Assign clean up costs known per gallon for large spills to uncleaned spills
	Infrastructure impacts associated with exploration and production	P	Revealed pref., polling
	Inland & coastal infrastructure impacts associated with refining	P	"
Coal	SOX,NOX, CO-2	P	Control & offset costs
	Misc. carcinogens, mutagens, etc.	P	Damage function
	Land use damage	P	Revealed pref., polling

Notes: M=Management or Design Restrictions on Resource, P=Penalty in Proportion to Damage Cost Estimate, R=Research, NA=Not Applicable
a) Include indoor air quality assessment programs in all programs that install energy efficiency measures.
b) Disallow use of CFC-containing insulation.
c) Because the health effects of fiberglass are speculative, research is the appropriate response.

Table 1 (Con't). Appropriate Regulatory Response to the Environmental Impacts of Individual Energy Sources

ENERGY RESOURCE	Environmental Impact	Appropriate Regulatory Response	Possible Costing Method
Incineration of wastes	SOX,NOX,CO-2	P	Control & offset costs
	Increased mobility of heavy metals in ash	P	Control cost, damage function
	Dioxin	P	Damage function
	Airborne heavy metals	P	"
	Hydrochloric acid	P	Control costs, once standards finalized
	Stress	P	Revealed pref., polling
Conventional nuclear	Routine emissions	P	Damage function
	Risk of reactor accidents	P	Revealed pref., polling
	Risk of spent fuel accidents	M[a)]	NA
	Future risk from nuclear waste releases	P	Damage function
	Radon from mill tailings	P	"
	Risk of weapons proliferation	M[b)]	NA
Idiot-proof nuclear	Same as Above	R[c)]	
Wet geothermal	Water pollution.	M[d)]	NA
Dry geothermal	Risk of earthquakes	R	NA

Notes: P=Penalty in Proportion to Damage Cost Estimate, M=Management or Design Restrictions on Resource, R=Research, NA=Not Applicable.
a) Require cask storage rather than spent fuel storage on site.
b) The link between domestic nuclear power and proliferation is difficult to quantify.
c) Presumably, the cost assigned to accident risk will be much lower than for conventional nuclear power plants.
d) Require re-injection of extracted waters.

Table 1 (Con't). Appropriate Regulatory Response to the Environmental Impacts of Individual Energy Sources

ENERGY RESOURCE	Environmental Impact	Appropriate Regulatory Response	Possible Costing Method
Photovoltaics, solar thermal.	Change in land use values (e.g. wildlife) not included in price of land.	P,M[a)]	Revealed pref., polling
	Pollution during production of materials.	P	Control costs, damage function
	Herbicides	P	Damage function, polling
Utility- supported residential solar	Pollution during manufacture	P	Damage function
	Risks of fire	M[b)],P	"
Biomass (solar energy Collected in the Form of biological material).	CO, NOX	P	Control costs
	Benzo-a-pyrene & other complex organics	P	Damage function
	Destruction of habitat and loss of biological diversity.	M[c)]	NA
Wind	Aesthetic.	P	Revealed pref., polling
	Noise.	P	"
	Wildlife collisions	P	"
Hydro (big and small)	Direct loss of habitat	P	Land values X wildlife density factor X uniqueness factor
	Indirect loss of habitat through loss of natural flow variability and sediment	P	See text
Run-of-river hydro	Direct loss of habitat	P	See above

Notes: P=Penalty in Proportion to Damage Cost Estimate, M=Management or Design Restrictions on Resource, R=Research, NA=Not Applicable.
a) Exclude land for photovoltaics that is currently of special environmental value.
b) Restrict utility-supported photovoltaics to materials with low toxics. Require designs that do not get hot enough to catch fire.
c) Require forest-management plans that respect biodiversity.

WHY WE NEED AN ENVIRONMENTAL TRUST FUND

NARUC National Conference on
Environmental Externalities

October 2, 1990
Jackson Hole, WY

Presented by David H. Moskovitz
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Designing a regulatory mechanism that gets us where we want to go requires that we know where it is we are going and why.

There are three reasons for considering environmental externalities:

1) There are environmental costs associated with the production and consumption of electricity, which, if hidden from consumers, will lead to poor decision-making.

2) Electricity production and consumption produces environmental costs which, if hidden from utilities, will lead to the acquisition of the wrong resources.

3) There are environmental costs associated with the operation of power plants, which if hidden from utilities, will result in the wrong plants being run.

Methods of incorporating environmental externalities should be judged by how well they address these three concerns.

Of course, there are other externalities that people may also wish to take into account. The most obvious relates to the costs associated with protecting the oil we use to fuel our economy. Operation "Desert Shield" isn't the first time our armed forces have gone into action to defend the free flow of oil. During physical years 1985-86, the United States spent $47 billion escorting tankers through and clearing mines from the Persian Gulf. Had this cost been borne by the oil companies whose oil was being protected, oil would have cost $450 per barrel. Current military exercises in the Mideast have already run in excess of $2 billion and the estimates are rising faster than the cost of oil. But, the subject of this paper is environmental externalities, not the mideast crisis.

The efforts of the states and NARUC to incorporate environmental externalities in the least-cost planning decision-making process is commendable. Nothing should detract from the efforts that have been made thus far, or the continuing efforts to incorporate environmental externalities in the states that are now considering the issue. Nevertheless, the strength of NARUC is that each member can learn from others and is free to implement desired programs in new and more potent ways.

The measures taken by states to date are but a tiny first step. Only a small part of the reasons why people want environmental externalities considered are being addressed today.

Generally, the states have adopted what can be called shadow pricing systems. Under these approaches, environmental costs are assigned to alternative <u>new</u> supply- and demand-side resources. These costs are then considered when deciding which new resources to add to the system.

For example, we might have a competitive bidding system such as New York's, which imposes a $0.015 environmental cost on coal-fired facilities, $0.01 per kilowatt hour on oil-fired facilities, $0.005 per kilowatt hour on natural gas-fired facilities, and finally zero on demand-side options. The following table shows several different scenarios under a New York type of process.

RESOURCE OPTIONS	CASE 1	CASE 2	CASE 3
COAL			
BID PRICE	5.0	5.1	5.0
ENV. COST	1.5	1.5	1.5
TOTAL PRICE	6.5	6.6	6.5
GAS			
BID PRICE	6.0	6.0	6.1
ENV. COST	0.5	0.5	0.5
TOTAL PRICE	6.5	6.5	6.6
ENERGY EFFICIENCY			
BID PRICE	6.4	6.6	6.6
ENV. COST	0.0	0.0	0.0
TOTAL PRICE	6.4	6.6	6.6
WINNER/COST TO CONSUMERS	DSM 6.4	GAS 6.0	COAL 5.5

This table shows conservation winning the bid under Case 1; under Case 2, the gas-fired facility wins; and, under Case 3, the coal-fired facility wins. The bottom line is the important one: it shows that if conservation wins, consumers will pay $0.015 more per incremental kilowatt hour acquired through DSM resources than they would have, had the same resource been acquired through a coal-fired facility. However, as illustrated by Cases 2 and 3, if either supply-side resource wins, the resource cost to consumers is equal to the facilities' bid price, which does not include the environmental costs associated with the resource.

One can generalize from these scenarios that if supply-side resources win, they are added to the system at their actual direct cost, which does not incorporate the environmental externalities associated with the added resources. Prices are increased to cover the difference between the environmental costs of the dirtiest resource and the resource selected.

Clearly, this approach does not fully satisfy the goal of reflecting environmental costs in consumers prices. We have accomplished the goal of reflecting environmental costs when deciding which new resource the utility selects. In total we have satisfied perhaps 1.25 of the three goals stated at the outset.

Incorporating environmental externalities in decision-making for the acquisition of new resources may seem like the most important first step if you view the operation of existing plants as a sunk cost. But is it?

The environmental damage currently borne by the population is due to the operation of existing facilities; it has nothing to do with the operation of new facilities. Yet, environmental externalities as currently being pursued rarely, if ever, applies to existing facilities.

Let me take a few minutes and share with you some of the typical emission data for existing oil-fired facilities in New England, and selected data for new supply resources.

The following chart shows the environmental emissions of the proposed and existing facilities.

PLANT TYPE	SO2 (LBS/ MWH)	NOx (LBS/ MWH)	COMBINED (SOx, NOx)
OIL 2.5% S	31	4	35
1.5% S	19	4	23
0.3% S	4	4	8
NEPOOL MARGIN	12	5	17
GAS	0	2.6	2.6
BIOMASS	0	8.5	8.5
NEW COAL	3.5	5.9	9.4
COAL CFB (AES)	2	.8	2.8

As you see, on an emission-per-kilowatt hour basis, any of the new facilities is far better than the operation of the existing facilities.

Adding SOx and NOx together shows that for new supply resources, air emissions range from 9.4 to 2.6 pounds per megawatt hour compared to as much as 35 pounds per megawatt hour for existing facilities. Oddly enough, if new, unneeded facilities are added to displace the operation of existing facilities, air pollution emissions decline substantially.

Under a scheme such as New York's, the relative environmental costs suggest that we are prepared to pay an additional 1 cent (10 mills) to save roughly 7 pounds per megawatt hour of emissions. Compare this result with switching from high-sulfur oil to low-sulfur oil, or imposing environmental dispatch so the cleanest plant is run first rather than the cheapest. Typically, the running costs of a low-sulfur oil plant is 2 to 5 mills per kilowatt hour more than the costs of a high-sulfur plant. Thus, if we are prepared to pay 10 mills more to acquire the new resource that emits 7 lbs. less air pollution, it seems that we ought to be more than happy to pay less than half that much and save 3 to 4 times (20 - 27 lbs.) as much pollution!

The significant gap between our goals and the current treatment of environmental externalities suggests new approaches are needed. The one I like best combines the creation of an Environmental Trust Fund with the work done thus far on quantifying the environmental costs of each pound and each type of pollutant. Under such an approach we would assess environmental costs on both new and existing facilities. The assessment would be phased in over time and would ultimately equal the cost of the environmental damage caused by the relative emissions from all facilities. Payments would be made to the fund on the basis of actual annual or monthly emission.

Assessing the costs results in several important improvements. First, collecting the payment means that if a particular resource is selected, the cost of that resource to consumers is the bid price plus the reasonable environmental costs associated with the operations of the particular facility. Second, assessing the charge to new and existing facilities recognizes that pollution from existing facilities is as important as pollution from new facilities. Finally, assessing the charge on the basis of actual

plant operation means that environmental costs will be considered in dispatch decisions.

In short all three of the goals will be addressed.

The most attractive aspect of such an Environmental Trust Fund is not that it meets all three of the original goals. Rather, it is the far-reaching social, political, and institutional implications of a well-endowed and properly directed fund.

Let's start with the size of the fund. Clearly, the assessed costs will not simply add to the utility's revenues. Instead, funds will be deposited in a special Environmental Trust Fund. Currently, electricity sales in the U.S. are about 2,500,000 million kilowatt hours. Roughly 60-70% of the electricity sold is produced by coal-fired facilities. Assuming an average cost of environmental externalities at $0.005 a kilowatt hour, an environmental trust fund would accumulate about $12.5 billion a year.

$12.5 billion is roughly 600 times EPRI's annual R&D budget for energy efficiency improvements and almost 100 times the energy efficiency budget of the U.S. Department of Energy.

What will the purpose of the Environmental Trust Fund be? The Environmental Trust Fund will be a dedicated fund used for environmental mitigation, environmental redress, research and development into resources that reduce pollution, including renewables and energy efficiency, and public education on energy and environmental costs.

The most interesting questions to ponder are what institutional and political changes will follow from the creation of such a well-financed and independent Environmental Trust Fund. Consider the change that has been brought about by PURPA. When it was originally passed, qualifying facilities were expected to fill only a small market niche. Today the annual capacity additions of Qualifying Facilities (QF's) exceed utility additions. The birth of the QF industry has changed the entire fabric of the industry. Clearly, the Environmental Trust Fund can be at least as powerful an engine for change.

Is it practical? Obviously no one in the U.S. or any other country for that matter, likes government taxes, and the pollution assessments will look like a tax. Still, polling in this country says that consumers

would be willing to pay higher prices if it results a cleaner environment. In depth polling says, on the average, consumers will pay 6.6% more for energy if it leads to a cleaner environment.

Experience in Europe and the Scandinavian countries show that green taxes are widely accepted by the population if the public understands that the funds will be used to actually improve the environment. Simply having higher energy taxes and using the taxes to pay the federal deficit will not likely receive the level of public support that would be needed.

The creation of an Environmental Trust Fund is one way to begin the process of moving toward energy priced to reflect what would be needed to assure a cleaner, safer and sustainable environment.

PROPER PRICE SIGNALS: THE CASE FOR REFLECTING EXTERNALITIES IN UTILITY RATES

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NARUC Environmental Externalities Conference
Jackson Hole, Wyoming
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As a general proposition, proper pricing of utility energy products is honored more in the breach than the observance. As a result, and also as a general proposition, energy is underpriced. More of it is consumed and hence more scarce resources are devoted to its production than is wise. Increasingly, external cost are being recognized and accounted for in utilities' resource planning. Relatively uncharted is the issue of external costs being reflected in rates to consumers.

This paper makes the case for having externalities reflected in utility rates, not by complete internalization which while ideal may be unrealistic and therefore unachievable but by a method that simulates the outcome sought when all social costs are internalized and correct price signals transmitted.

Most thoughtful observers are in favor of setting prices right. But many then assert that once prices are right there remains more fish to be fried; that the job of ensuring proper levels of energy consumption will remain undone and that it must therefore be tackled with unremitting and expanding programmatic efforts. Given consumers' notoriously high discount rates, it probably is unrealistic to rely on prices alone to do the job. But pricing may be the most cost-effective and least appreciated way to achieve appropriate levels of energy use.

Because it is relatively simple and unglamorous, the pricing mechanism is often given short shrift. After all, setting utility prices at proper levels does not involve adoption of large budget expenditures or establishment of battalions of apparatchiks. It does not require creation of government and utility bureaucracies for enforcement, implementation and evaluation. It does not entail development of a numbing array of programs or cultivation of special-interest constituencies looking to obtain and then maintain tax subsidies and other benefactions.

In short, proper prices alone allow concerned folk to sit back and watch, no more. That is a positively disagreeable prospect for those who feel that in the absence of persistent scolding and interference, the world will go to hell in a handbasket; that expensive and complex programs that so far, quite frankly, have not yielded credible results are superior to cheap and simple solutions that have worked marvelously and unexpectedly well.

There is an instinctive desire by many to see large programmatic efforts launched and, once launched, perpetuated. That is especially so if progress in conservation is measured not by units of energy saved, which is what counts, but by dollars spent, programs offered, workers employed, regulations promulgated, infrastructures erected, bureaucrats assembled and conferences held. My guess is that enthusiasm for structured programs would be tempered were the power of pricing appreciated.

THE POWER OF PRICING

Just how powerful is the price mechanism? A look at energy conservation is instructive. A few graphs tell the tale.

Prior to 1973, with the exception of the Great Depression, U.S. energy consumption, from colonial times onward, was almost unremittingly upward. Coincidentally, real energy prices during that extended period kept going down, down, down; particularly, from their introduction onward, for gas and electricity.

Since 1973, America has been on a modest roller coaster with ups and downs in energy consumption. Figure 1 shows energy consumption from 1970 through 1989. Two pronounced dips, 1974-75 and 1980-82, are evident. Since 1985, we have resumed our habit of marked year-to-year increases in energy use. Last year, the U.S. consumed about 81 quadrillion Btus (quads) of energy. That was about 9 percent more energy than was used in 1973.

The economy, however, is about 51 percent larger today than it was in 1973. In terms of energy intensity, the U.S. is much more efficient today than it was in 1973. Figure 2 shows performance of the U.S. economy since 1970 expressed in constant 1982 dollars.

If for each year the amount of energy consumed is divided by the amount of real GNP produced, a quotient is obtained: Btus per dollar of GNP. It measures energy productivity. For decades prior to 1970 there had been no consequential change in this quotient. Economic performance and energy consumption were bound in lockstep with one another. That is the principal reason why 20 years ago most experts (although not all economists) did not think it possible for the U.S. to lower energy use in response to higher energy prices.

Figure 3 shows that in each year since 1970, virtually without exception, less energy was consumed per unit of GNP than in the preceding year. It took about 42 percent more energy in 1970 to generate a unit of GNP, corrected for inflation, than is required today. Why?

There may be several reasons, but if one were required to identify that single reason which was more important than any other, the answer would have to be "price." Figure 4 plots both nominal and real energy prices from 1970 through 1988.

Recall the two pronounced dips in total energy consumption from Figure 1: 1974-75 and 1980-82. Notice how those dips in energy use followed closely on the heels of two energy price shocks, the first triggered in October 1973 when Arabs embargoed exportation of crude petroleum to the U.S., and the second precipitated by the Iranian hostage crisis in the fall of 1979.

The price of crude vaulted from about $3 a barrel before the 1973 embargo to $35 a barrel by 1981. Gasoline at the pump jumped from about 36 cents a gallon to $1.35. There were no price controls on Canadian gas imported into the U.S. It shot up from 33 cents per million Btu in 1973 to almost $5 in 1981. Electricity switched abruptly from being a decreasing-cost industry to an increasing-cost industry.

Just because one event occurs after another does not mean that the first event caused the second. That is the well-known *post hoc, ergo propter hoc* fallacy. Fortunately, multiple regression analyses can inform us whether or not a relationship exists and which among many variables is the most influential. Logic tells us which is cause and which is effect. Beyond doubt and quite in a class by itself, price accounts for most of the two dips in energy use. As might be expected, since nominal energy prices began to decline in 1985, energy use patterns have returned, at least partially, to their historic rates of growth.

ENERGY SAVINGS SINCE 1970

Figure 5 is the *pièce de* résis*tance*. It compares actual U.S. energy consumption with what it would have been had energy efficiency not improved since 1970. Assuming similar economic performance (and no shift in product mix), instead of consuming 81 quads last year, America would have consumed 115 quads, 42 percent more.

Energy conservation savings, induced primarily although not exclusively by price increases, permitted the U.S. economy to use 34 quadrillion Btus less in 1989 than it would otherwise have used. That is an amount of energy equivalent to every drop of petroleum, far and away America's leading energy source, used in the U.S. last year.

Figure 6 illustrates the distribution of energy conservation savings among end-use sectors. The industrial sector accounted for 38 percent of those conservation savings followed by the residential sector, 35 percent, the commercial sector, 18 percent, and the transportation sector, 10 percent.

If there is anyone yet unpersuaded about how powerfully prices impact on the quantity of energy consumed, one more graphic is instructive. Figure 7 shows 1988 average annual residential consumption of electricity plotted for the U.S., for each of the nine regions of the lower 48 states, and for Idaho, Oregon and Washington separately, those three states having the lowest electricity rates in America. Question: In what direction does the curve slope? Answer: Unambiguously downward to the right. It is not necessary to be a Nobel laureate in economics to appreciate the importance of that observation.

The more pertinent question to ask is: What has this got to do with externalities?

ENERGY PRICES ARE OUT OF WHACK

It can be demonstrated that energy prices today inadequately reflect internal or conventional accounting costs. That is because, for the most part, average prices of energy products, particularly for electricity, reflect average costs but are below long-run incremental cost.[1] It can certainly be demonstrated that energy prices do not reflect externalities -- by definition.

If energy prices do not adequately reflect LRIC (in accountants' conventional terms), they are transmitting inappropriate price signals to consumers. If, additionally, prices do not reflect external diseconomies (in economists' terms), they are even more seriously out of whack. To raise prices across the board might not only be politically unrealistic but would confront regulators with the problem of recovering and redistributing unwarranted windfall profits.

RAMSEY TO THE RESCUE

We need not despair. There is a solution. A brilliant English mathematician, philosopher and economist named Frank Ramsey, has galloped from his grave to our rescue. Quite unwittingly, Ramsey provides an elegant theory to support a pricing mechanism which when cleverly constructed tends to make people's consumption decisions comport with marginal-cost pricing and with the internalization of what are now exter-

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[1] In some jurisdictions, Oregon for example, energy utilities claim that additional resources are available at costs which are slightly below, not above, present average-cost rates. Those resources, however, are limited and, unlike generic powerplants, cannot be replicated. Once those resources are exhausted, and that might occur sooner than the utilities relying on them think, significantly higher LRICs are likely to surface. Perhaps there should be a distinction between long-run incremental cost and long long-run incremental cost.

nal diseconomies. Simultaneously, the problem of unwarranted windfall profits is neatly solved.

Shortly after his graduation as Cambridge's top mathematics student, Ramsey joined a group of economists headed by John Maynard Keynes. He wasn't interested in energy pricing; he was interested in taxes. The question he asked was, How should taxes be structured to be most economically efficient, that is, to cause the minimum amount of economic disruption? His answer was to place the heaviest taxes on products that are most price inelastic in supply or demand. Such a tax would produce the least change in production and consumption. It is called the "Ramsey tax rule."[2]

We also want to achieve the economically efficient outcome, which in this case leads us to do just the opposite. We should ask, How ought energy prices to be structured not to minimize changes in production and consumption but to cause an optimum impact on energy production and consumption, to induce consumers to behave as if they are receiving theoretically correct price signals. In other words, what pricing mechanism can change production and consumption levels appropriately without increasing or decreasing utility revenues? I call it "Reverse Ramsey" pricing.[3]

The Ramsey tax rule places taxes on the most inelastic products; those that will go on being produced and consumed with minimum change regardless of higher price. What I call Reverse Ramsey pricing takes advantage of this concept but places higher prices on the most elastic blocks of energy consumed by each customer. It is achieved through inverted or increasing block rates.

THE GEOMETRY OF INVERTED BLOCK RATES

Figures 8, 9 and 10 illustrate this reverse Ramsey pricing technique.

Figure 8 shows a typical American residential customer consuming 800 kilowatthours a month at a flat rate of 8 cents per kilowatthour. The price generates monthly revenues

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[2] Tragically, in 1930, Frank Ramsey died of complications from abdominal surgery -- at the age of 26!

[3] What has come to be known as "Ramsey Pricing" suggests that when it is necessary to "gross up" or "gross down" from LRIC prices for utility revenues to recover neither less nor more than fully distributed, historically embedded costs, plus a reasonable return on investment, higher or lower prices, respectively, should be imposed on customer classes whose demand for the product is most price inelastic. That is calculated to ensure minimal distortion of consumer behavior from ideal LRIC pricing.

from that customer of $64, presumably appropriate when added to other customers' payments to meet the utility's revenue requirements. These values are quite close to actual U.S. average data.

Figure 9 shows how that typical residential customer might fare under an inverted block rate which charges 4 cents per kWh for the first 200 kWh a month, 6-1/2 cents per kWh for the second 200-kWh block, 11 cents per kWh for the third 200-kWh block, and 14 cents per kWh for all additional kilowatthours.

The first few kilowatthours consumed each month are extremely inelastic. They are more or less essential -- providing lights, refrigeration, television, and other "necessities" of modern life. Presumably, those first kilowatthours would be consumed whether the price was high or low.

Each additional block of electricity is characterized by progressively greater price elasticity. The last block consumed is the most elastic. It is at the margin where consumers decide to take or not to take. It is that block which should be priced at a level which reflects marginal costs and externalities.[4]

Notice that where annual consumption for a flat rate structure was 800 kilowatthours per month (Figure 8), consumption under the hypothetical inverted-block rate is illustratively reduced to 750 kilowatthours (Figure 9). The 50-kilowatthour monthly reduction in usage is attributable to the high end-block rate of 14 cents per kilowatthour which, if adequately publicized, should capture consumers' collective attention and induce less wastefulness than would the flat 8 cents per kilowatthour rate.

Finally, Figure 10 shows the two rate structures, flat and inverted, superimposed on one another. The utility's revenues from the inverted-block rate are diminished for each kilowatthour sold under the first two blocks and increased for each kilowatthour sold under the last two blocks. Rates should be designed so that the extra revenues gained from the last two blocks offset the revenues lost from (1) the first two blocks plus (2) diminished overall sales. In other words, the area of "A" plus the area of "B," revenue lost, is exactly the same as the area of "C," revenue gained.

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[4] Alternatively, customers can be charged a very low (if necessary even negative) demand charge and a high flat rate.

CONCLUSION

Externalities should be reflected in the prices of all businesses, not only in the prices of utility products. What is required for regulated energy utilities, if we wish to send proper price signals to consumers, is a pricing mechanism which simulates the effect of pure marginal-cost pricing, which reflects costs of external diseconomies, which is practical and politically realistic, and which does not result in the generation of excess revenues that produce unwarranted windfall profits. Inverted-block rates are that mechanism.

U.S. Energy Consumption (Quadrillion Btu)

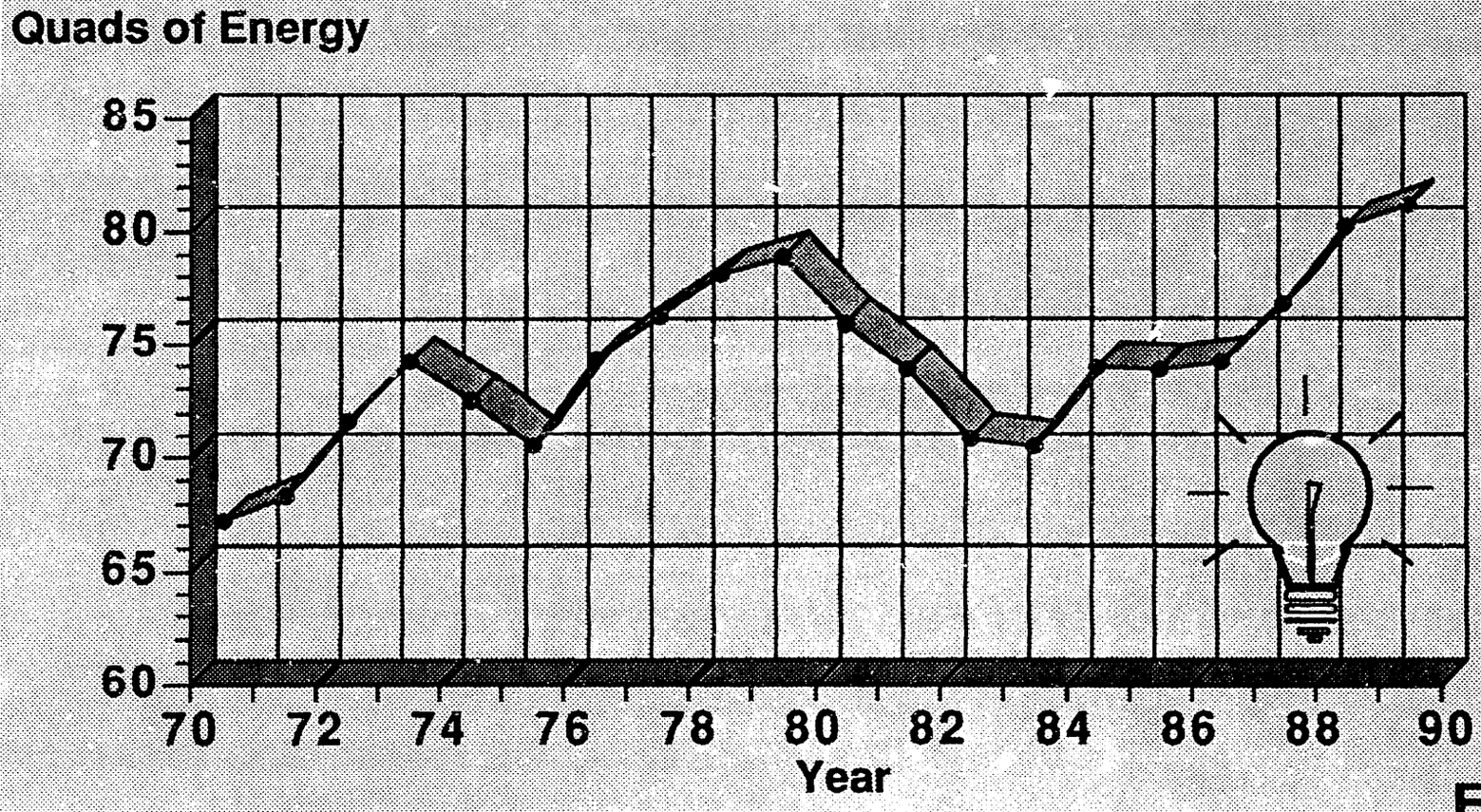


Figure 1

U.S. Real GNP (Trillion 1982 Dollars)

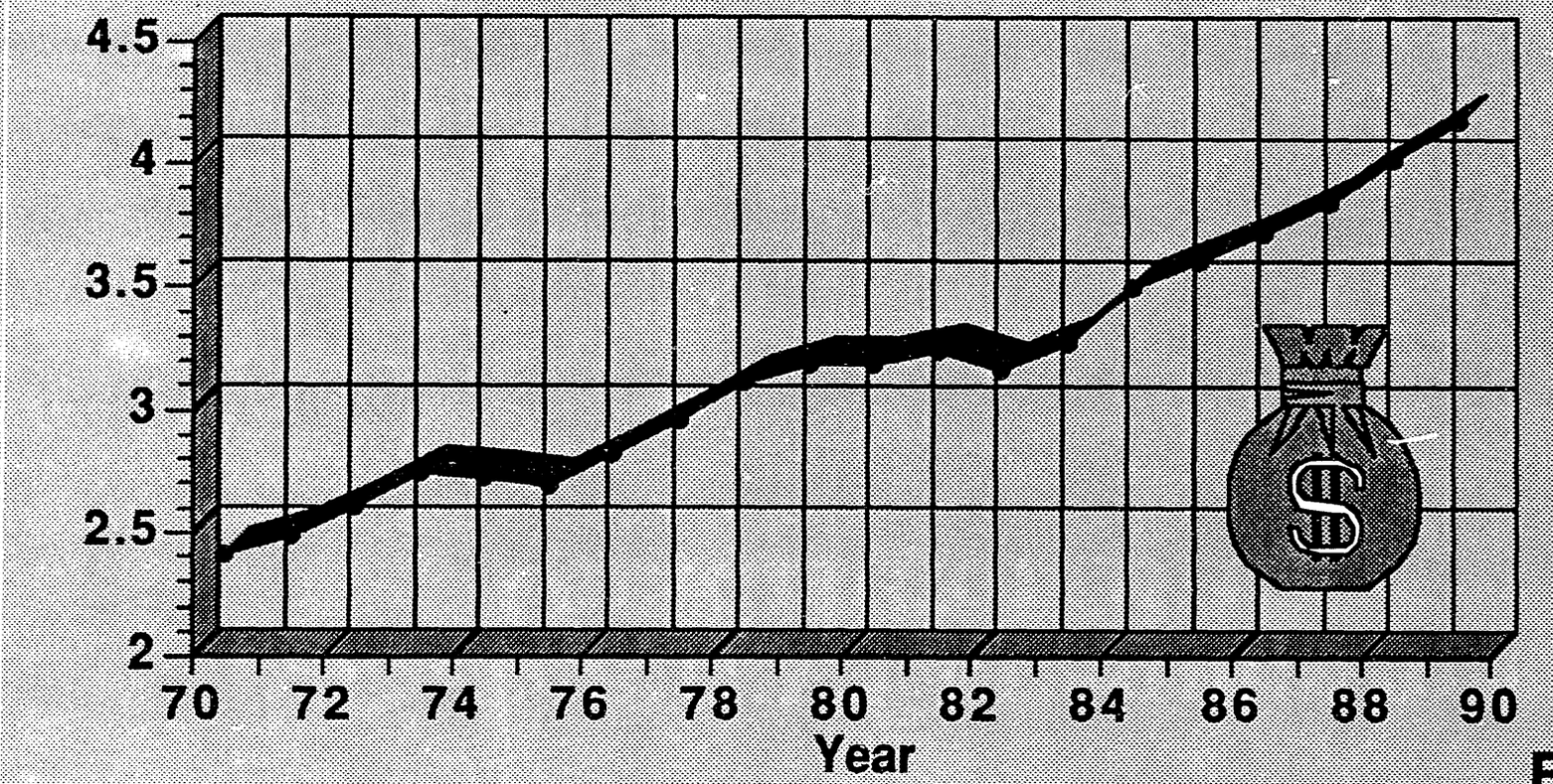


Figure 2

U.S. Btu Consumed Per 1982 $ of GNP

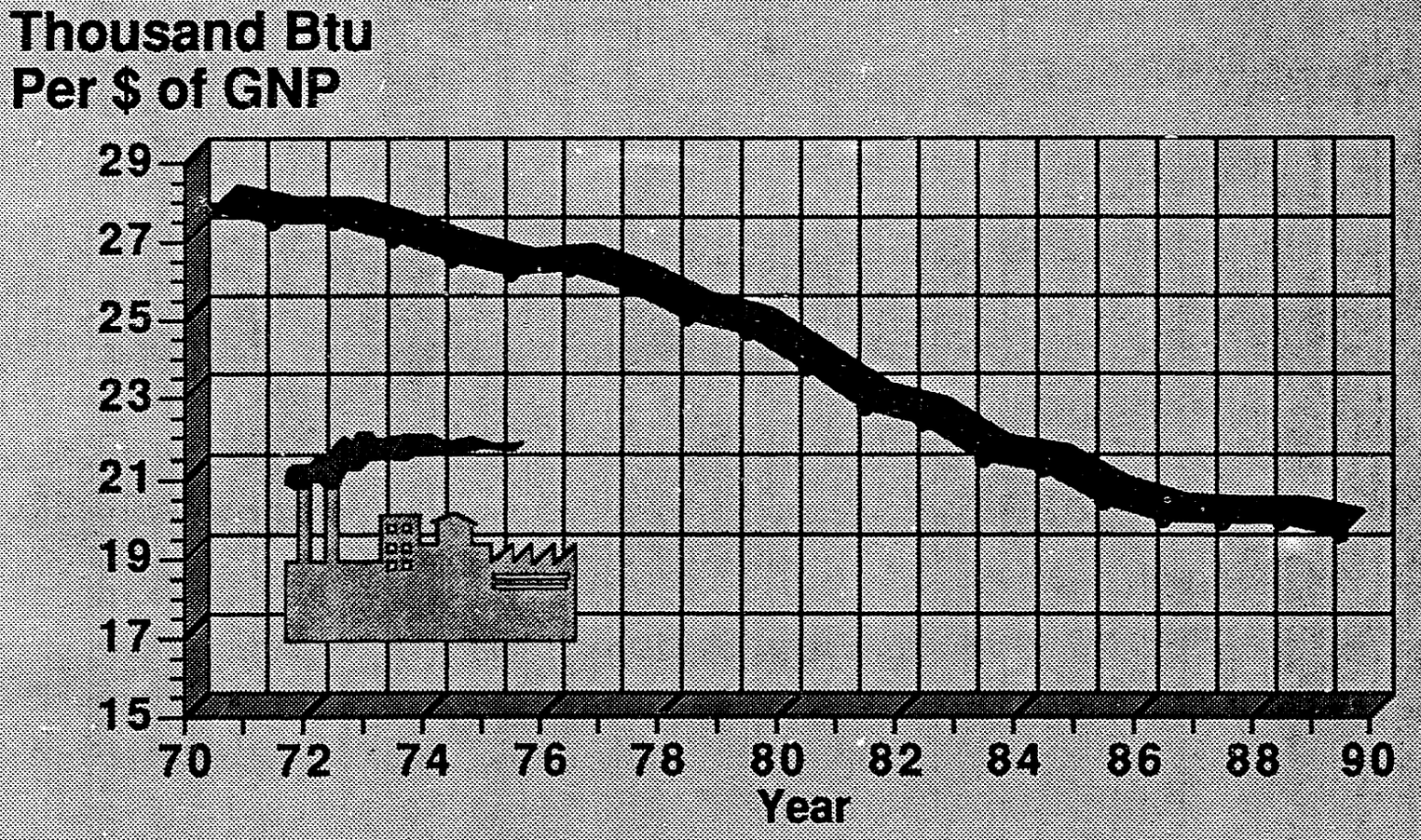


Figure 3

U.S. Average Energy Prices

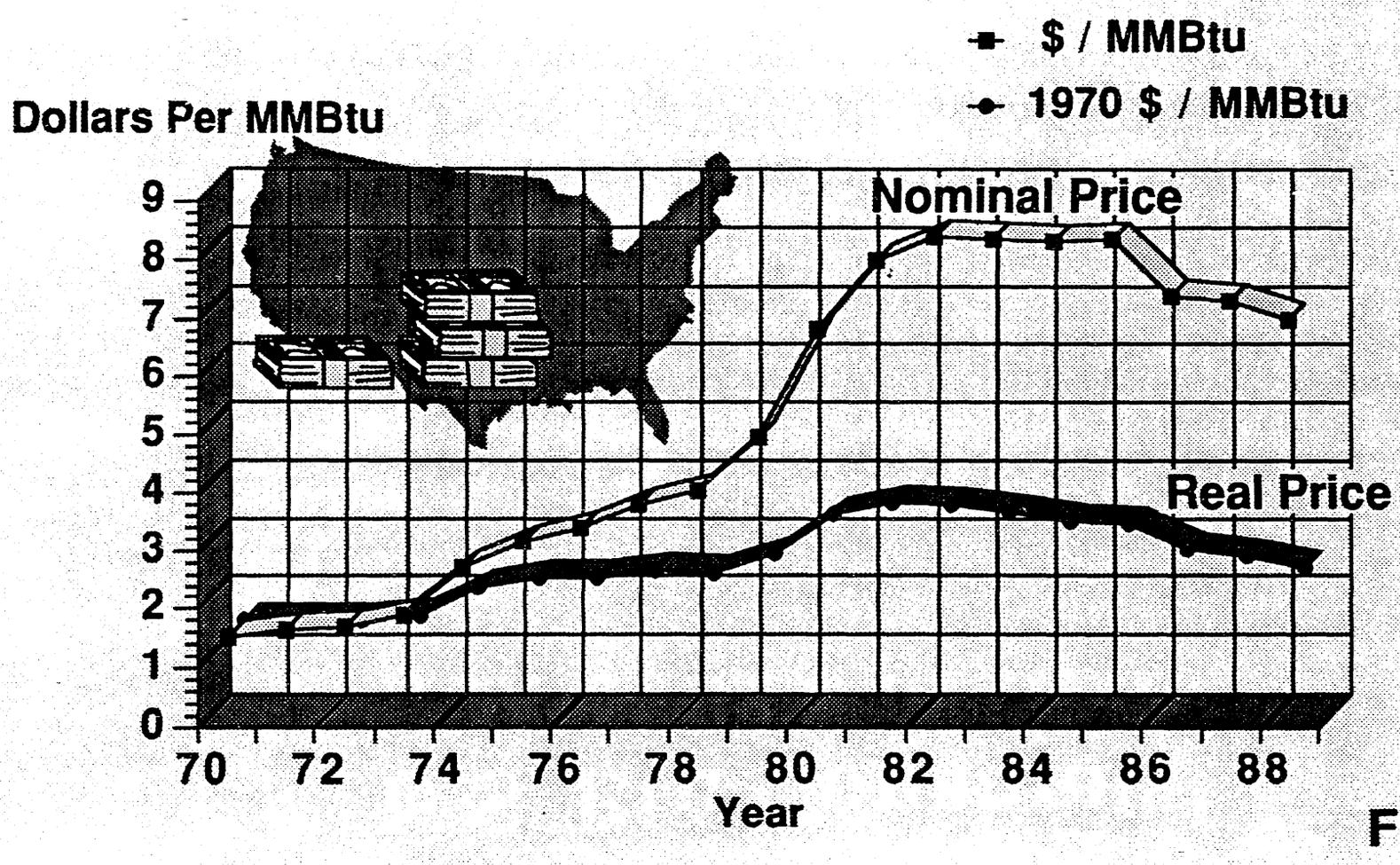


Figure 4

U.S. Energy Conservation: 1970-89

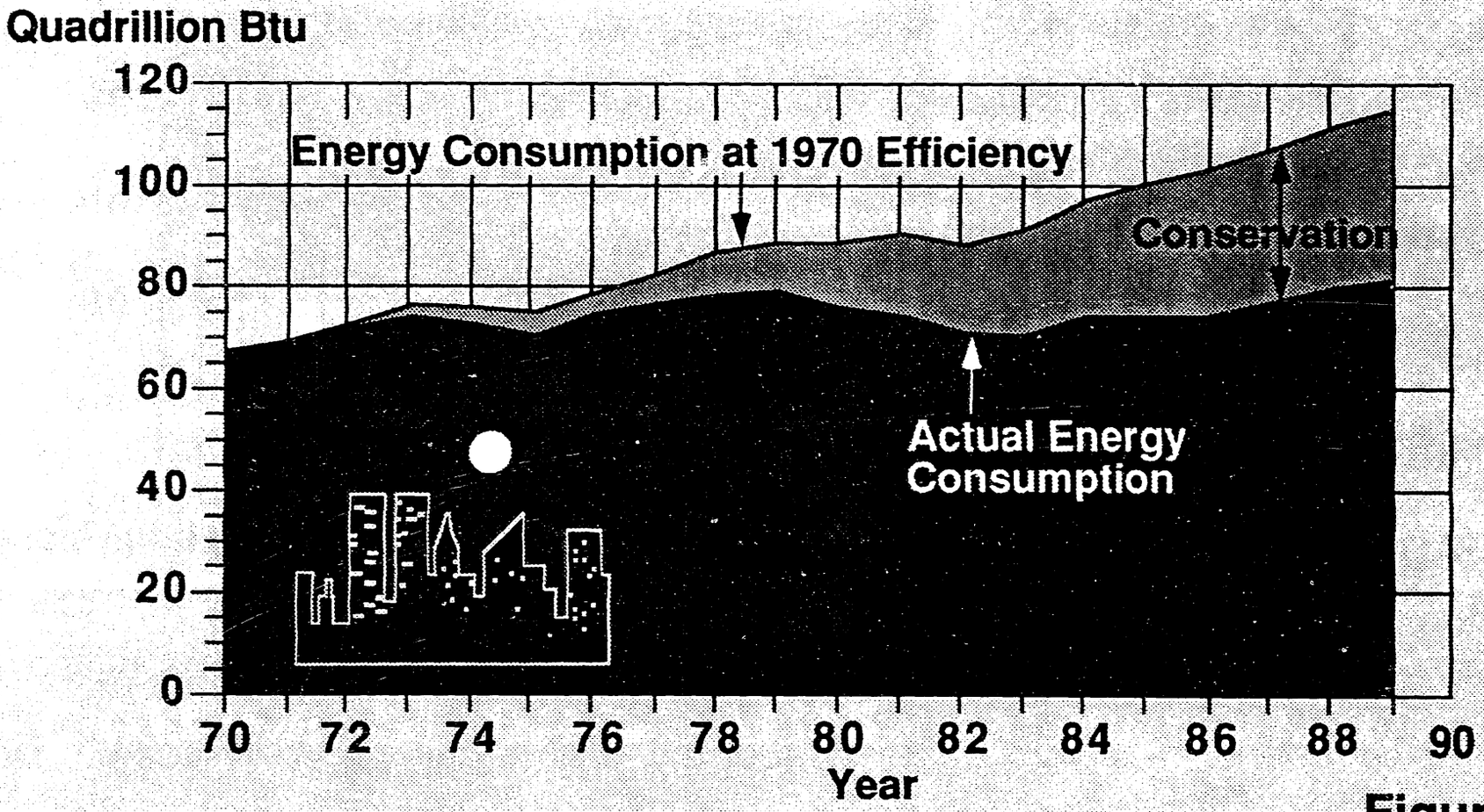


Figure 5

Conservation Savings Distribution by End-Use Sector

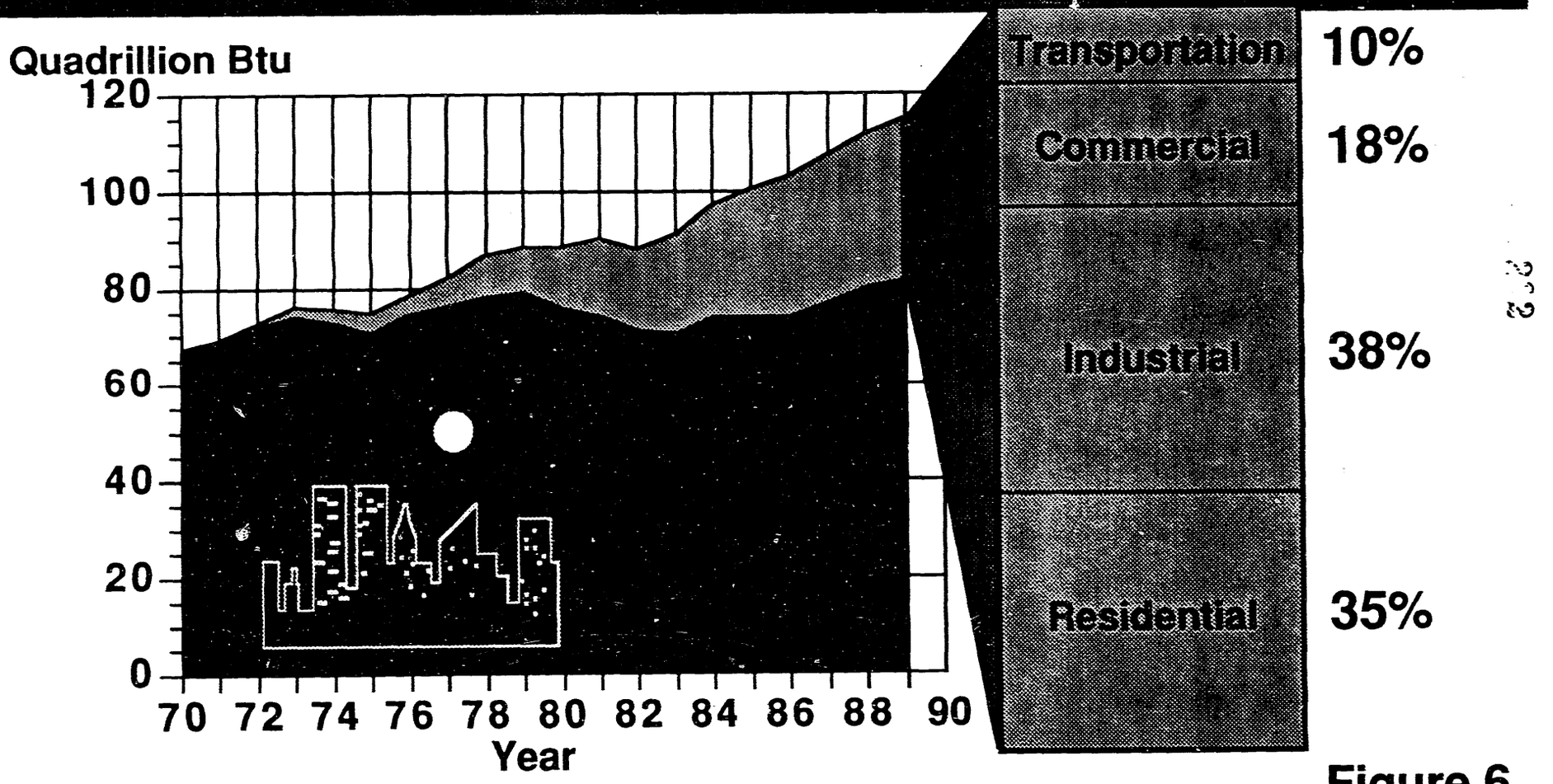


Figure 6

1988 Average Annual Residential Demand for Electricity

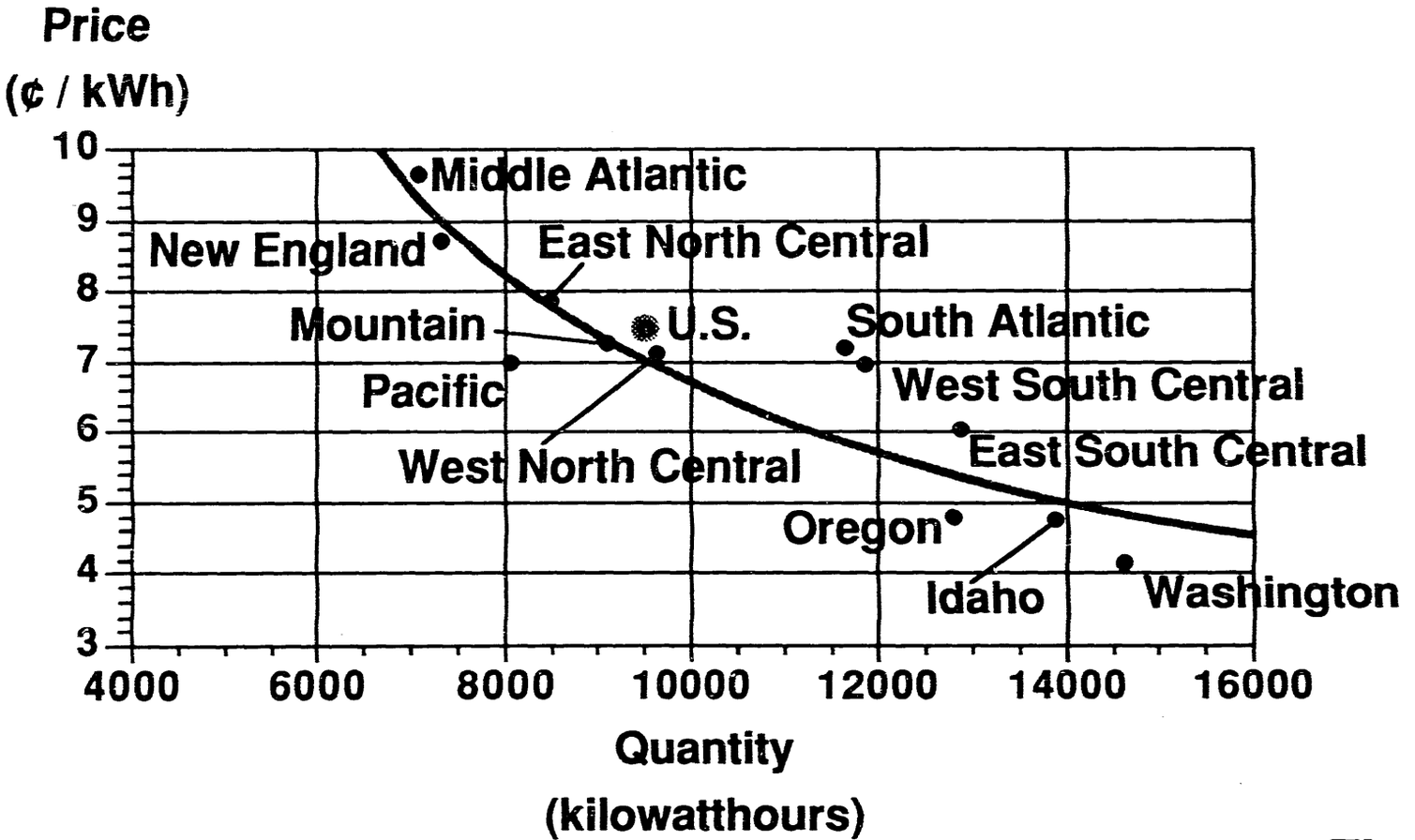


Figure 7

Typical Residential Customer
Monthly Electric Bill
Flat Rate

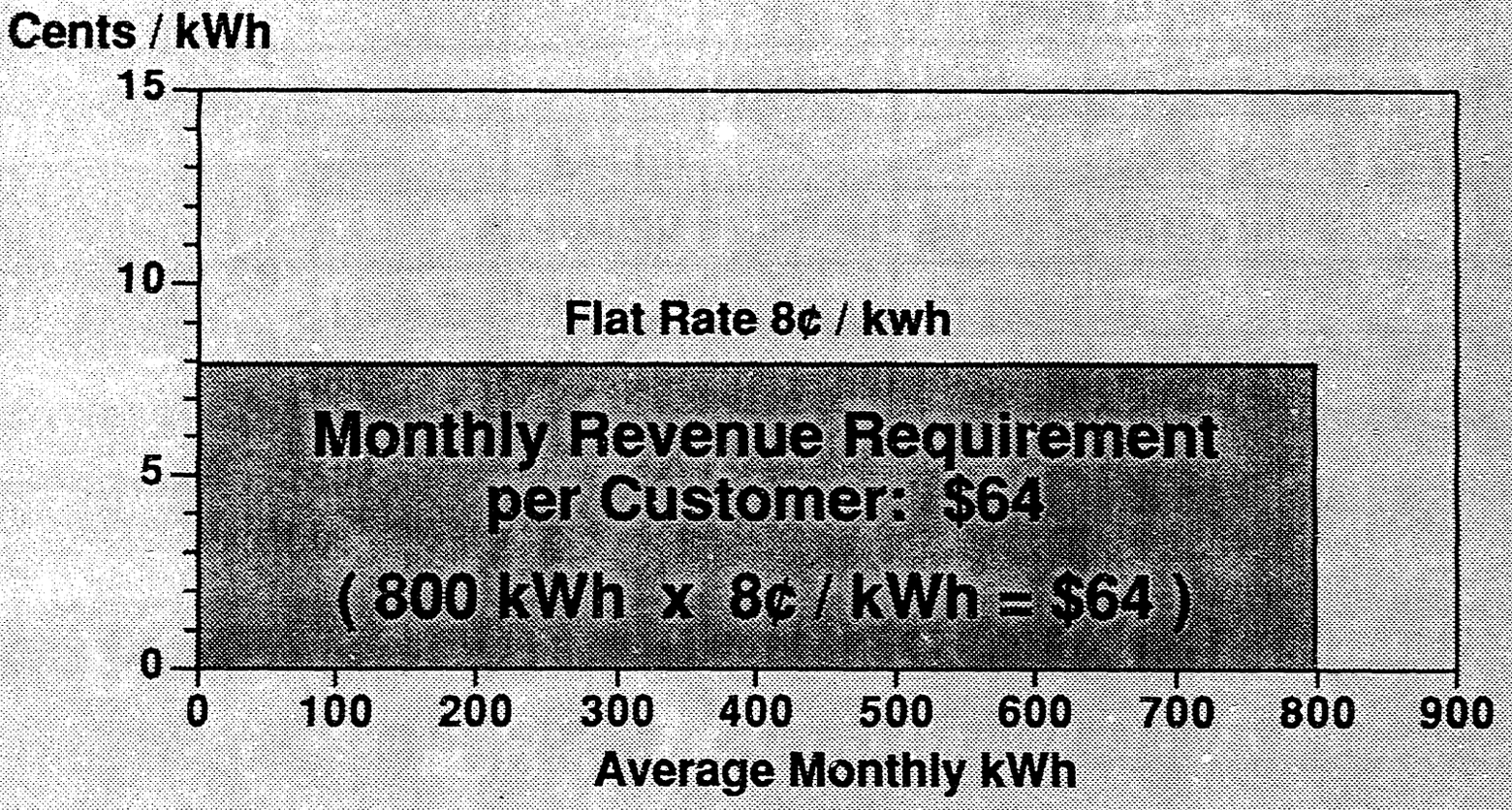


Figure 8

Typical Residential Customer Monthly Electrical Bill Increasing-Block Rate

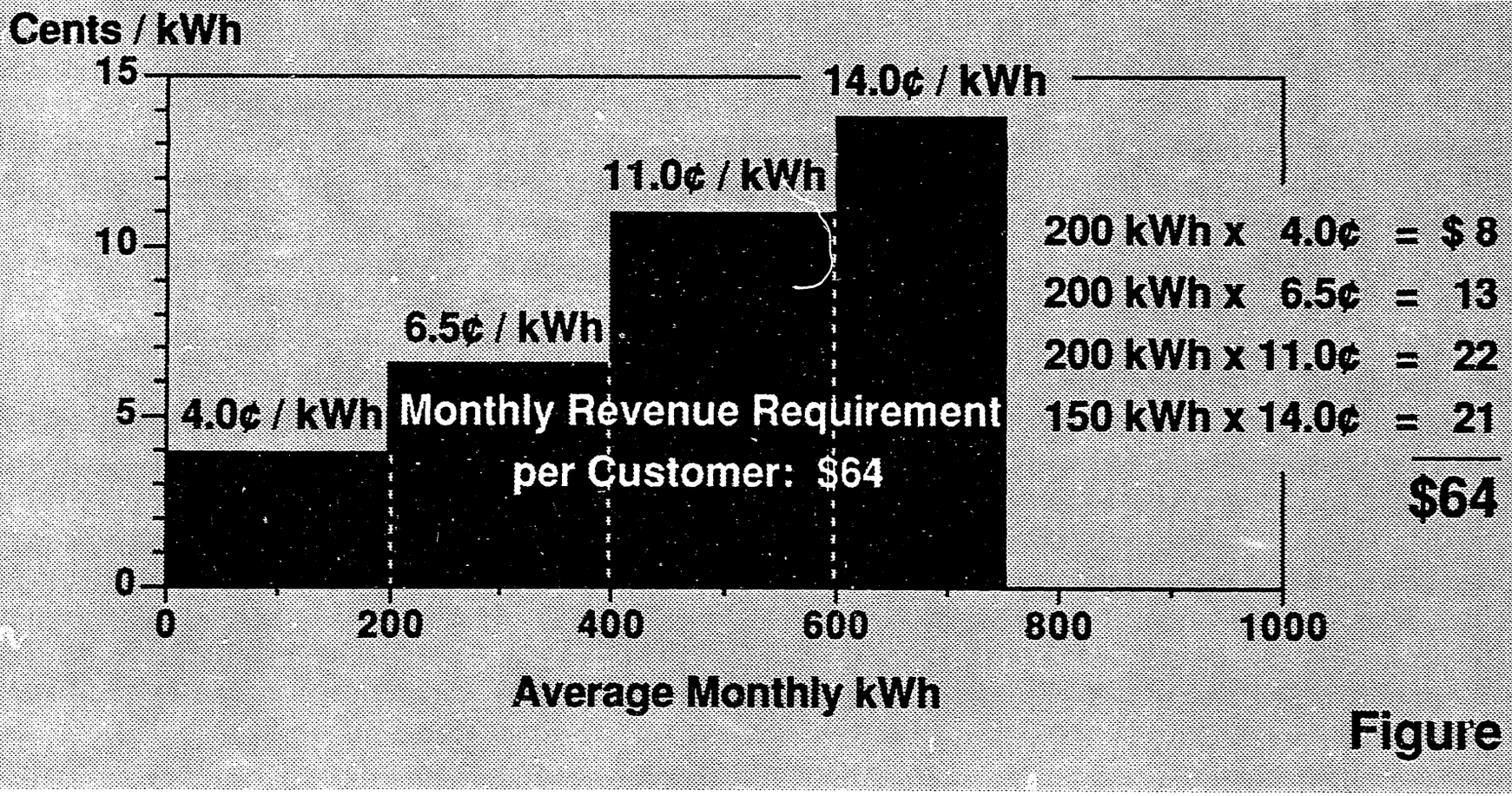


Figure 9

Typical Residential Customer
Monthly Electric Bill
Comparison: Flat Rate v. Inverted-Block Rate

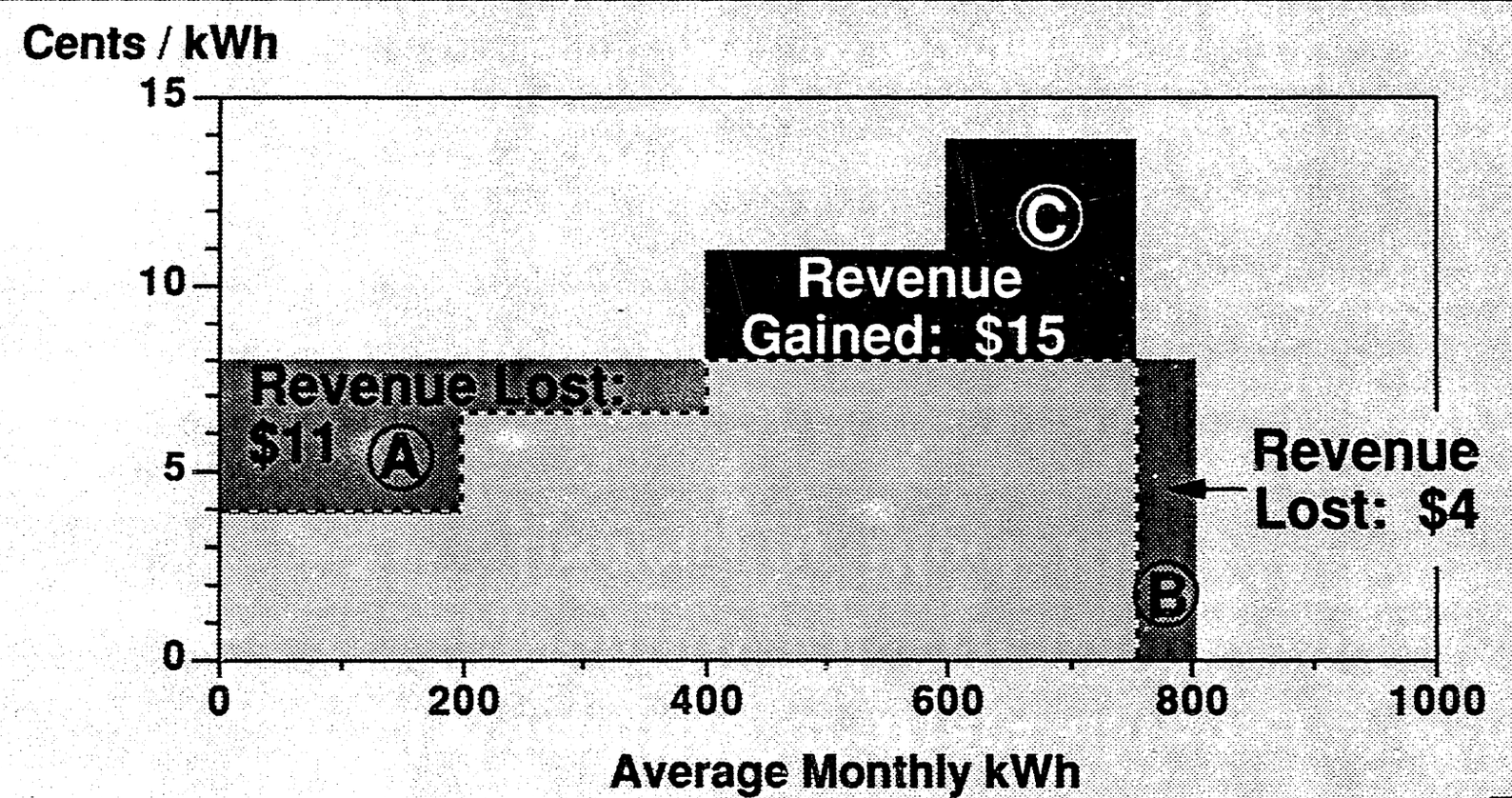


Figure 10

COOPERATIVE OPPORTUNITIES IN ENVIRONMENTAL EXTERNALITIES AND ENERGY PLANNING

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Prepared for the

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Abstract

Environmental concerns are playing an increasing role in energy planning. Projects have been initiated to characterize the direct and indirect environmental consequences of energy production, conversion, and end-use. These efforts have helped identify the positive and negative environmental and economic effects of Federal and State energy and environmental planning and policy decisions. However, substantial additional efforts lay ahead in validating initial actions and in achieving the desired end result: "technology neutral and value-based energy supply and demand markets." This paper provides examples of precedent-setting work, and describes "lessons learned" and the emerging analytical frontiers in externalities research. It concludes with a call for continued collaboration among Federal agencies, State governments, utilities, public utility commissions, research organizations, consumer groups, and other interested parties.

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Introduction

Environmental and economic externalities and energy planning are likely to be inextricably linked from now on. Significant progress has been made over the past several years by various stakeholders in establishing a basis for factoring externalities into energy decisions and operations. In particular, the States and State regulatory authorities have been instrumental in shaping the initial externalities research agenda and in moving to apply the concept in practice. This has been accomplished while recognizing the need to balance the legitimate interests of utilities, consumers, and other interested parties in the research and development process.

The authors recognize this State leadership and believe that it reflects the appropriate, essential manner by which energy is produced, consumed, and regulated in the United States. The authors also recognize that energy production and use have important regional, national, and international implications which are worthy of research attention. Accordingly, this paper presents - for discussion purposes - a potential set of programmatic goals and objectives, an analytic framework, and a set of analytical research needs to help shape an increasingly visible and results oriented, multi-year national research effort.

The constructive efforts of States are paving the way for innovative methods that will result in environmentally sound energy planning and operations. Federal efforts play a meaningful support role in the process of developing environmental approaches to planning and facilitating their implementation and evaluation. This paper examines examples of these cooperative support avenues and the frontier opportunities for further research and advancement.

The authors do not explicitly consider the concepts and issues raised in this paper to be exhaustive or definitive. However, this an opportune time for the community of interest to cooperatively define an ordered set of priorities and objectives to guide research in this important national and international arena.

Goals, Objectives, and Strategies

The ultimate goal of integrated resource planning is to facilitate the development of technology-neutral, market "value-based" planning and operations. Several underlying purposes help define what is meant by this objective: 1) to ensure that markets are free to make optimum energy, economic, and environmental investment decisions, considering both supply and demand options, 2) to promote the richest possible set of reliable energy supply and demand options, available at reasonable cost, and 3) to encourage that full fuel cycle costs are considered in investment decisions. In the utility sector, these objectives are best pursued in conjunction with power marketing authorities, States, FERC, utilities, independent energy producers, trade organizations, research organizations, consumer/citizen advocacy groups, and other interested parties.

Realizing these goals and objectives requires examination of potential programmatic objectives and the progress made to date toward achieving these ends. Research to date suggests that future electric supply and demand

options can achieve:

- o Low initial and life-cycle costs,
- o Improved competition among technology choices including both supply and demand options,
- o Market-based pricing which reflects total fuel cycle costs and benefits,
- o Environmentally sound and systematically reliable operations, and
- o Improved opportunities for utility returns from investments on the demand-side and on environmentally attractive technologies.

Current progress in the field has reached the juncture where it is opportune to briefly review the analytic foundations which have supported the development of externalities work to date and to frame the types of future analyses which may be required.

An offspring of our Least-Cost Utility Planning Program is the Integrated Resource Planning Program that has as one of its missions the fostering of rational methods for estimating externalities accounting methods. Promising options exist for allowing supply-and demand-side options to compete on an equal basis. In addition utility and utility planning experience suggests that one can simultaneously pursue the multiple objectives of integrated resource planning, including:

- o **COST-EFFECTIVE POWER AND CAPACITY,**
- o **RELIABILITY,**
- o **ENVIRONMENTALLY SOUND OPERATIONS,**
- o **INDUSTRY PROFITS AND EQUITABLE PRICES.**

Bottlenecks and infrastructure impediments often slow and discourage progress towards cost-effective investments on both the demand and supply sides of the equation. However, with help from the States, future options include reliable, cost-effective utility systems. These will be systems which are managed efficiently by regulations designed to allow the market to determine the best all-around investments -- investments where energy, environmental and economic goals are balanced.

A number of cooperative projects involving research and development of environmental externalities methods and analysis are underway or have been completed. These include the Pace University study on the Environmental Costs of Electricity (Pace, 1990), DOE/U.S Environmental Protection Agency (EPA) study with the Lawrence Berkeley Laboratory on the probable rate impacts of incorporating externalities in New England, the MSB & Associates'

Pennsylvania, New Jersey, Maryland (PJM) Power Pool/externalities study, and the NARUC survey of State PUC activities which incorporate environmental externalities into electric utility planning and regulation. These efforts first describe a significantly large universe of externality definitions and approaches. The study at LBL has modeled the probable effects of externalities programs on electricity rates for a Northeast utility, with the intent of extending the analysis to forecast the effects of programs in other service areas. The MSB work addresses regional intertie questions and the effects of externalities programs on power pools. And finally, the NARUC survey brings to the forefront the ongoing State PUC activities in this arena and the information needs that PUCs consider vital to furthering our progress. A significant number of other efforts are also contributing to this body of information which forms the cornerstones of the multi-stage research process. Figure 1 depicts the stages in environmental externalities research process.

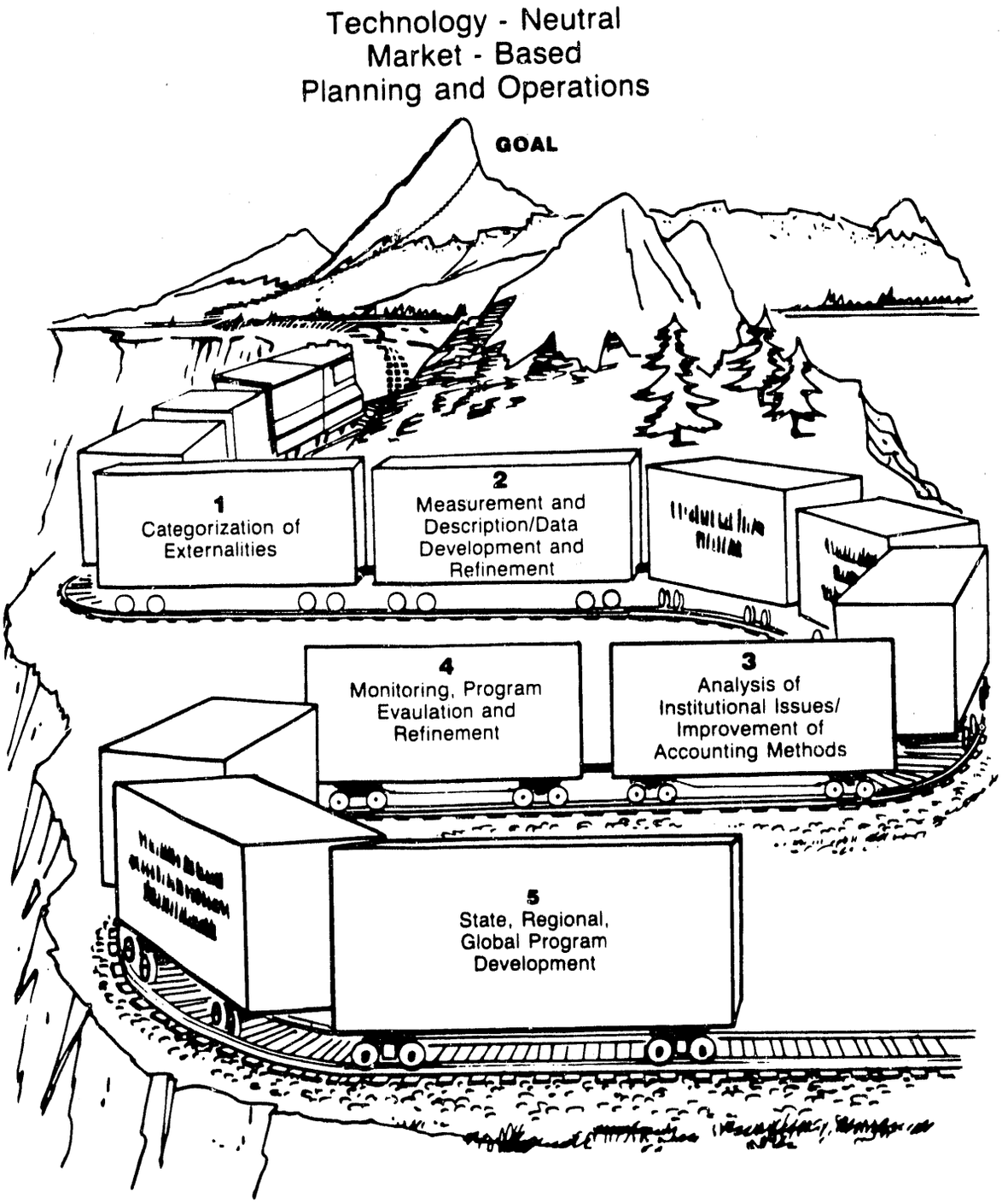
Research Stages

Research on environmental externalities appears to be progressing through a series of stages, each contributing to the accounting for environmental concerns in energy planning. A rough sketch of these stages follows:

- **Categorization of Externalities**, specifically directed at the environmental and socio-economic effects of energy use at all stages of the fuel cycle;
- **Measurement, Description, and Data Base Development and Refinement** of the types and magnitudes of environmental impacts of energy generation, delivery, use, and by-product disposal;
- **Development and Refinement of Accounting Methods** for characterizing environmental effects, including the derivation of economic costs or comparable factors within the context of resource planning;
- **Analysis of Institutional Issues** in the context of dynamic regulatory and utility structures, involving local, State, Federal, and international boundaries (including analysis of jurisdictional issues, market characterizations, and other limiting factors)
- **Monitoring, Program Evaluation, and Refinement** to assess and incorporate the lessons learned from on-line environmental accounting programs, leading to improved applications.
- **State, Regional, Global Program Development** involving the widespread implementation and subsequent continued improvement of externalities accounting programs that take into account State, regional, and international priorities.

These are overlapping research stages, involving a significant number of feedback loops, perhaps best approached as a process rather than as a single

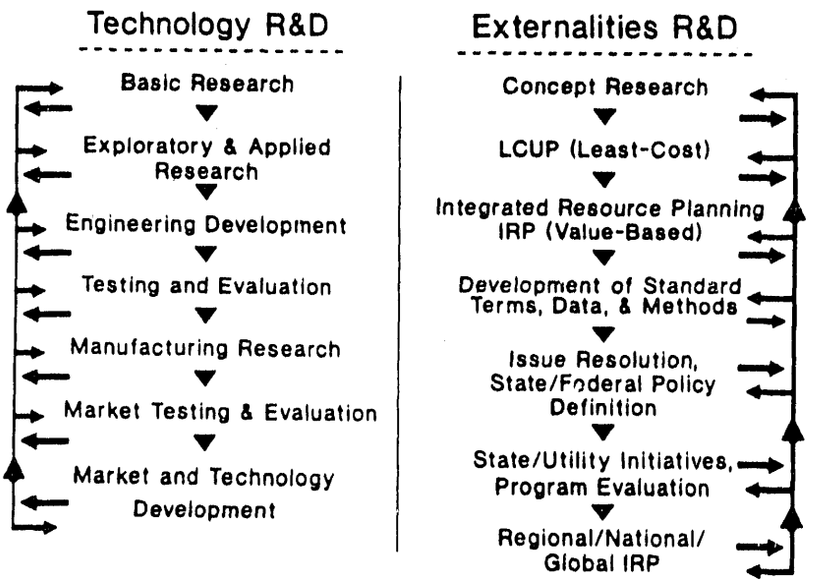
Figure 1. **Environmental Externalities Research Stages**



research path. Accurate data and rational methods are an integral part of the development of viable accounting methods. So too, are the development of implementation strategies and analysis of institutional issues key inputs to the process of developing technology neutral market-based planning and operations. Along similar lines, the results of monitoring and evaluating on-line programs are essential inputs in the effort to develop accepted and standardized methods. To be successful, each of the stages must be supplemented by strong technology transfer and information sharing activities.

Figure 2 compares an externalities research process with a similar description for technology research and development. Many of the stages are comparable, and the feedback loops are as important to one process as they are to the other.

Figure 2: Comparison of Research and Development Processes



Lessons Learned and Limitations

A key observation in environmental externalities research efforts thus far has been that States have taken the innovative leadership role in developing and implementing accounting methods. The leadership role of the States affords us a number of opportunities to enhance these efforts through cooperative research, development, demonstration, and program evaluation projects. One of the most interesting aspects of the State approaches developed to date is that no single approach has emerged as the be-all-end-all method, therefore, leaving the opportunity for further improvements and refinement.

Where some states have resources to develop (state-level) accounting methods or approaches, the Federal government and other organizations have the opportunity to extend the scope of these efforts. Federal resources can be used to develop regional and then national externalities approaches, transferring elsewhere the lessons learned in specific States and regions.

Sharing experiences will be an important ingredient in developing and implementing viable accounting methods. New York, Wisconsin, Maine, California, the Northwest Power Planning Council, and others have learned that involving all the major players early in the program development phase makes them more apt to try to work with new environmental accounting methods and the regulators. Problems are more apt to occur in the absence of consensus building, and this is a well established finding in the literature (Rogers and Rogers, 1976). If utilities are afforded the opportunity to help develop the accounting methods for incorporating environmental externalities in planning decisions, they are more likely to work with the PUCs when regulators institute the new procedures. This is certainly the case at present where control cost estimates underpin most of the currently deployed externalities methods, and utilities are in one of the best positions to provide cost of control values. For example, New York utilities played a pivotal role in developing the methods now on record in that State. These findings also suggest that working closely with utilities creates the opportunity to be sensitive to the barriers that utilities face with investments such as those in demand-side management. In summary, each of the State experiences has come face to face with the complexity of the issues, but there are some mitigative approaches that are more likely to be effective than others.

Uncertainty and Opportunity: With Some Progress, Where Are the New Frontiers?

Analysis of Jurisdictional Uncertainties

The scope of the analysis activities completed and underway thus far suggests that there a number of unanswered questions. One of the significant subject areas with unanswered questions involves the jurisdictional issues of how to establish definitional and system boundaries and who will be responsible for regulating, monitoring, and enforcing the accounting procedures for externalities programs.

Definitional uncertainties pinpoint one of the key questions in environmental externalities research -- what factors are to be legitimately considered externalities? Given the extraordinary difficulties in defining the boundaries associated with externalities, one must ask whether to direct future analytic resources toward expanding program breath or depth. Posed differently, in the interest of intellectual completeness, how does one determine whether primary, secondary, or tertiary order effects must be analyzed in depth? For example, it is currently accepted as a first order conclusion that demand-side efficiency options: a) are environmentally attractive, b) are currently utilized below their level of economic efficiency, c) face major institutional barriers (capital hurdles) with both utility investors and facilities operators, building owners, and other potential adopters, and d) have positive influences on local, regional, and national economic productivity and employment. How far down the fuel cycle should one go in validating these conclusions?

For integrated resource planning initiatives at the State, regional, and Federal levels to be broadly successful, there will need to be a process for

data gathering, estimation, and analysis, addressing issues such as:

- At what level of market adoption does energy efficiency begin to exhibit neutral or even negative energy, environmental, or economic returns, compared with the other alternatives on the margin?

- At what levels of market adoption would energy efficiency pass through the so-called "market innovator" stage of the supply curve and therefore command a reduced incentive as compared to a market entry premium?

- At what level of detail does one monitor program effects in order to best characterize the effects on utility load profiles and dispatching regimes?

- For each of the above data elements, what levels of accuracy are required for future decision making at the Federal level, the State PUC level, the individual utility level, the level of the utility investment community, and at the level of consumer/ ratepayer interests?

- How far down the total fuel cycle continuum does one go in analyzing secondary or tertiary environmental impacts associated with the manufacture of energy efficiency and renewable energy applications (primary level manufacturer/assembler, secondary suppliers, etc.)?

If externalities are defined as everything from electromagnetic fields (EMF) to mining emissions and safety concerns, then considerable definition, measurement, and up-keep work is necessary. Additional definitional questions include how to deal with: land-use and drinking water externalities, species diversity uncertainties, and potentially positive externalities such as the economic efficiency resulting from supply- and demand-side management programs, trade, tourism, economic development, and other effects.

System boundary uncertainties are another area where consensus has not been reached on the treatment of environmental effects that do not obey local, State, regional, or international boundaries. Which State, regional, national and/or international environmental approaches offer the potential for addressing regional and national utility emission challenges? At the first level of analysis, one can concentrate some effort on distinguishing between urban and rural externalities, as the costs and benefits of energy fuel cycles often appear inequitably distributed when considered from these two perspectives.

And lastly with respect to system boundary uncertainties, who should be responsible for **regulating, monitoring, and enforcing** the accounting procedures for externalities. Should State PUCs be those responsible for implementing regional programs? What should the FERC do at the national level with regard to incorporating externalities into wholesale power transactions? or into public power ratemaking? How does one consider combining the efforts of States at the one level and the efforts of the Federal government at the other? Are PUCs and the Federal government those that should be addressing

externalities or should methods be implemented and enforced at some other level? These are the issues at the crux of the needed research and analysis on incorporation strategies.

In trying to find **the effective medium between local, State, regional, and Federal levels**, the lessons learned in the U.S. appliance industry offer salient advice to those in search of cooperative avenues. California took the innovative lead with minimum product energy efficiency standards for appliances. Other states followed the West's lead, resulting in a fragmented market. Energy efficiency improvements were achieved, but at a cost to the industry, in analysis, R&D, and marketing, suggested by some to be, significantly higher than the cost of meeting standards set at consistent national levels. However, without the innovative lead of the States, and the impact that the potential regulations were able to place on the market, it may have been much more difficult to reach the consensus eventually achieved. One of the key questions is how to learn from this or other examples and how to best use the innovative force of the States, supplementing it with Federal support? This is an opportunity to work cooperatively with the states and the regional power councils. The utility industry has the challenge to: a) think the externalities problem through and b) get out in front and help develop the viable accounting methods to assure the procedures instituted will be acceptable. The integrated resource planning participants should view the utility industry as the cooperating colleague. It is necessary to collectively improve the understanding of the utility business environment and to represent information on externalities methods and programs in terms that the industry can a) understand and b) use to make decisions. Part of this task involves understanding issues such as the limits on utilities with demand-side management investments (eg. profitability, see for example Moskovitz, 1990) and the impacts of potential Federal policies (eg. taxation of rebates).

A strong lesson learned is the dialogue must continue and be strengthened. Consideration of the information and decision needs of IOUs and public power companies in shaping the future analytic agenda for integrated resource planning and externalities is a key to productive accomplishment.

Normalizing the Available Methods

One of the next key steps is to distill the methods of the innovative states and regions into a package that calls on the best attributes from each of the approaches, but at the same time is consistent in the treatment of resources and effects that have very different values as a function of locale. The Pace University study team (1990), Koomey (1989), Chernick and Caverhill (1989), the Ohio PUC (1990), and the NARUC survey (Cohen et al, 1990) move in the direction of consistently describing the presently on-line and developing approaches. But some fundamental questions remain unanswered. First, how best to account for State and regional distinctions in fuel and energy supply, load variations, etc.? Second, how best to account for the differing priority placed on capacity across State and regional boundaries? Third, how best to account for the differing values that States and regions may place on distinct types of environments and services? At the next level, what are the distributional effects of a 2 cents/kwh surcharge in a state where electricity is priced at 8 cents/kwh and in one where the price is 14 cents/kwh? There is

much to be tested before one can consider developing a normalized method, but the bright side is that some methods are in practice and can be used to start the process.

The Effect of Legislative Activity

Further uncertainties and analysis opportunities exist in the area of legislative activities, specifically regarding the new Clean Air Amendments. The uncertainties created by the legislation are significant, beginning at the level of cost of compliance. Based on a system of offsets and credits, the Federal government is proposing a market control plan to reduce the emissions of acid rain precursors. Additional analysis is needed to assess the effects of the new legislation on the costs and benefits incurred by utilities, stockholders, ratepayers, other interest groups, and by the environment. Some of the big questions are:

1) how will the new legislation affect existing state level initiatives, including on-line externalities programs?

2) how will the costs of compliance for the Clean Air Act affect utility resource mixes?

3) how to distinguish between the externalities that are considered in the new legislation and those considered in the on-line State initiatives, so as to avoid double counting?

4) how will the legislation affect the value and development of up-and-coming technologies such as photovoltaics, wind, municipal solid waste incineration, and demand- and supply-side energy efficiency improvement options?

5) how will the conventional non-fossil fuel options, such as nuclear and hydroelectric technologies, be affected, and

6) from the externalities accounting perspective, what does the new legislation, based principally on a control cost view of the world, hold in store for a field of research and testing activity that appears to be moving in the direction of damage costs?

Damage and Health Costs as the Elusive Objective

In the Federal legislative arena and in the state activity thus far, control cost estimates have served as the surrogate, in the absence of any more accurate estimates, for the value of the environmental effects of generation technologies. The value of the damages to the environment imposed by technologies at each stage of the fuel cycle has yet to be accurately incorporated into the mainstream of externalities accounting methods. There are several reasons for the absence of accurate damage cost estimates that present frontier opportunities. First, as one might expect, different

interest groups value the effects of energy and the services that energy provides differently. The simplest example involves the way in which bass and trout fisherman value the damage created by the construction of a hydroelectric facility. Needless to say, the revealed preference approach to accounting for externalities leaves open the possibility of a wide range of responses.

The Challenges of Program Evaluation

With on-line externalities programs in several States and close to fifty percent of the public utility commissions in the nation considering environmental programs, there is a rapidly increasing need to develop measures to evaluate program performance. There are a number of fundamental questions to be answered in approaching the evaluation of externalities programs. First, the general question is: what would comprise an effective environmental externalities program? This question is best defined by the program objectives. Consider the possibility of achieving the ultimate goal, technology-neutral, market "value-based" planning and operations. To phrase the question differently, if a State were to evaluate an externalities program, what would it need to know? Some of the program evaluation criteria might include:

a. **Load Profile Effects?** (ie. Are programs moving load profiles away from baseload capacity units towards less reliable intermediate load facilities?)

b. **Supply Mix Effects?** (ie. What supply mix shifts will result from externalities programs, including coal to natural gas, coal to nuclear, nuclear and/or coal to other supply sources?)

c. **Demand-Side Effects?** (ie. Are utilities and customers participating at the desired rate of adoption for demand-side management in States where initiatives have been launched? Are programs causing demand-side management to reach levels of economic efficiency? What impediments remain (eg. first versus life-cycle cost)?)

d. **Supply- and Demand-Side Effects** (ie. What are the new supply-side options on the margin in states where externality initiatives are active? and are DSM incentives in reality competing at the margin with the renewable energy technologies?)

e. **Economic Indicators?** (ie. What effects will programs have on energy prices and the distribution of risks between ratepayers, investors, taxpayers, and others?)

f. **Business As Usual Forecasts?** (ie. What would happen under normal operating conditions in the absence of externalities programs?)

g. **Ecosystem Effects?** (ie. How do we best measure the results of externalities programs on the environment? Which indicators should be those on which to concentrate?

h. **Distributional Effects?** (ie. How will the programs affect different interest groups, including utilities, ratepayers, investors, taxpayers, and others?)

i. **Social System Effects?** (ie. What effects will programs have on development, social programs and services, elderly and handicapped citizens, and other societal concerns?)

j. **Utility Investment Effects?** (ie. Where will utility investment portfolios shift in the future as a result of programs, towards diversification, towards lower risk investments, towards environmental management, etc.?)

k. **Engineering/Research Effects?** (ie. Where will research and development efforts concentrate as a result of programs? and where should one expect to see innovative advances?)

l. **Communication Effects?** (ie. Is the value of externalities and the effects of programs being expressed in such a way as to influence consumer and utility behavior?

These are some of the questions that must be answered collectively in evaluating environmental externalities programs. All the answers are not known, but it is essential to continue a program aimed at obtaining accurate responses. The information acquisition process for resolving these uncertainties starts with the field data from the States and others, followed by ongoing synthesis and integrative analysis conducted by many organizations.

Conclusions

Recall that one of our ultimate objectives in the U.S. DOE Integrated Resource Planning Program is the development of technology-neutral, market value-based planning and operations. To accomplish this, we need to ensure markets are free to make optimum economic and environmental investment decisions, promote availability of a rich set of reliable energy supply and demand options at reasonable costs, and encourage consideration of full fuel cycle costs and benefits.

There are a number of options for accomplishing these objectives, and a framework is in place for pursuing these alternatives. A second important deduction is that initial findings suggest cost-effective power and capacity, reliability, environmentally sound operations, and utility profitability at equitable prices are not mutually exclusive objectives. Moreover it must be recognized that the answers to the large set of remaining uncertainties can only be generated in a collective process where local, State, regional, and Federal efforts are pooled into a cohesive whole The answers lie in the recognition that different problems require different analytical and policy treatments. States offer some of the best test-bed opportunities for solving practical problems with approaches to externalities, whereas, the Federal government may be able to complement the State and regional activity with integrative research, analysis and legislative support.

There is consensus that any bottlenecks in the infrastructure often slow and discourage progress towards cost-effective investments on both the demand and supply sides of the equation. To mitigate this state of affairs a number of cooperative projects are underway aimed at assessing the options for refining regulatory structures to allow for proper accounting of externalities. It is also suggested that there are as yet untapped opportunities in each stage of the research, development, and demonstration process.

One of the most important observations to date is that States have again taken the lead in innovation and in developing and implementing accounting methods. The prowess of the States provides a number of opportunities to support these efforts through cooperative research, development, demonstration, and program evaluation projects.

A large number of uncertainties have been identified, and it is suggested that these can, and should, be viewed as opportunities. Included in the set of uncertainties are: definitional and boundary uncertainties, regulation, monitoring, and enforcement uncertainties, uncertainties as to how best to normalize amongst the on-line State and regional methods, uncertainties regarding the effects of new legislative activities at the Federal level, questions as to how best to capture the value of damage costs, and finally, opportunities to define the most appropriate criteria for evaluating programs.

The good news appears to outweigh the bad news on first inspection. There is now consensus among a large number of interested parties that the environmental costs and benefits of energy options can no longer be ignored or assumed through omission to be zero.

References

Rogers, Everett M. and Rekha Agarwala-Rogers (eds.), Communications in Organizations, New York, Free Press.

Berry, L. and E. Hirst. 1989. Recent Accomplishments of the U.S. Department of Energy's Least-Cost Utility Planning Program. ORNL/CON-288. Oak Ridge National Laboratory. Oak Ridge, TN.

Cavanaugh, R. 1986. "Least-Cost Planning Imperatives for Electric Utilities and Their Regulators." The Harvard Environmental Law Review, 10, no.2: 299-344. Cambridge, MA.

Center for Clean Air Policy. 1989. An Efficient Approach to Reducing Acid Rain, Prepared by the Center for Clean Air Policy. Washington, D.C.

Chernick, P. and E. Caverhill. 1989. The Valuation of Externalities from Energy Production, Delivery, and Use. PLC, Inc. A Report prepared for the Boston Gas Company. Boston, MA.

Congressional Budget Office. 1989. The Role of Technology and Conservation in Controlling Acid Rain. Staff Working Paper, Congressional Budget Office. Washington, D.C.

Dudek, D. 1988. Offsetting New CO_2 Emissions, Environmental Defense Fund. New York, NY.

Cohen, S., J. Eto, C. Goldman, J. Beldock, and G. Crandall. 1990. "A Survey of State Public Utility Commission Activities to Incorporate Environmental Externalities into Electric Utility Planning and Regulation." National Association of Regulatory Utility Commissioners, Washington, D.C.

---------- What States are Doing About Externalities. The Electricity Journal. July 1990. 24-35.

Geller, H., M. Ledbetter, E. Miller, and P. Miller. 1987. Acid Rain and Electricity Conservation. American Council for an Energy Efficient Economy and the Energy Conservation Coalition. Washington, D.C.

Goldman, C., E. Hirst, and F. Krause. 1989. Least-Cost Utility Planning in the Utility Sector: Progress and Challenges. Lawrence Berkeley and Oak Ridge National Laboratories. LBL-27130, ORNL/CON-284. Berkeley, CA. and Oak Ridge, TN.

Hohmeyer, O. 1988. Social Costs of Energy Consumption: The External Effects of Electricity Generation in the Federal Republic of Germany. Springer-Verlag. Berlin, FRG.

Koomey, J. 1990, "Comparative Analysis of Monetary Estimates of External Costs Associated with the Combustion of Fossil Fuels." Lawrence Berkeley Laboratory. Berkeley, CA.

Krause, F., W. Bach, and J. Koomey. 1989. Energy Policy in the Greenhouse. Volume One: From Warming Fate to Warming Limit: Benchmarks for a Global Climate Convention. Published by the International Project for Sustainable Energy Paths in conjunction with the European Environmental Bureau. El Cerrito, CA.

Moskovitz, D. 1989. Profits & Progress Through Least-Cost Planning. National Association of Regulatory Utility Commissioners. Washington, D.C.

New York State Energy Office. 1989. Environmental Externalities Issue Report. New York State Energy Office, Division of Policy Analysis and Planning. Albany, N.Y.

Pace University Center for Environmental Legal Studies. 1990. Environmental Costs of Electricity. Oceana Publications. Dobbs Ferry, NY.

Public Utilities Commission of Ohio. 1990. Including Societal Benefits in Rates for Cogeneration and Small Power Production: Prepared by the Public Utilities Commission of Ohio with the Assistance of Battelle Memorial Institute and the Cincinnati Gas and Electric Company. Columbus, OH.

Rosenfeld A. and R. Mowris. 1989. Energy Efficiency: The Best Way to Save Money and Slow Global Warming. Testimony for the Hearing on an Integrated National Energy Efficiency Strategy, U.S. House of Representatives, Committee on Energy and Commerce, Subcommittee on Energy and Power. Berkeley, CA.

United States Department of Energy. 1989. A Preliminary Analysis of U.S. CO_2 Emissions Reduction Potential from Energy Conservation and the Substitution of Natural Gas for Coal in the Period to 2010. DOE/NBB-0085, prepared for the U.S. DOE Office of Energy Research, Office of Basic Energy Sciences, Carbon Dioxide Research Division. Washington, D.C.

U.S. Department of Energy. 1988. Energy Technologies & the Environment: Environment Information Handbook. DOE/EH-0077. Washington, D.C.

U.S. Environmental Protection Agency. 1989. Policy Options for Stabilizing Global Climate: Draft Report to Congress, Office of Policy, Planning, and Evaluation. Washington, D.C.

Wiel, S. 1989. "Making Electric Efficiency Profitable." Public Utilities Fortnightly, July 6, 1989. Arlington, VA.

CONSIDERING SOCIAL COSTS IN UTILITY DECISIONMAKING:

ALTERNATIVE APPROACHES AND IMPLEMENTATION

Prepared for:

NARUC ENVIRONMENTAL EXTERNALITIES CONFERENCE

Panel on "Externalities: Federal Views, Social Costs, and Environmental Assessment Regulations"

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TABLE OF CONTENTS

		Page
1.0	INTRODUCTION - CHALLENGES AND OPPORTUNITIES	1
2.0	A REVIEW OF METHODS FOR QUANTIFYING SOCIAL COSTS	3
2.1	Overview	3
2.2	Framework and Review of Analytic Techniques	4
	1) Description and Characterization of Impacts	4
	2) Ranking and Weighting of Social Costs	5
	3) Cost of Control or Abatement	6
	4) Full Costing of Externalities	8
	5) Strengths and Weaknesses of Methods	9
3.0	METHODS FOR INTEGRATING SOCIAL COSTS INTO UTILITY BIDDING SYSTEMS	16
3.1	Overview	16
3.2	Different Methods of Accounting for Attributes Affect Outcomes	22
4.0	UTILITY AND REGULATORY PERSPECTIVES ON SOCIAL COSTS	24
4.1	The Utility Challenge	24
4.2	The Regulatory Challenge	25
4.3	Resolving the Utility/Regulatory Challenge on the Valuation and Implementation of Social Costs	26
	1) Total Costs	28
	2) Mandate	29
	3) Capability	29
5.0	SUMMARY AND CONCLUSIONS	30
	BIBLIOGRAPHY	32

"Make environmental considerations and concerns part of any decision you make right from the beginning. Don't think of it as something extra you throw in the pot."

Richard Clarke, CEO,
Pacific Gas and Electric Company,
Fortune magazine, April 1990.

"...at the risk of painting ourselves more into the corner of New Thinking than we already are, we would counsel utilities to pay attention, whether they like what they are hearing about 'externalities' or not."

Editorial appearing in
The Electricity Journal,
July 1990.

1.0 INTRODUCTION - CHALLENGES AND OPPORTUNITIES

Today, the need to account for the environmental ramifications of energy production has become more acute. Mounting evidence suggests that the biosphere is incapable of sustaining much more human waste, pollution or deforestation without dramatic consequences. Furthermore, there is a growing understanding that damage to the global environment and the ecological systems in which we all live could be permanent and irreversible.

This concern is amplified by the fact that nationwide, the country will need nearly 100,000 MW of additional electricity generating capacity by the year 1998 -- less than 8 years from now. Shortages have already occurred in New England, the mid-Atlantic states and other parts of the U.S., and the reserve margins in the Midwest are declining at uncomfortable rates.[1] In addition to the reliability issue, in some states such as California, new capacity will be required to replace aging oil and gas-fired plants or to meet air quality standards.

Policy decisions made in the 1990's will determine the impact of future growth, cost, and environmental issues on the supply of energy. These choices will involve long and enduring environmental consequences -- the typical fossil fuel or nuclear power facility has an expected operating life of 30 years or more. The lifetime of some air pollutants and other related impacts can last much longer. Within such a long life expectancy, even more stringent environmental laws and regulations are virtually certain. Regulators are now espousing new concepts in integrated resource planning, least-cost power planning, and competitive bidding strategies.

Some analysts believe that environmental externalities must be captured through the regulatory arena where the decisions on technology, production and pollution are being made. Because externalities have substantial effects on costs and are not considered in the current planning process, the selection of supply resources may not be appropriate. The absence of renewable energy technologies as a significant component of utility planning is a prime example of this. Market introduction of new energy technologies based on renewable energy sources such as wind

[1] Fifteen of the 27 geographic electric regions in the U.S. are projected to have adjusted summer reserves of 5% or less. Many of these reserve margins extend to sharp negative figures ranging from -2.0% to -18.6% throughout this decade. The areas at greatest risk extend from New England, through the Northeast, Mid-Atlantic, and into the East Central U.S., parts of the South and Florida (Staff Report: Electric Power Supply and Demand for the Contiguous U.S. 1989-1998, Office of Energy Emergencies, U.S. Department of Energy, Table 3.3, page 3-8.)

or photovoltaic systems depends largely on the market price of the energy supplied by the new technologies. As long as the environmental costs associated with conventional energy technologies are not considered, the viability and market penetration of utility-scale renewable energy applications and other cleaner technologies will be delayed.

Regulators are now seriously considering the inclusion of environmental and other hidden costs into power planning processes to influence the selection of cleaner technologies. For example, the state of New York is pioneering this approach under an innovative program where a competitive market is being set up for power supply contracts. Suppliers planning to burn fossil fuels are required to add a factor (using points) that is equivalent to nearly one-cent-per-kilowatt-hour to their bids to account for air pollution, and an additional factor of a half-cent-per-kilowatt-hour to account for other environmental costs.

This paper is based on a review of social costs conducted by Meridian Corporation for a private sector client in the utility industry to identify the current procedural and methodological approaches to quantifying and pricing externalities.[2] This paper examines various state-of-the-art methodologies used in measuring externalities and reviews a number of approaches that are either underway or under consideration by various utilities to translate these values into an environmental attribute.

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[2]This paper is based on an earlier study performed for a private sector utility client. The authors wish to acknowledge their colleagues, Ken Boras, Kevin DeGroat, Ken Green, Deborah Kelly, and Mac Rogers, who provided valuable input and review of this paper.

2.0 A REVIEW OF METHODS FOR QUANTIFYING SOCIAL COSTS

2.1 Overview

This section reviews methods that are being developed or practiced to account for social costs[3] in considering future energy options. For policymakers to provide power and energy products at the lowest social cost and to ensure economically efficient energy resource decisions, it is necessary to quantify and, to the extent possible, price the environmental and other externalities associated with energy resources.

A review of current literature revealed some of the difficulties in valuing social impacts. There is an inherent difficulty in establishing values for environmental effects that are not traded in markets, and therefore, have no established price. For example, placing a value on smoke from a power plant which may obscure views, create respiratory problems, or lead to acid rain is a highly complicated and subjective process.

The most common technique for placing values on these externalities has been through the "damage cost function." This method involves the straightforward calculation of damages by multiplying the unit market price or replacement cost of a commodity (e.g., fish in a lake) by the number of units of the commodity impacts. Other methods take into account that individuals are aware of pollution-caused damage and are thus capable of responding to these damages. Economists have relied on "indirect links" to measure willingness-to-pay for environmental quality through such techniques as hedonic property value and travel cost measurement approaches. On the other hand, if this information is not available, economists have elicited willingness-to-pay values based on "direct links" obtained through surveys and interviews using contingent valuation measurement approaches.[4]

Some authors have cautioned against trying to put too much information into one value. The alternative is to develop a range of plausible environmental costs for various energy production technologies, stating that:

> "Environmental analyses can easily be abused by proponents or opponents of a given technology if the many uncertainties in the analysis are collapsed into a single cost figure....While this does not mean that an environmental analysis should embrace every numerical estimate, no matter how implausible, it should nevertheless try to preserve legitimate uncertainties wherever possible." (Shuman and Cavanaugh)

Further, choosing an appropriate discount rate is also critical in valuing externalities, particularly for inter-generational issues. Discount rates are used to compare future economic benefits and costs with today's benefits and costs and imply a subjective valuation of present versus future use of resources. A low discount rate is often viewed as weighing the future more heavily and high

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[3]Definition of Terms: For this analysis, external or social costs relate to any cost or impacts which are not directly paid for in the process of energy production or use. An internalized cost, on the other hand, is one which is paid for during the building or operation of the energy conversion technology such as the cost of scrubbers, which partially cleans the air emissions from the plant. The cost of scrubbers is included in the estimate of a coal plant's cost per kilowatt-hour. One externalized cost of a coal plant, for example, is the acid rain that results from only partially cleaning the air emissions from the plants. This is a cost borne by society, which is not normally included in the cost per kilowatt-hour of a coal plant.

[4]Energy and Resource Consultants, Inc, *Benefits of Environmental Controls: Measures, Methods, and Applications*, prepared for the Electric Power Research Institute, EPRI EA-6030, Project 2661-10, October 1988.

discount rates reduce the weight given to future costs and benefits. The process of discounting damage in the form of human injury or mortality has the effect of encouraging investments in technologies with delayed but likely adverse health effects.[5] Failure to choose a rate which reflects the policy perception of the relative importance of short-term versus long-term costs and benefits of externalities, may significantly distort the analyses' results.

2.2 Framework and Review of Analytic Techniques

The Northwest Power Planning Council's (NPPC)[6] series of assessment options provides a good analytical framework for reviewing techniques that are being used to examine social costs. In the following sections, a similar approach is taken to categorize the following type of analyses:

1. Description and Characterization of Impacts
2. Relative Ranking of Social Costs
3. Costing of Control Efforts
4. Full Costing of Externalities

This grouping spans a continuum with each study requiring more detail and effort involved in evaluating social cost. Like the Council's approach, categories are not always exclusive; however, it does provide a good sampling of state-of-the-art techniques available for quantifying externalities.

1) Description and Characterization of Impacts

DESCRIPTION: This category is similar to the Northwest Power Planning Council (NPPC) Assessment Option 1 which states that such efforts "would not delve into pathways or valuations of the environmental effects, but would simply describe and characterize the impacts." The resulting descriptions of environmental effects might include: description of the primary effect (e.g., release of sulfur oxides); significant consequences (e.g., lake acidification, forest dieback, property degradation, human health effects); and means and effectiveness of mitigation (e.g., scrubbers, low sulfur coal). Costs, however, are not specifically calculated. The NPPC also states that this information would assist in flagging environmental problems that have not been adequately addressed by regulating agencies or the Council and therefore may merit further attention.

This type of cost comparison is depicted in Exhibit 3. While *Resource B* would generally be selected by the market, the inclusion of additional information permits a renewed consideration of *Resource A*.

Although this category does not include any work on the valuation of impacts, those studies that describe and characterize impacts were deemed important, and were therefore included.

SUMMARY OF STUDIES: The first study, *Environmental Effects of Electricity Generation*, by the Organization for Economic Cooperation and Development, develops estimates on air pollutants for the generation stage for electric generating technologies and makes general recommendations for

[5] Some analysts (Pace University Report) believe that the discounting of future environmental costs and benefits should be from the time when risks are first created, not from the time when the actual environmental effects are expected to occur. For example, health risks are created when people are first exposed to toxic substances. The value of those risks should be discounted from the time that exposure first occurs, not from the time when cancer or other diseases first become evident.

[6] Northwest Power Planning Council, *Accounting for the Environmental Consequences of ELectricity Resources During the Power Planning Process*, April 1989.

environmental strategies, e.g., increased efficiency, substitution of cleaner technologies for older, less efficient ones, increased waste heat utilization, and increased pursuit of renewable energy technologies.

The second set of studies, *Energy Systems Emissions and Material Requirements* and *Environmental Emissions from Energy Technology Systems: The Total Fuel Cycle*, by Meridian Coporation, improves state-of-the-art knowledge by quantifying and comparing emissions for up to 14 generating technologies using a life-cycle approach. It points out the environmental advantage of a material-intensive technology such as photovoltaics compared with a fuel-intensive system such as coal.

The third is a model, which has been developed by the Oko Institute, by compiling standard energy and emission-related data for fuel cycles of various energy systems which provide space heating and electricity. The objective is to provide a computerized data base to provide a method for comparative assessment of energy systems, based on one unit of delivered energy, and to develop options for integrating non-comparative and qualitative impacts of energy systems into the decision-making process. The authors stress that this model is descriptive rather than prescriptive and is not meant to free decisionmakers from their responsibility to value environmental effects, but is to enhance available information and present it in a form that can support the decision process.

OBSERVATIONS AND IMPLICATIONS: The importance of this approach cannot be underestimated, as it forms the basis for any detailed analysis of externalities. Efforts such as these are required to determine the full range of effects. However, these methodologies are not prescriptive in terms of amelioration methods. The approach can only deal with nonquantifiable issues in the most general of terms. Such an approach may end up overwhelming the decision-making process with a flood of new information without prescribing methods for trading off dissimilar attributes.

This research could be used to develop qualitative information and then combined with making a subjective rank-ordering of resources by environmental impact, which is what the NPPC ultimately decided to do.

2) Ranking and Weighting of Social Costs

DESCRIPTION: The studies in this category describe ranking procedures for various energy resources to reveal which resources are most or least environmentally damaging. Such approaches may simply use qualitative or subjective judgment to aid in ranking resources, or may rely on quite rigorous cost information. Through the use of adjustment factors or adders, divergent impacts are weighted to explicitly rank resources.

SUMMARY OF STUDIES: The first study is a methodology developed by the California Energy Commission (CEC) designed to take advantage of early land use planning and environmental impact analysis methods. Its pursues an exhaustive list of costs, including the usual private costs (capital, operation, and fuel) as well as government subsidies, environmental impacts, and issues of economic development and system reliability/security. The authors deliberately take a qualitative approach by developing a relative ranking scale to establish broad boundary limits rather than making specific cost assumptions.

The second study in this category was developed by Temple, Barker, and Sloane, Inc. (TBS) for New England Electric. The TBS study goes a step further than the CEC work by attempting to specifically evaluate characteristics in a bidding framework. The TBS methodology is a highly

developed ranking and weighting scheme and attempts to simultaneously consider a number of disparate environmental and operating characteristics.

In developing this approach, TBS reviewed a number of qualitative and quantitative methods. They decided to value environmental categories and develop weights for other characteristics through a combination of simple Delphi survey techniques and a limited amount of existing environmental costing data. Eleven surveys were completed by environmental professionals both at the primary level (where respondents weighted individual environmental effects) and the secondary level (where respondents assessed the total environmental score). They found that while sources used to develop factor weights were not necessarily consistent in the implied or stated weights, they did exhibit consistency in the relative weighting of environmental issues.

The third methodology reviewed for this category was a study performed for the Bonneville Power Administration (BPA) to evaluate five generating resources.[7] The investigators relied on very rigorous costing methods to evaluate a broad range of external effects, and arranged the information to display the effect it would have on power resource selection. This approach essentially worked in reverse from a sampling of existing sources to develop a sensitivity test, or set of "switch points," that explicitly showed how large social costs would have to rise before resources switched place in the least-cost portfolio.

OBSERVATIONS AND IMPLICATIONS: Because of the difficulties involved in full costing measures (see following sections), the attempt to develop relative values for resource options may be the best way to build consensus on the weighting of different resources in an energy pricing evaluation. In practical terms, any evaluation of social costs may have to be translated in some fashion through ranking or weighting approaches, particularly since many operational characteristics (such as dispatchability, diversity, and reliability) may be difficult to accurately represent through dollar values.

The amount of subjectivity in such approaches may vary enormously. While ranking and weighting techniques may simplify the evaluation process, they may also obscure a significant amount of detail. The apparent objectivity of the resulting framework may create a false sense of accuracy. The potential pitfalls in arranging information in this way will depend on whether the results are rigidly prescriptive or merely suggestive.

Such ranking may only be applicable within a relevant range. The relative weights or ranks developed are somewhat a function of the existing resource mix and will not remain static as new resources with different characteristics are selected.

3) Cost of Control or Abatement

DESCRIPTION: This option, rather than actually attempting to calculate the costs of environmental effects resulting from energy production and use, starts with basic assumptions about the preferred level of damage. It then ranks energy sources in terms of the costs required for the emission control technologies needed to meet those assumed or accepted standards. Thus, current (or proposed) emission standards are used as a proxy for the social costs.

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[7] ECO Northwest, Ltd.; Shapiro and Associates, Inc.; and Seton, Johnson, and Odell, Inc. *Estimating Environmental Costs and Benefits for Five Generating Resources.* Prepared for Bonneville Power Administration under a Multiple-Award Contract Agreement with the U.S. Department of Energy (Contract DE-AC79-83BP11551). March 1986.

Conversely, if control costs are not known with accuracy, or are not regulated, the estimated costs of abating emissions through another approach may be substituted. In the case of CO_2, for instance, the cost of reforestation to absorb CO_2 could serve as a proxy. For other emissions, abatement through the purchase of offsets may be less expensive than scrubber technologies. Such an approach essentially depends on administratively defined levels of desired emissions.

SUMMARY OF STUDIES: This approach, being applied in New York in varying degrees by the State Energy Office and Public Service Commission, is the use of abatement costs as indirect measures of the values of air quality impacts. According to this line of thinking, optimal air quality control policy sets emission limits where the marginal costs of abatement are equal to the marginal benefits (where these benefits are conceptually the same as the external costs associated with the emission). Thus, the abatement costs associated with a given emission (say, NO_x) can be used as a proxy for the external costs of the emission. In this case, the cost of control or abatement of various stack emissions was used as a comparison to environmental damage estimates from other sources to estimate a probable cost for damage.

Some authors, Sebold et al., give some reasons as to why there are a variety of conceptual and practical problems associated with this use of abatement costs:

> "First, any reasonable approach to valuing air quality impacts must recognize the variation in the value of changes in air quality across air basins resulting from differences in air chemistry, topography, geography, and target populations. However, air quality standards (abatement levels) are generally set at the national level. Even if these national standards are based on careful calculations of costs and benefits, it is highly unlikely that the resultant abatement levels are optimal in each air basin. This means that abatement costs may be well above the benefits of abatement (the external costs of the emissions) in some air basins and considerably below in others. Second, even within an air basin, the abatement cost for a given emission may vary significantly across sources. For instance, NERA (1988) has estimated the cost of NO_x controls in California's South Coast Air Basin to range from $8,800 per ton for petroleum refineries to $42,600 per ton for electric utilities. Assuming that the external cost of a ton of NO_x is the same across sources within a basin (and all other factors remain constant), it is unclear which abatement cost level (if any) should be chosen to reflect the external social costs of this emission."

OBSERVATIONS AND IMPLICATIONS: While this approach has strong merits, its assumption that current control standards are an accurate indicator of social costs is in some ways a default mechanism. Thus, using information on pollutant control costs as a proxy for additional controls assumes that the current control level has some firm relationship to actual social costs; this may not be the case. Also, the cost of removing the final increments of a pollutant may not be the same as the costs for removing the first increments, weakening its validity as a proxy. However, the information on control costs is often much more straightforward, clearly definable, and generally more readily available than specific information on the value of environmental damage. An added benefit is that the parameters of the impacts considered are very clearly defined.

In the case of CO_2, the absence of measured or defined levels of current impacts makes it very difficult to quantify possible effects, but information on amelioration through reforestation can be used to develop benchmarks. Even if full damage costs are never known, a reasonable inference can be made as to whether the damage costs are greater, or less than, the known cost of reforestation. Finally, the use of emission standards may underestimate costs, as emission damages and affected populations -- and thus the economic costs -- vary considerably across air basins.

4) Full Costing of Externalities

DESCRIPTION: This assessment option involves developing methods of identifying the environmental impacts of alternative generating resources and developing a rigorous means of valuing the associated damages. Such costs may then be used to develop, for example, environmental credits for particularly benign resources, or conversely, a cost penalty for key unmitigated pollutants.

SUMMARY OF STUDIES: These full costing studies vary in detail and intent. Full costing studies are an ongoing effort at the BPA, and their efforts are among the most rigorous. They examine impacts, dispersion, exposure, and valuation in a number of site-specific and generic studies on valuing the social costs associated with power plants.

A recent memo from BPA summarizes their findings on cost ranges, and indicate that 80 to 95 percent of local economic damage attributable to fossil fuel combustion is accounted for by health risks. Even with low sulfur coal and remote siting in the West, coal plants can be expected to impose levelized environmental costs of between 2-10 mills per kWh for health risks alone. This does not include costs associated with acid rain, ozone depletion, and global warming.

As stated earlier, Olav Hohmeyer of the Fraunhofer Institute in West Germany completed a detailed full costing study of impacts in that country in 1988. In addition to social costs themselves, his analysis also addresses the delay imposed on the development of many renewable energy technologies that results from the failure to account for the social costs of conventional energy sources.

The Pace University study is a review of studies that quantified the externality costs of environmental damage caused by electric power services. Externalities were reviewed for coal, oil natural gas, nuclear, renewables, and demand-side management resources. Pollutants examined included CO_2 and global warming, acid rain and its precursors (sulphur dioxide and nitrogen oxides), ozone, and NO_x pollution, particulates, radiation damage from operation of nuclear power plants, water pollution and land contamination risks. Types of environmental impacts of electric power included effects on individuals (health), production (effects on agricultural crops, forests and fisheries), materials (effects on buildings and structural metals), and social assets (effects on recreation, wetlands, and visibility).

Environmental externality values were calculated for "starting point" values. The report states that these values were used because "the figures do not pretend to be cost estimates," rather they do give an order-of-magnitude idea of what the studies reviewed indicate and should provide a good starting point for research. The "starting point" externalities for coal-fired facilities range from 2.5 - 5.7 cents/kWh; 2.5 - 6.7 cents/kWh for oil-fired; 0.7 - 1 cent/kWh for natural gas-fired; 2.91 cents/kWh for nuclear; 2.79 - 2.88 cents/kWh for waste-to-energy plants; and 0-0.7 cents/kWh for renewables (solar, wind, and biomass).

Despite uncertainties and data gaps, the study concludes that "... the environmental externality damage costs of most electric utility-generated pollution can be calculated, and that the uncertainties involved are no greater than the uncertainty of pollution standards adopted by federal and state agencies (and upheld by the courts) to avoid 'significant risk to human health and the environment' or 'with a reasonable margin of safety' as prescribed by the environmental protection statutes."

The study states that if these costs are not considered, it is akin to "...allowing electric utilities to account for their environmental impacts merely by requiring them to meet applicable governmental environmental laws and regulations, ignoring the externality costs of these impacts to society, effectively values these substantial damages at the clearly inaccurate value of zero."

The study makes a case for the incorporation of all environmental externality costs in planning, bidding, and other resource selection, recommends an assessment of residual environmental externality cost against resources selected, to be placed in a Pollution Mitigation and Demand-Side Management Fund, as well as testing "environmental dispatch" where clean sources are used before dirtier generating sources.

OBSERVATIONS AND IMPLICATIONS: One inherent difficulty in this approach is reaching a consensus on which cost measures to include and in what detail. Even if all aspects and theoretical links are known, it is difficult and expensive to produce accurate data to fill in the theoretical framework. This results in a need to make tradeoffs between the veracity of the selected methodology, staffing, and budget constraints.

5) Strengths and Weaknesses of Methods

Any and all of the methodological categories described in this paper can result in useful approaches to the problem of accounting for externalities. Within any of these categories, the individual design of the methodology remains most important. The value of a particular methodology ultimately depends on the assumptions made, the level of detail required, and the care taken in putting it all together. A summary of the methodologies reviewed in this report is included as Exhibits 1 and 2.

A visual representation of the four categories of methodologies presented is included in Exhibit 3. In this diagram, two of the most important characteristics of the methodologies graphically represent some of the tradeoffs inherent in the selection of a methodology. The X-axis represents the relative cost and complexity of the method, while the Y-axis scales the relative degree of accuracy (or avoidance of subjectivity) each approach provides.

"**Description and Characterization of Impacts**" methodologies are relatively low on both scales. Such approaches are relatively simple, but provide few answers to the many questions they raise.

"**Ranking and Weighting**" schemes introduce more complexity, but presumably provide some guidance in how resource options stack up against each other. Most of the increase in apparent "accuracy" is a function of increased subjectivity, and thus may be suspect. However, the careful design of such a methodology can provide a consistent approach to the complete unbundling of a disparate range of attributes.

"**Cost of Control**" techniques lend themselves very well to the problem of awarding price factors to certain attributes. Avoiding the subjectivity of ranking and weighting essentially requires deferring judgment to the will of regulatory bodies, but results in an effective translation of the regulatory mandate. However, certain attributes may still need to be described through ranking and weighting approaches.

"**Full Costing**" approaches -- the most expensive and complex -- purport to provide the most accurate view of the true cost of power. The implicit question raised is whether the marginal increase in accuracy is worth the increase in complexity (a complex trade-off problem).

Estimates of social costs by generating technology from various studies are summarized in Exhibit 4.

Exhibit 1

METHODOLOGICAL CATEGORIES

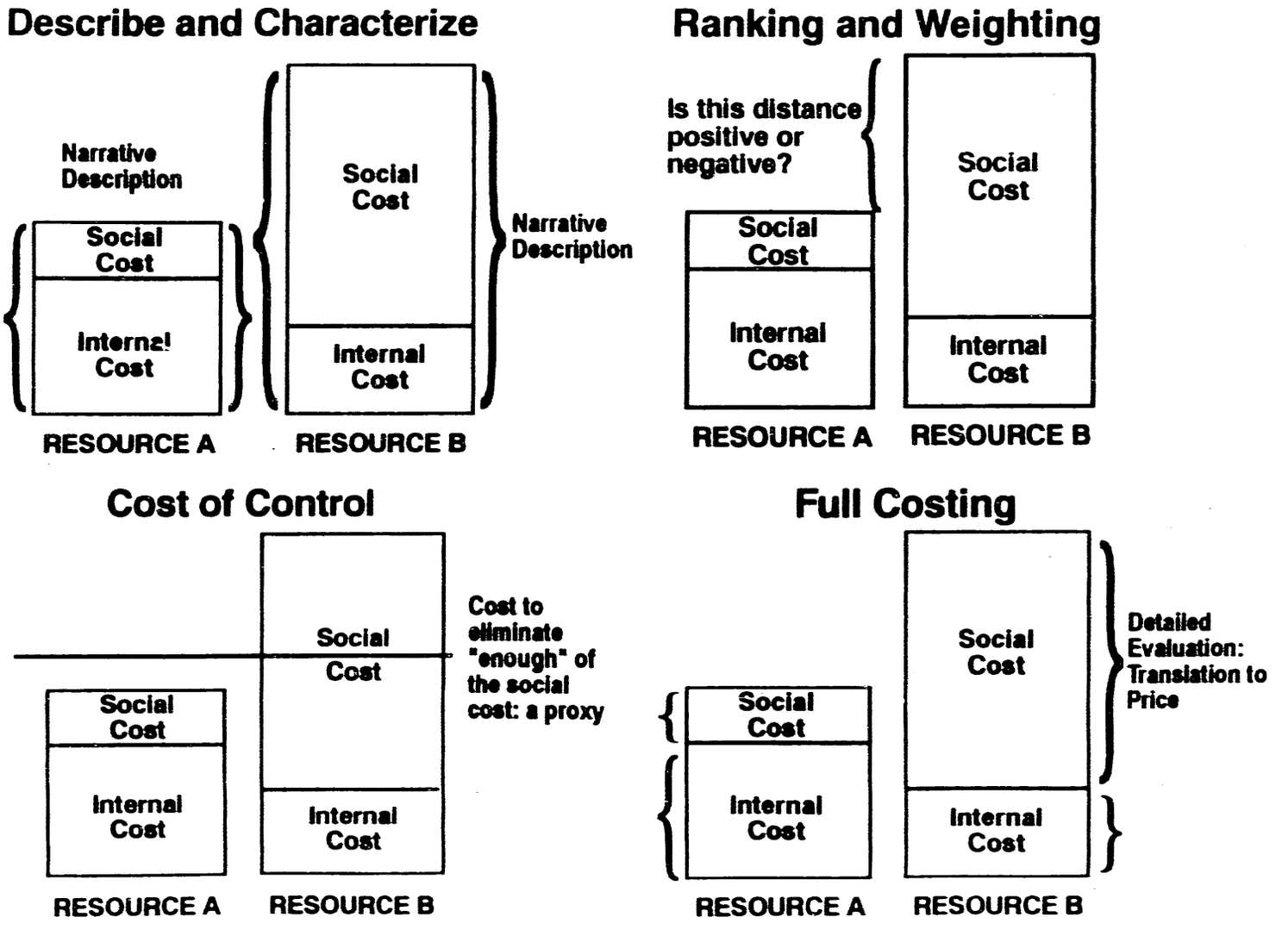


Exhibit 2

METHODOLOGIES TO ESTIMATE SOCIAL COSTS

Describe and Characterize

1. **Environmental Effects of Electricity Generation** - Describes the range and types of environmental impacts associated with electricity generation from various primary energy sources in both qualitative and quantitative terms.

2. **Energy System Emissions and Material Requirements and Environmental Emissions from Energy Technology Systems** - Quantifies and compares life-cycle emissions from various power generating technologies.

3. **Environmental Analysis of Energy Systems: The Total Emissions Model for Integrated Systems** - Fuel cycle energy and emissions data to assess and compare various energy systems.

Ranking and Weighting

1. **The Social Benefits and Costs of Electricity Generation and End-Use Technologies** - Focuses on the need for improved energy planning to incorporate social benefits and costs from generating technologies. Uses weighting criteria to value both the importance and magnitude of various impacts.

2. **Integrating Environmental Externalities into Resource Planning at New England Electric** - Develop a hybrid approach to weight environmental impacts.

Cost of Abatement

1. **Energy and Cleaner Air: Costs of Reducing Emissions** - Attempts to relate emissions abatement technologies and their costs.

2. **Environmental Externality Issue Report** - An evaluation of approaches to valuing environmental impacts and incorporating those values into state-level energy planning.

3. **Case 88-E-241 Proceedings on Motion of the Commission as to the Guidelines for Bidding to Meet Future Electricity Capacity Needs of Orange and Rockland Utilities** - A study of how environmental factors should be incorporated in the competitive bidding rate structure.

Full Costing

1. **Social Costs of Energy Consumption** - Externalities of Electricity Generation in the Federal Republic of Germany. Monetarizes environmental and economic costs upon society to demonstrate the need for internalizing social costs of electricity generation.

2. **Social Cost Priority Matrix** - Ranks survey-generated energy and environmental concerns. Also attempts to quantify associated social costs.

3. **Testimony and Exhibits of Michael Nicklas before the North Carolina Utility Commission or Least - Cost Integrated Resource Planning** - Utilizes a limited set of clearly quantifiable societal costs to determine least-cost power.

4. **Estimating Environmental Costs and Benefits for Five Generating Resources** - Estimates the economic value of environmental impacts from renewable power generating technologies. Identifies and analyzes impacts, then calculates the present value of expected environmental impacts.

5. **A Model Electric Power and Conservation Plan for the Pacific Northwest** - Uses low discount rates to analyze generic yet significant environmental impacts of coal, nuclear, and wind powered generation as well as solar water heating and household weatherization.

6. **A Methodology for Integrating Air Quality Impacts into Energy Resource Planning** - This is a review of the conceptual role of social costs in the competitive bidding process. Recommends values for air quality impacts and integrates these values into bid rating structures.

7. **Environmental Costs of Electricity (Pace University)** - This report reviewed the literature on the methodologies used to assign monetary costs to environmental externalities and the means by which federal and state legislatures and regulatory authorities have incorporated and might incorporate environmental costs.

Exhibit 3

Trade-offs Between These Approaches

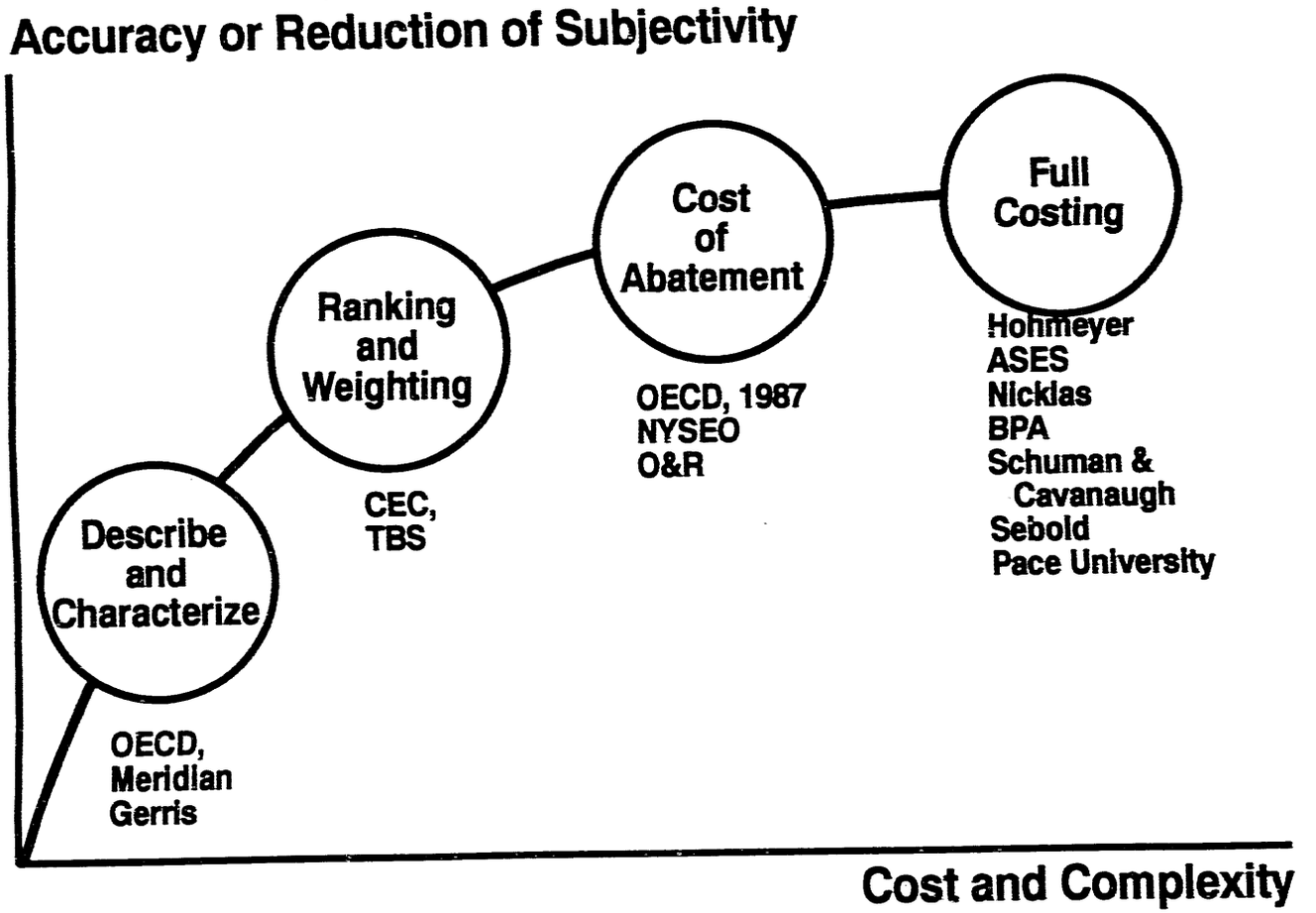


Exhibit 4

Environmental Externality Estimates by Source and Generation Technology (cents per kWh - 1989 Dollars)

	Low-High	Hohmeyer[a]	Pace	BPA	Other
Fossil and Nuclear					
Combustion Turbine: Gas	0.09 - 2.8	0.53 - 2.8	0.7 - 1	0.09	X
Combustion Turbine: Oil	0.28 - 6.7	0.53 - 2.8	2.5 - 6.7	0.28	X
Coal	0.04 - 25.81	0.53 - 2.8	2.5 - 5.7	0.72 - 1.07	0.04 - 25.81
Nuclear	0.001 - 37.78	0.5537 - 5.5371	2.91	0.001 - 0.014	0.06 - 37.78
Renewables					
Photovoltaic	0 - 0.4	0 - 0.204	0 - 0.4	X	0 - 0.15
Wind	0 - 0.15	0 - 0.0042	0 - 0.1	X	0 - 0.15
Biomass	-0.012 - 0.7	X	0 - 0.7	-0.012[b] - 0.55	X
Geothermal	0 - 0.02	X	X	0 - 0.02	X
MSW	-3.56 - 46.56	X	2.79 - 2.8	-3.56[c] - 46.56	X

REFERENCES:

The following studies were examined to begin the process of developing ranges for social costs: Olav Hohmeyer's *The Social Costs of Energy Consumption*; Richard Ottinger et. al., *Environmental Costs of Energy*, Pace University; three studies undertaken for the Bonneville Power Administration entitled 1) *Estimating Environmental Costs and Benefits for Five Generating Resources, 2) Generic Coal Study: Quantification and Valuation of Environmental Impacts, and 3) Environmental Cost and Benefits Case Study: Nuclear Power Plant -- Quantification and Economic Valuation of Selected Environmental Impacts/Effects*. Other studies examined include: Mike Nicklas's *Testimony and Exhibits Before the North Carolina Utility Commission on Least-Cost Integrated Resources Planning* and Shuman and Cavanaugh's *A Model Electric Power and Conservation Plan for the Northwest*.

[a] Hohmeyer does not separate fossil fuel impacts by technology but provides an estimate for average of fossil fuel technologies.

[b] More complete and cleaner burning of forest slash in cogenerator will replace less-complete burning of piled slash in the forest and thus have a net benefit in visibility impacts.

[c] The minus (-) sign denotes a negative cost, or benefit, e.g., waste-to-energy systems have benefits associated with their use such as the reduced need for landfill space.

3.0 METHODS FOR INTEGRATING SOCIAL COSTS INTO UTILITY BIDDING SYSTEMS

3.1 Overview

One area in which some efforts have already been made to incorporate externalities into utility planning is the competitive bidding process for power purchase agreements. This section will give an overview of some of the specific techiques taken.

Competitive bidding for new electric generation by private power producers is becoming an increasingly important feature of utility resource planning and represents a major departure from the historical practices of the electric utility industry in which new generating resources were constructed by vertically integrated utilities. Competitive power procurement may fundamentally reshape the market for power producing technologies.

In some states multiattribute systems, which take into account externalities as well as direct financial resources costs, are being considered as a means of improving allocation.

The design of bid evaluation systems is a challenging task because it requires the explicit valuation of many "non-price" factors in utility planning. All bidding systems require that these non-price factors or attributes which had not been previously priced in the market such as fuel diversity and risk, dispatchability, and environmental impacts be valued explicitly and independently. The multiple attributes are then simultaneously evaluated in order to arrive at the best outcome for long-term power contracts. The design of bidding systems allows the utility to retain an overriding influence in the final selection of a generating system.

The introduction of external cost information into utility bidding systems can be accomplished through various methods. Methods already discussed, such as ranking and weighting, abatement cost approaches, and economic valuation of damage costs (full costing), combine the actual resource selection process with the social costing methodology; others do not. Following is a brief overview of other implementation options, and a discussion of some of their strengths and weaknesses.

QUOTA SYSTEMS - or "rule-based" approaches involve the design of bidding systems so that a certain portion of capacity requirements are filled by technologies with relatively favorable external effects. For instance, the Wisconsin PUC chose a rule-based approach when it elected to give noncombustion resources like hydroelectric and conservation a 15 percent advantage. Rules can also be used to limit the absolute amount of a particular resource that would be accepted in a portfolio or in a resource bid.

By making the assumption that the optimal mix of resources is known, the (relatively) positive aspects of particular resource options are exaggerated without equally considering their (relative) shortcomings. Such approaches may preclude established forms of energy prematurely, and do not solve the problem of how to select dissimilar or even similar proposals in a bid. While fairly easy to implement, it neither avoids or solves the problem of valuation.

POINT SYSTEMS - points are allocated to technologies on the basis of their associated externalities to reduce external and non-price effects to consistent score. Planners faced with monetary bids and point scores for each resource option are still faced with the difficult trade-offs between points and price.

Despite reducing bid factors to points, methodologies must be evaluated to ensure that the **nominal** weight awarded to a category does in fact survive methodological processing in its intended form

and that categories do not cancel themselves out in such a way to render the actual weight meaningless. Kahn et al., has shown that despite the point systems for these externalities, many decisions basically are made on the basis of price.

SIMPLE RULES OF THUMB - Sebold et al., state that perhaps as a natural reaction to the complexity of the problem, some individuals have suggested the use of simple rules of thumb for valuation. For instance, some analysts in California have suggested that air quality impacts be quantified in terms of a single primary emission, NO_x, and that a rough reference value of this emission (say $20,000 per ton) be used for valuation.[8]

The use of several of these approaches is traced in more detail through the following review of several actual case approaches for applying social costing methods into utility bidding: 1) The New York/Orange and Rockland case which uses cost of control; 2) Sebold and Thayer's approach to the possible use of full costing procedures; and, 3) New England Electric System's approach which uses a ranking and weighting approach.

1. Proceedings on Motion of the New York Public Service Commission as to the Guidelines for Bidding to Meet Future Capacity Needs of Orange and Rockland Utilities (USE OF COST OF CONTROL TECHNIQUES)

In June 1988, the New York State Public Service Commission (NYSPSC) requested (in Opinion 88-15) that the state's electric utilities file a Draft Environmental Impact Statement (DGEIS) in order to assess the potential environmental impact of utility bidding procedures. This utility became a test bed for methodologies including environmental externalities in utility bidding systems.

Orange and Rockland had originally proposed a 10 percent environmental block for bid evaluation. However, the State Energy Office, had developed data based on a 200 MW coal-fired plant meeting New Source Performance Standards (NSPS) for several control cost scenarios. These scenarios ranged from mixed control to advanced control technologies and indicated that environmental effects comprised 20-30 percent of avoided costs, and that bid scoring should reserve that amount for environmental effects. They estimated that air emissions alone were in excess of 8-24 percent of avoided cost, and recommended reserving 40-80 percent of the environmental block for NO_x, SO_x, and CO_2 emissions.

The issues then faced by NYSPSC staff included determining the appropriate weight to assign to environmental effects, and within this environmental block, the most appropriate methods for apportioning weights among individual environmental factors.

Both NYSPSC and the New York State Energy Office (NYSEO) assumed that new projects would comply with federal New Source Performance Standards. For most air impacts, abatement costs for meeting NSPS were thus used as a proxy for the value of environmental damages. Other costs were developed using estimates from other sources. These costs were used as guidelines to confirm

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[8] Sebold et al., also states that:

> "Rough rules of thumb that deal with single emissions (e.g., NOx) are extremely narrow, and may really further distort resource decisions. Generating resources tend to have different 'relative mixes' of emissions. Focusing on a single emission may minimize some adverse environmental impacts while exacerbating others. The result is far worse, rather than better than that which could be obtained by ignoring air quality impact altogether."

the size of the components of the environmental block, modifying what had been a more subjective ranking and weighting scheme. Their figures are as follows :

Effect	Cost per kWh (Proxy)
Sulphur Oxides	0.25
Nitrogen Oxides	0.55
Carbon Dioxides	0.10
Particulates	0.005
Total Air Emissions	0.905
Water Discharges	0.10
Land Use Impacts	0.40
Total cost	1.405 cents/kWh

By assuming that winning bids would come in at no more than the company's avoided cost of 6.42 cents per kWh, environmental externalities were calculated to be about 24 percent of average cost. This price factor was then reinterpreted into a point factor that could be integrated into Orange and Rockland's existing point system. The final NYSPSC recommendation was for an environmental block sized at 24 percent of the **price** score (not the total score) where the price score comprised 47 percent of the total score.

The strength of the New York-Orange and Rockland methodology is that it eliminates the problem of comparing price and point factors by essentially reducing them both to one price factor (even though they are later reconverted to points). Also, the size of the environmental block that should be considered in a bidding process is automatically defined by the components of the price factors themselves, and different resource options can be compared on a consistent basis. Thus, all factors that *can* be reduced to price are included in a price block where they may be compared consistently with price factors of competing resources. Non-price factors (such as dispatchability, fuel diversity, risk, etc.) are considered in a separate block.

However, the major shortcoming is one of subjectivity. The use of abatement costs as a proxy for environmental costs is wholly dependent on the level of environmental control that is considered "sufficient," whether it be legislated emission limits or an academic best guess. While such a methodology could very quickly accommodate a new set of emission requirements, its focus is on targets rather than actual costing information.

2. ***A Methodology for Integrating Air Quality Impacts into Energy Resource Planning,*** **Frederick D. Sebold and Mark A. Thayer of Regional Economic Research, Inc. (San Diego, California) undertaken for the California Energy Commission. (USE OF FULL COSTING TECHNIQUES)**

This paper by Sebold et al., which was prepared for the California Energy Commission, reviews the conceptual role of externalities in utility bidding systems and makes recommendations for valuing air quality impacts and integrating these values in bidding systems.

Sebold et al., believe that a large body of literature already exists on dose-response relations and that the dollar value of physical impacts can be estimated from this information. They discuss the

resource approach, contingent valuation, and revealed preference methods, which are all variations on full costing approaches.[9]

They recommend the construction of reference values of external costs, e.g., the air quality impacts per unit, the physical dose-response functions, and the dollar values of key physical responses. Impacts are measured as the dollar value of a one-unit ton change in each emission in each air basin. The next step is the integration of reference values into the bidding system:

- Each technology/resource offered in the auction would be reviewed to determine the level a set of emissions factors, e.g., level of emissions per kWh of each subject of emission.
- These values would be multiplied times the reference value (dollar values per ton) for each emission for the basin in question, to estimate the external costs associated with the resource per kWh.
- Then, an assumed capacity factor and resource lifetime would then be used to translate this value into the implied external cost per kW of capacity.
- Finally, the external cost per kW would be added to the bid price of the resource in question.

While assembling the information in useful form would be complex, it results in a practical yet rigorous methodology that they feel is superior to other methods. Sebold and Thayer make the very important observation that many environmental effects are site-specific, making it difficult to evaluate them generically. Moreover, the fact that the economic value of an environmental effect may vary depending on where it originates also has broad implications. For certain impacts in some areas -- those that have health or material damage implications, or occur in areas where the dose-response relationship is already high -- using a generic cost would underestimate the actual impact. Other emissions, such as CO_2, have no localized impacts in the short run, and generic worldwide costs may be the more effective proxy.

Such an approach would be costly and time-consuming, and would only be fairly applicable if it were performed consistently over a very large area. Little guidance is suggested regarding the integration of results into the bidding process; however, since their methods would deliver strict price results, integration should not be very difficult.

3. Integrating Environmental Externalities into Resource Planning at New England Electric (RANKING AND WEIGHTING)

In Massachusetts, the Department of Public Utilities (Document 86-36-F) ordered the state's electric utilities to consider environmental effects in their resource planning process. During the summer of 1989, various Massachusetts utilities, regulators, and selected individuals with environmental concerns met in a collaborative series of meetings to review environmental effects of power production and attempt to agree on proposed approaches to the problem. The environmental groups preferred full costing methods, while utilities embraced ranking and weighting methods.

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[9]Sebold uses the following definitions: the *resource cost approach* involves the estimate of values through the use of data on directly affected markets, e.g., changes in agricultural productivity, etc.; *contingent valuation* entails the use of survey methods to ascertain individuals' willingness to pay for the avoidance of an adverse environmental effect; and *revealed preference approach* refers to the use of data on related markets to assess economic values which could use the hedonic method in where a commodity like housing, has value partly determined by locational factors like air quality.

As previously noted, New England Electric hired Temple, Barker and Sloane, Inc. to develop a methodology for incorporating these environmental effects into the resource planning process in the development of NEESPLAN II: 1990.

TBS compared a wide range of qualitative and quantitative approaches and arrived at what they termed a "hybrid approach." The TBS approach borrows much of the "cost of control" as a proxy for environmental impacts methodology used in Orange and Rockland, but rather than using this, they generated environmental categorizations and weights through Delphi survey techniques and from existing data related to regulatory requirements mandating various emissions levels. A limited number of surveys (11) were completed by environmental professionals at both the primary level (where respondents weighed individual environmental effects) and the secondary level (where they assessed the total environmental score).

TBS and NEES determined some ground rules that formed the basis for their methodology as follows:

- externalities are best characterized as "issues"; i,e., global warming or acid rain rather than specific emissions
- externalities should be considered from **society's**, not the utility's, point of view
- only environmental externalities occurring in the operating stage would be considered initially

Ten environmental issues were selected from their surveys and included: global warming, acid rain, land use, solid waste, water use/quality, emissions to air, aesthetics, indoor air quality, fuel issues and ozone. Each environmental issue set was then broken down into one or more sub-issues. The relative weighting of issues was determined by compiling information from studies and reports, Delphi polling of experts, and the use of weights determined in previous methodologies. Its one-page evaluation sheet provides a simple but succinct evaluation of a resource option. (Exhibit 5 presents the worksheet that resulted from the TBS work).

Factors Contributing to Score for Environmental Attribute

The TBS methodology is a highly developed ranking and weighting scheme, and attempts to integrate a number of approaches to evaluating disparate environmental characteristics in order to minimize subjectivity. While the methodology purports to borrow some of the strengths of the Orange and Rockland approach, it does not, however, actually consider impact factors on any kind of price or cost-related basis, and is consequently much more arbitrary. The methodology depends on a limited number of expert opinions, and the results are relatively subjective. Available information on the method does not specify the size of the environmental block, nor how it is considered in overall bid evaluation.

ISSUES AND CONTRIBUTING FACTORS

Exhibit 5

Environmental Concern Weight	Issue	Contributing Factor Weight	Factor	(Least 264 → Impact → Most) 0	1	2	3	4	Impact	Issue Sc
	Global Warming		Carbon Dioxide (lb/kWh)							
	Acid Rain		Sulfur Dioxide (lb/mmbtu) Nitrogen Oxides (lb/mmbtu)							
	Land Use		Amount (acres) Character							
	Solid Waste		Overall Assessment (lbs/kWh) Adjustment							
	Water Use/Quality		Amount (gallons/MWh) Attributes of Input Water Thermal Attributes of Receiving Water Chemical Attributes of Receiving Water							
	Emissions to Air		Air Toxics (fuel type) Particulates (lb/mmbtu) Sulfur Dioxide (lb/mmbtu) Nitrogen Oxides (lb/mmbtu)							
	Aesthetics		Visual Effects Noise Signal Interference (households affected)							
	Indoor Air Quality		Creation Retention (air changes)							
	Fuel Issues		Overall Assessment							
	Ozone		VOCs (lb/mmbtu) Nitrogen Oxides (lb/mmbtu) CFCs							

3.2 Different Methods of Accounting for Attributes Affect Outcomes

Ultimately, the selection of a particular methdology to account for social costs may not be as important as the care taken in defining a final implementation methodology. As demonstrated in a recent study, the choice of a bidding framework has significant influence over final technology selection. The report, *Evaluation Methods in Competitive Bidding for Electric Power*, by Kahn et al., examined the overall complexity of bidding systems, its nuances and how different methods could affect ultimate outcomes, e.g., the allocation of points for "non-price factors."[10] Kahn compares and evaluates several bid systems to determine the impact of the methodology chosen on the technology selections that result.

In a California conference on competitive bidding, a hypothetical auction was held in which five technologies were competing: gas-fired cogeneration, gas-fired combined cycle, biomass, geothermal, and small hydro. From the results of that workshop, Kahn found that the approach taken to scoring and ranking projects can affect the outcome of projects selected. He notes significant differences in the "nominal" weights assigned to price and other factors compared to real weights, or the weight that actually influences outcomes.

For example, he found that two systems that placed very different nominal weights on price (50 percent for Orange and Rockland Utilities vs. 70 percent for Niagara Mohawk) effectively ranked bids in the same order as a price-only system. This indicates that different methods of accounting for these non-price factors can affect future resource decisions.

Kahn is dissatisfied with current tendencies to allocate environmental blocks within bidding procedures. However, he found it difficult to effectively articulate environmental impacts in a form that can be accurately assessed in the competitive bidding process. Despite his difficulties in resolving these larger issues, Kahn's observations regarding nominal weights are very important. They warn against including a multitude of complex factors that are effectively cancelled out by the systems. He advocates critical review of the methods to determine their effect on project selection.

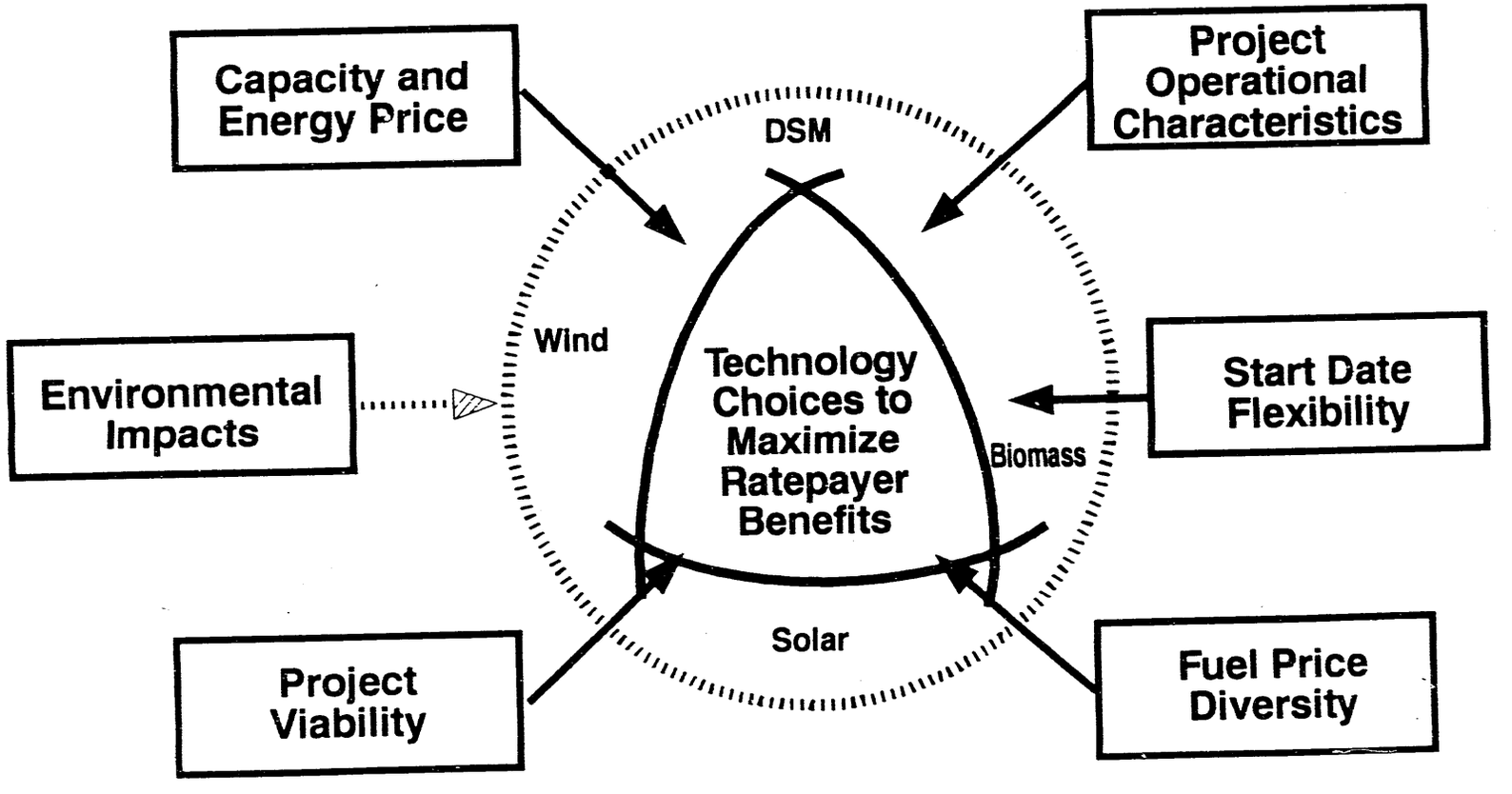
Thus, incorporating social costs into bidding and other resource acquisition processes will be a major challenge because it will be reconciling social costs within an already large and complex decision framework. Exhibit 6 describes some of the attributes that are considered in acquiring generation resources. These attributes, although they are in many cases as hard to value as social costs, are used to determine the optimal mix of resources for a utility to acquire. They are already highly interdependent and difficult to balance. Incorporating environmental impacts into the decision framework will tend to further expand the range of technologies that must be considered in determining an optimal resource mix. Many of the technologies with the most promising environmental profiles have operating characteristics, financial structures, etc., that are very different from the current mix of technologies. Thus, introducing social costs into the decision framework also implies a reconsideration of the values of other decision criteria, and the balance between them.

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[10] Kahn, E.P. et al., *Evaluation Methods in Competitive Bidding*. Applied Science Division, Lawrence Berkeley Laboratory, University of California. Prepared for the U.S. Department of Energy under Contract Number DE-AC03-76SF00098. June 1989.

Exhibit 6

The Impact of Valuing Social Costs on the Range and Complexity of Technology Choices



4.0 UTILITY AND REGULATORY PERSPECTIVES ON SOCIAL COSTS

4.1 The Utility Challenge

From the utility business perspective, resource decisions based on social costs must be evaluated in terms of their real contribution and impacts in a world where many other externalities are consistently ignored. A business that invests in pollution control equipment of its own volition (and is thus required to raise its rates) would not be as competitive as others that do not take social costs into account, making it difficult to continue to represent those costs. If this resulted in any loss of market share, competitors would assume that share, eventually bringing output and externalities back up to previous levels.

The assumptions made in evaluating social costs may lead to the reduction of certain social costs, but this reduction could be translated into other negative costs or effects. For instance, methodologies that give overly generous credit to environmentally benign technologies may result in a resource mix that is environmentally cleaner but less reliable. Thus, paying increased attention to one set of social costs increases the need to accurately assess non-price factors such as reliability, dispatchability, curtailability, and diversity. These factors ultimately affect not only the utility but the ratepayer and society as well.

In contrast to these possibilities, a utility that exercised early implementation of social cost considerations might be viewed as progressive and better able to minimize the costs of meeting pollution abatement requirements at a later date. If creating such a public perception enabled the utility to gain a stock-price premium and thus reduce its borrowing costs, any competitive disadvantage to social costing might be offset. Likewise, if the use of social cost information results in a utility gaining experience with new generating technologies, that experience could lead to new business opportunities.

In considering social costs, practicality and accuracy are of paramount importance. No methodology is useful if it is so complex that it obscures the realities behind decisions. Likewise, something that depends only on subjective or relative factors fails to effectively deal with the economic nature of social costs. The goal is to narrow methodology choices down to the most relevant factors that can be cogently represented in a selection methodology. In achieving that goal, utilities are faced with several questions :

- What kinds of resources -- financial or otherwise -- are needed to accomplish the task of social costing?
- Can the information be translated into price or cost, and can that information in turn be effectively applied within the bidding planning process and/or environment?
- Does the use of this information create other effects that are reflected in profitability, competitiveness, market share, or other risks?
- Are requirements set by regulators consistent and capable of implementation?

Questions of utility responsibility for social costs, and their ability to effectively address them, must be answered before social costs can be reduced through utility planning.

4.2 The Regulatory Challenge

From the regulatory perspective, the definition of the selection of the characteristics used to define social costs raises significant questions as well. The CEC has stated that their criteria are to: minimize total system economic costs (production and capital costs, reliability, and operations), account for uncertainty, preserve environmental quality, maintain a sound economy, conserve resources, and protect public health and safety.[11] While the items on this menu are not mutually exclusive, maximizing all of them at the same time is an enormous challenge.

While contexts for reducing social costs need to be created, definitions set by a utility may be overridden by regulatory bodies, whose decisions may in turn be overridden by national or global political requirements. Whether social costs are considered on a regional, state, national, or global scale will have very different results. Considering only the social costs that occur within a utility's service area fails to account for any localized impacts resulting from power imported from generation sources located outside the service territory, and likewise ignores the effects of emission exports. A state such as California, which receives relatively fewer pollutants from other sources, does not have as great a need to count imported external costs. Other areas, such as Eastern Canada or New England, which are suffering from acid rain largely produced in the Midwest, are already attempting to mobilize political resources to ensure that exporting impacts carries some prohibition or penalty.

States producing or burning large quantities of coal could resist efforts to ameliorate large CO_2 discharges by defining new bidding methodologies to give minimal consideration of the potential damage due to CO_2 emissions. States that produce or use little coal -- such as California -- might not be adversely affected if CO_2 emissions receive a heavy weighing in mandated national standards. However, if such standards are implemented solely within California, the implications for regional inter-competitiveness are enormous. Again, large energy consumers may simply resort to self-generated electricity via inexpensive, yet environmentally harmful, technologies.

Thus, one possible outcome is that efforts to account for social costs are circumvented, and the intended reduction in emissions is thwarted. The other result could be the loss of business opportunity and income, accompanied by a transfer -- rather than reduction -- of emissions to another region. Regulatory attempts to account for social costs must carefully define boundaries, or run the risk of unintended effects. For example, in order to meet their sulphur emission targets, Ontario Hydro has agreed to purchase power from Illinois Power, which burns high-sulphur coal. Ironically, these emissions tend to find their way towards Canada, which has more severe acid rain problems than Illinois. Ontario has met the required target, but not the intent of the acid rain legislation. In this case, inadequate definition of the necessary boundaries has resulted in a situation where externalities were increased rather than being reduced.

Similarly, attempts to reduce emissions can result in disincentives to demand-side management (DSM) if they are described in terms of emission rate limits rather than emission caps or ceilings. Under an emission ceiling, lower emissions resulting from DSM can reduce social costs as much as scrubbers or fuel switching. Yet, DSM lessens total emissions by reducing the number of hours that existing plants operate, and does not change the rate emission from that plant during operation. Thus, emission ceilings rather than rate requirements are more likely to result in the intended outcome. Such boundary issues -- regarding source, effect, and jurisdiction --- are likely

[11] DeAngelis, Michael and Rashkin, Samuel. *The Social Benefits and Costs of Electricity Generation and End-Use Technologies.* California Energy Commission. 1989.

to become more important over time as issues are politicized and as mitigation attempts are pursued on a piecemeal, rather than comprehensive basis.

Additional issues for regulators is the concern that can the "right" values be developed as the current process evolves. For example, New York is recommending 40-80 percent of the environmental block be used for air emissions. Wisconsin has a 15 percent credit for noncombustion sources granted by Wisconsin. Yet a utility that diverts streamflows in a pristine area (such as the proposed Hydro-Quebec James Bay hydroelectric project) may be worse in social terms than generating some amount of NO_x. To the extent that other external costs are embodied in resource options, the sole consideration of air quality impacts to the exclusion of other externalities may worsen, rather than improve, the planning process. Such problems may not be the "fault" of either utilities or regulators, but is a reflection of an incomplete process.

To the extent that the right values are developed, will they actually affect the outcome? Data used in the process may not be well correlated with final results. For instance, as Kahn et al. has shown, different methods of accounting for attributes affect technology outcomes. Or the process may simply select factors that are currently represented in the bidding process and bypass others that do the same damage. For example, if utilities incorporate values for CO_2 and these values result in higher electricity to customers, these higher rates may cause large customers to switch to self-generation fired by the cheapest fuel (probably gas) or might lead customers to locate their new facilities in another state which produces electricity without CO_2 guidelines. Thus, economic changes could be created without necessarily accomplishing the desired reduction in CO_2.

4.3 Resolving the Utility/Regulatory Challenge on the Valuation and Implementation of Social Costs

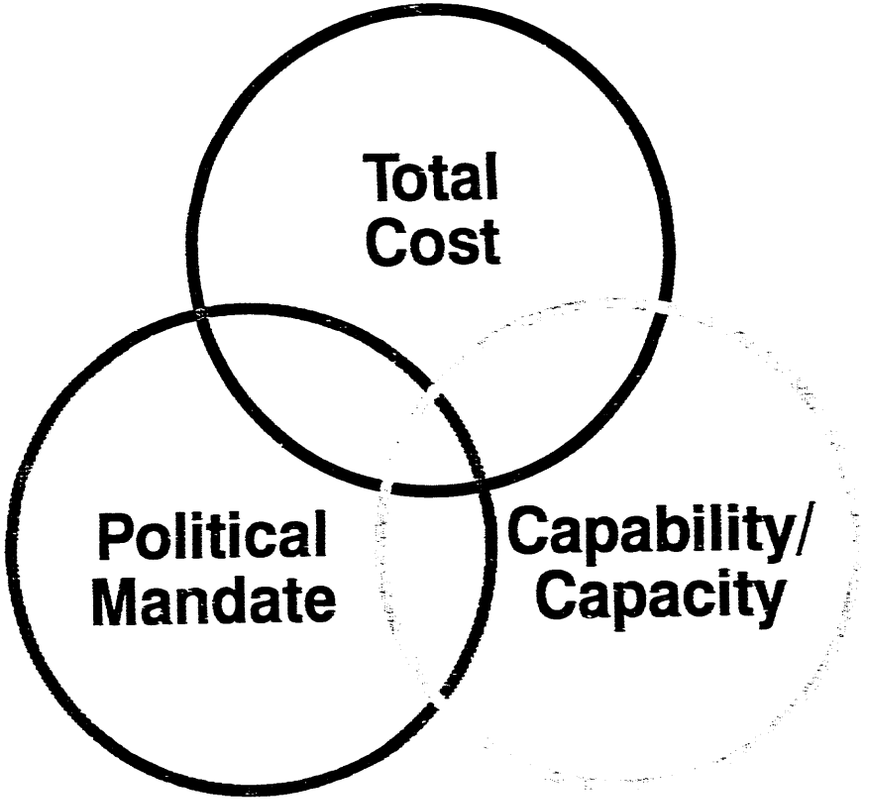
Valuing the externalities associated with energy production will require the resolution of larger institutional issues which will affect parameters used in social cost methodologies such as: geographical, political, perceptual, and definitional. In this discussion, these institutional considerations have been consolidated into three categories:

- the perception of <u>cost</u> that prevails: shareholders, utility consumers, or other stakeholders;
- the choice of a methodology may depend on the <u>capability</u> of the individual utilities and/or regulatory bodies to effectively implement research on external costs; and
- the existence and strength of a <u>mandate</u> will largely dictate which methodologies are implemented.

In addition, there are difficult equity and countercompetitiveness issues raised by applying social costs to only one sector in isolation. For any social cost effort to succeed, these issues must be addressed, and to some degree reconciled with each other. These three intrinsic institutional issues exist independently of the methodological and implementation concerns raised in this report. Without achieving a dynamic balance between these issues, efforts to account for social costs will likely lead to an impasse. These are depicted in Exhibit 7 and are more fully discussed below.

Exhibit 7

Three Intrinsic Institutional Issues



1) Total Cost

The question of how to value economic welfare is a matter of whose opinion on defining and valuing social costs prevails; for example, shareholders, utility customers, auto manufacturers, drivers, Californians, or Americans. Although economists have devised constructs for valuing social costs, the underlying assumption that an economic value can be placed on life or on nature is not acceptable to many people who view these as moral issues beyond the purview of economics. Thus, even when impacts are known, an element of subjectivity remains in valuation.

Total costs include the value of social costs in addition to private costs (those costs internalized in the current market). The definition and valuation of social costs (i.e., what cost should be measured and how should they be valued) is a function of the factors that determine an individual's welfare. The factors that determine welfare may include: health, property values, labor, aesthetics, wildlife, tourism, etc. The number of factors and combinations of factors that determine welfare are as varied as there are individuals. This makes the analysis difficult from a consistency point of view since analysts who have attempted to value social costs do not have a consistent set of factors or methods for combining and estimating social costs. This is one of the most complex and vexing factors in valuing social costs because social cost estimating is influenced by law, economic theory, and by public perceptions of equity. With heightened public awareness of the social costs of energy production, this problem of valuation has complicated the regulatory environment because the public interest welfare function is now being considered.

Also, social cost valuation methodologies are disputed by critics who point out that there simply isn't a known, direct, quantifiable cause and effect relationship between, for instance, emissions and human health. The argument is simply that there is not enough scientific certainty about causes and effects to determine the social costs of incremental changes in energy production and emissions, and incorporating invalid estimates of the social costs would distort the market as much or more than ignoring social costs. Often, the best that can be done in valuing the social cost component of total cost is to explicitly state the factors and methods to estimate social costs and proceed from that point.

The issue of changing social cost values as a function of perspective also applies to the larger question of how broadly social costs should be considered. For instance, if it is more cost-effective to reduce pollution from the transportation sector, shouldn't that be part of a social costing methodology for emissions that attempt to adopt a societal perspective? NO_x emitted from the tailpipe of a car is as potentially damaging as NO_x emitted from a utility boiler. While this approach of comparing damage costs and control costs is sensible and is well-covered in academic economic literature[12], it is not explicitly addressed in the methodologies reviewed. Generally, social costs were only considered within the utility sector and were not carefully compared with emissions from other sectors to determine the least-cost means of reducing social costs.

A change in energy costs due to the inclusion of social costs, or the use of more expensive energy technologies to mitigate social costs, will impact the market for energy by changing its price. In turn, price impacts demand and supply, and thus the general equilibrium of the energy market. The distribution of wealth, income, productive resources, etc., will readjust to any new equilibrium, sometimes in unforeseen ways. The broader market implications of methodologies for determining social costs must be considered.

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[12] Mansfield, Edwin. *Microeconomics: Theory and Applications*. Fourth Edition. W.W. Norton and Company, Inc. Toronto, Canada: 1982.

2) Mandate

The existence and strength of a mandate will largely dictate which methodologies are implemented. Any reasonable mandate must take into account the full ramifications of the requirements it sets, the jurisdictional authority that backs it up, and its political and methodological sustainability.

Some analysts believe that a national least-cost energy plan and process is necessary. It could be modeled after the Pacific Northwest Electric Power Planning Act under which Bonneville operates. If state least-cost planning processes are expanded to assure that energy resources having the lowest social costs are the first to be developed, then legislative bodies may require utilities to perform full costing along the lines of that conducted in the Pacific Northwest.

The outcome of this situation depends on regulators both at the federal level (Federal Energy Regulatory Commission) and the state level and their commitment to include environmental costs in energy prices.

It is not clear whether it is the responsibility of utilities to act, or if state regulators should act before federal regulators such as EPA, FERC, etc. Utilities may realize some benefit or loss from early action in the form of recognition and preparedness, possibly increasing the shareholder's stock value. However, the site-specific nature of many externalities (and, for example, the concurrent growth in stature of air quality management districts) means that new mandates taking unprecedented forms may arise from new sources. One example is the growth in the power and proposals of individual air quality management districts. The South Coast Air Quality Management District's plan to clean up the air in the Los Angeles area has major implications for California's electricity supply.

Despite these implications for the electricity business, state agencies with primary responsibility for electric resource planning, the CEC and CPUC, played no official role in developing the SCAQMD. This process may need to be changed so that energy and environmental issues are addressed concurrently.

3) Capability

Finally, the choice of a particular methodology may depend on the ability of the individual utilities and/or regulatory bodies to effectively implement it. As we have pointed out, accounting for externalities can be a confusing, complex, and costly task. The decision to implement a methodology that entails major effort and expense has to be tempered by the realization that the individual utility will not be able to implement the results on its own. An individual utility may also lack the necessary perspective or the resources to conduct an analysis at the appropriate level for implementation.

For example, the social costs of one utility's power generation are only a small subset of all the external costs of energy use in its state, which, in turn, accounts for only a fraction of the U.S. energy/environmental situation. Actions by governmental bodies at the international, national, and state levels could quickly render efforts by that utility moot.

5.0 CONCLUSIONS

The paper concludes the following:

1. **Further regulatory direction may be required before utilities can decide on the choice of a methodology and its implementation or whether utilities should even become involved in social cost analysis.** Ultimately, valuing the externalities associated with energy production will require the resolution of much larger conceptual issues. These include societal definitions of the total cost of electric power, the capability of individual utilities to conduct research into external costs to society, and the existence and strength of regulatory mandates that will largely dictate which methodologies are implemented.

2. **Despite these regulatory uncertainties, utilities may need to determine what they want to provide in terms of accounting for externalities, or run the risk of having it determined for them.** As pointed out in this study, social costs associated with power generation can be substantial and thus these costs should be reflected in order to allow optimal resource decisionmaking. Because the only change that is constant in the utility industry is for environmental regulations to become more stringent, it may be less costly in the long-run to account for these costs now.

3. **Based on our analysis and the strengths and weaknesses of the various methodologies, and the current uncertainties with regard to any mandate being required for utilities to perform social cost analysis, we make the following observations and recommendations:**

Each of the four methodologies reviewed can provide a good approach to accounting for social costs. The selection of each has tradeoffs in the degree of relative accuracy of the cost and complexity of the method. It was found that the last 3 categories of approaches are especially useful. The first category is basically a data collection phase, while the latter categories build on this information and provide a useful analytical framework for decisionmaking.

With lack of guidance and current lack of consensus on regulatory issues, utilities may not want to become involved in extensive data collection, since full costing techniques are expensive. In addition, it may also be difficult to pursue full costing approaches in the near term.

We advocate a hybrid ranking and weighting approach that makes the most of the information that exists by blending data, structured analysis, and informed human judgement. If properly structured, it can make the most of the information that does exist, while at the same time acknowledging the limitations of our current understanding of social costs. It also has the benefit of furthering expert consensus on the subject, which can influence the public and decisionmakers who are ultimately responsible for the mandate for action.

4. **Utilities and regulators need to be able to see "the forest from the trees" to accomplish concrete results, e.g., the development of social costs in isolation doesn't guarantee it will have an impact.** As Kahn et al. point out, lengthy and expensive efforts to factor externalities into resource selection might be inadvertently structured out of the bidding process, and not have an impact. There is a need to determine how different methods of accounting for externalities in bidding systems could affect future resource choices. Once an approach to valuing social costs is implemented, it is important to see if the results imply significant changes, or if they will have relatively little impact on resource acquisition decisions.

5. Externalities should be examined in an wholly integrated fashion to pursue imaginative, intersectoral solutions. A narrow definition of social costs as solely utility-related may overlook significa ıt intersectoral solutions. In California, the South Coast Air Quality Management District's (SCAQMD) plan to combat urban smog in the Los Angeles area in part by phasing out gasoline and revamping the region's transportation system. This has major implications for the state's electricity business. Because the air quality plan proposes extensive use of electric vehicles and other electro-technologies, it could significantly increase the demand for electricity. Since its success partially depends on the achievement of fundamental technological breakthroughs, the plan may require a new emphasis on electric vehicle research, development and demonstration. Thus, utilities may be able to provide part of the environmental solution by playing a role in the substantial mitigation of many current environmental problems of industrial societies through the continued development and application of electro-technologies.[13]

[13] A recent Edison Electric Institute (EEI) study highlighted the potential for reducing emissions of CO_2 through substituting electro-technologies for technologies currently using fossil fuels at the point of end-use in the industrial and transportation sectors. The study gives numerous examples of how short-wave electric infrared paint curing and new electric processes in glass production and others often improve production processes as well as reduce emissions. The EEI study concluded that 17 percent of the U.S. industrial sector's total annual CO_2 emissions and about 8 percent of the transportation sector total CO_2 emissions could be reduced through such substitutions. While such substitutions increase the overall demand for electricity, the net effect on the environment would still be a decrease in CO_2 emissions.

BIBLIOGRAPHY

1989 ASES Roundtable on Societal Costs of Energy. Compiled by Michael Nicklas. Boulder: 1989.

1989 ASES Roundtable on Societal Costs of Energy. Arlington: March 9, 1989.

Bonneville Power Administration. *Issue Backgrounder: Counting the Costs - How BPA Performs Environmental-Cost Analysis.* June 1985.

Bonneville Power Administration. *Methods for Valuation of Environmental Costs and Benefits of Hydroelectric Facilities.* Final Draft. Portland: Bonneville Power Administration, June 5, 1984.

California Air Resource Board. *California Air Pollution Control Laws.* Sacramento: California Air Resource Board, 1989.

California Energy Commission. *California's Energy Outlook. 1987 Biennial Report.* Sacramento: California Energy Commission, 1987.

California. Decision Before the Public Utilities Commission of the State of California. Decision 88-09-26. *Final Decision, Compliance Phase: General Resource Planning Issues, Performance Features ("Adders"); Availability of Standard Offer 2.* September 14, 1988.

Crane, Cynthia M. *Externalities and Intangibles: Air Quality Benefits.* Pacific Gas and Electric Company. August 1985.

Dasovich, Jeffrey. *Analysis of the Greenhouse Effect and Policy Considerations for the California Public Utility Commission.* San Francisco: California Public Utilities Commission, May 1989.

DeAngelis, Michael and Rashkin, Samuel. *The Social Benefits and Costs of Electricity Generation and End-Use Technologies.* California Energy Commission. 1989.

Dudek, Daniel J. *Offsetting New CO_2 Emissions.* New York: Environmental Defense Fund, September, 1988.

ECO Northwest, Ltd.; Shapiro and Associates, Inc.; and Seton, Johnson, and Odell, Inc. *Estimating Environmental Costs and Benefits for Five Generating Resources.* Prepared for Bonneville Power Administration under a Multiple-Award Contract Agreement with the U.S. Department of Energy (Contract DE-AC79-83BP11551). March 1986.

ECO Northwest. *Economic Analysis of the Environmental Effects of the Coal-Fired Electric Generator at Boardman, Oregon.* Final Report. December 29, 1983.

Energy and Resource Consultants, Inc., *Benefits of Environmental Controls: Measures, Methods, and Applications,* for the Electric Power Research Institute, EPRI EA-6030, Project 2661-10, October 1988.

Electric Resources Planning Department. *Multi-Attribute Bidding Framework.* PG&E. August 10, 1989.

Flavin, Christopher. *Slowing Global Warming: A Worldwide Strategy.* Worldwatch Institute. October 1989.

Fritsche, U. et al. *Environmental Analysis of Energy Systems: The Total-Emission-Model for Integrated Systems.* Germany: ÖKO-Institut, September 1989.

Goldman, Charles et al. *Least Cost-Utility Planning in the Utility Sector: Progress and Challenges.* Applied Science Division, Lawrence Berkeley Laboratory, Berkeley, California. Energy Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee. LBL-27130; ORNL/CON-284. May 1989.

Gregory, Robin. et al. *Review of Uncertainty and Risk in BPA-sponsored Analyses of Energy Resources - Final Report.* Oregon: Decision Research, November 18, 1987.

Gross, George. *A Multi-attribute Bidding System for California Electric Utilities.* San Francisco: PG&E, January 1989.

Hall, Jane V. et al. *Economic Assessment of the Health Benefits from Improvements in Air Quality in the South Coast Air Basin.* Fullerton: California State University Fullerton Foundation, June 1989.

Heede, Richard H. et al. *The Hidden Costs of Energy: How Taxpayers Subsidize Energy Development.* The Center for Renewable Resources. Washington, D.C.: October 1985.

Heede, Richard, H. "Hiding the True Costs of Energy Sources." *Wall Street Journal.* September 17, 1985.

Hohmeyer, Olav H. "Macroeconomic View of Renewable Energy Sources." *Sunworld.* International Solar Energy Society, Volume 13, Number 2, 1989.

Hohmeyer, O. H. *Social Costs of Energy Generation - How Does Wind Compare?* Germany: Fraunhofer-Institute for Systems and Innovation Research, 1989.

Hohmeyer, Olaf. *Social Costs of Energy Consumption - External Effects of Electricity Generation in the Federal Republic of Germany.* A report prepared under contract for the Commission of the European Communities. Springer-Verlag. Heidelberg, Germany: 1988.

Integrating Environmental Externalities Into Resource Planning at New England Electric. Temple, Barker & Sloane, Inc.

Kahn, E.P. et al. *Evaluation Methods in Competitive Bidding.* Applied Science Division. Lawrence Berkeley Laboratory. University of California. Prepared for the U.S. Department of Energy under Contract Number DE-AC03-76SF00098. June 1989.

Kleinman, Michael T. et al. *Effects on Human Health of Pollutants in the South Coast Air Basin.* Fullerton: California State University Fullerton Foundation, June 1989.

Leopold, Luna B. et al. *A Procedure for Evaluating Environmental Impact.* Washington, D.C.: U.S. Department of the Interior, 1971.

MacKensie, James J. and Mohamed T. El-Ashrey *ILL Winds: Airborne Pollution's Toll on Trees and Crops.* World Resources Institute. September 1988.

MacKenzie, Douglas. *Defining and Quantifying Externalities for the Evaluation of Demand-Side Programs.* Temple, Barker & Sloane, Inc. October 25, 1989 .

Mansfield, Edwin. *Microeconomics: Theory and Applications.* Fourth Edition. W.W.Norton and Company, Inc. Toronto, Canada: 1982.

Massachusetts Photovoltaic Center. *An Overview of the External Issues of Electric Power Production.* November 1988.

Massachusetts Photovoltaic Center. *An Overview of the External Issues of Electric Power Production.* Massachusetts: Massachusetts Photovoltaic Center, November 1988.

Meridian Corporation, *Energy System Emissions and Materiel Requirements,* prepared for the Deputy AssistantSecretary for Renewable Energy, February, 1989.

Meridian Corporation, *Environmental Emissions from Energy Technology Systems: The Total Fuel Cycle*, prepared for the Deputy Assistant Secretary for Renewable Energy, March 1989. 1989.

Meridian Corporation, *Considering Social Costs in Utility Decisionmaking: Alternative Approaches and Implementation*, prepared for Pacific Gas and Electric Company, July 1990.

Meyer, P. et al. *Calculation of Environmental Costs and Benefits Associated With Hydropower Development in the Pacific Northwest.* Portland: Bonneville Power Administration, April 1986.

Mitchell, E. D. *Cogeneration Design Considering Optimum Use of Surplus Power.* San Diego: San Diego Gas and Electric Company, 1989.

New York State Energy Office. *Environmental Externality Issue Report.* Division of Policy analysis and Planning. New York State Energy Office. February 24, 1989.

New York. Case 88-E-241. Proceeding on Motion of the Commission as to the Guidelines for Bidding to Meet Future Electric Capacity Needs of Orange & Rockland Utilities, Inc. March 24, 1989.

North Carolina Utility Commission. *Testimony and Exhibits of Michael Niklas Before the North Carolina Utility Commission on Least-Cost Integrated Resource Planning.* Filed October 6, 1989.

OECD. *Understanding Pollution Abatement Cost Estimates.* OECD. March 1986.

OECD. *Energy and Clean Air: Costs of Reducing Emissions. Summary and Analysis.* Paris: OECD, 1987.

ÖKO-Institut. *Compilation of Climate-Related Emissions Data for Energy Systems in the FRG.* Final Report, Draft Version. Translated from German. June 1989.

ÖKO-Institute, Gemis model on Environmental Analysis of Energy Systems: The Total-Emission-Model for Integrated Systems, Federal Republic of Germany: September 1989.

Ottinger, Richard L., et al. *Environmental Costs of Energy*, Prepared for the New York State Energy Research and Development Authority and the U.S. Department of Energy by the Pace University Center for Environmental Legal Studies, July 1990.

Oregon. Order before the Public Utility Commission of Oregon. Order No. 89-507. *In the Matter of the Investigation into Least-Cost Planning for Resource Acquisitions by Energy Utilities in Oregon.* April 20, 1989.

Organization for Economic Cooperation and Development. *Environmental Effects of Electricity Generation*. Paris: Organization for Economic Cooperation and Development, 1985.

Ottinger, Richard L. et al. *Least-Cost Utility Planning and Demand-Side* Management: A Bibliography. New York: Pace University, Fall 1988.

Sebold, Frederick D. et al. *A Methodology for Integrating Air Quality Impacts Into Energy Resource Planning.* Developed under contract to the California Energy Commission (CEC) by Regional Economic Research, Inc. San Diego, California: 1989.

Shuman, Michael and Ralph Cavanagh. *A Model Electric Power and Conservation Plan for the Pacific Northwest: Environmental Costs.*

South Coast Air Quality Management District: *Air Quality Management Plan.* Final. South Coast Air Quality Management District. March 1989.

State of New York Public Service Commission. *Proceeding on Motion of the Commission (Established in Opinion 88-15) as to the Guidelines for Bidding to Meet Future Electric Capacity Needs of Orange and Rockland, Inc.* At a session of the Public Service Commission held in the City of New York on March 22, 1989.

Susan Babb. Bibliography of Nuclear Costing. Draft. August 9, 1989.

Technical Support Division. *The Effects of Oxides of Nitrogen on California Air Quality.* Sacramento: State of California, March 1986.

Testimony of Thomas D. Morron. Vice President Customer Services and Marketing. Edison Electric Institute Before the United States Senate Energy and Natural Resources Committee on the National Energy Policy Act of 1989. Subtitle B of Title III of S. 324. Novembert 7, 1989.

Therkelsen, Robert L. *Valuing Emission Reductions for Electricity Report 90.* State of California Energy Resources Conservation and Development Commission. November 21, 1989.

Trexler, Mark C. et al. *Forestry as a Response to Global Warming: An Analysis of the Guatemala Agroforestry and Carbon Sequestration Project.* Washington, D.C.: World Resources Institute, June 1989.

U.S. Congress. Senate. Committee on Energy and Natural Resources. *Hearing on PURPA and the National Energy Policy Act of 1989 (S.324).* 101st Cong. 2d sess., 1989.

Vine, Ed. *Evaluating Energy and Non-Energy Impacts of Energy Conservation Programs: A Supply Curve Framework of Analysis.* California Institute for Energy Efficiency, Program on Energy Efficiency and Air Quality, Review Draft, September 18, 1989.

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Abstract of Presentation for Panel Discussion:

"Externalities: Federal Views, Social Costs, and Environmental Assessment Regulations"

Recent international geo-political events and domestic energy-related environmental accidents, as well as continuing attention to the potential for climate change and stratospheric ozone depletion, have all served to renew and heighten concern regarding energy's pervasive effect on the environment. Energy production, transportation, and use have significant adverse impacts on air, water, land use, and larger global environmental systems. Energy production and consumption are responsible for the bulk of air pollutants that comprise or cause urban air pollution, acidic deposition, and air toxins. Energy-related sources are responsible for nearly 60% of anthropogenic sources of greenhouse gas emissions in the U.S.

The rising awareness of the ubiquity and persistence of an industrial society's environmental impacts challenges policy makers to find alternative effective and efficient ways to mitigate adverse environmental effects. Traditional technology-forcing command-and-control regulatory approaches, although providing for the incorporation of some negative externalities into production and consumption decision-making, offer limited further potential to reduce emissions from specific sources and do little to halt the proliferation of pollution sources. Moreover, technology-forcing solutions often create perverse incentives that do not prevent pollution, rather a pollutant is simply transferred from one medium to another -- e.g., in the case of power plant emissions, the pollutant is removed from the air and is transferred to a landfill repository in the form of scrubber ash. Greenhouse gas scrubbing is likely to be prohibitively expensive.

As a result of the limitations of traditional environmental regulations, environmental policy makers will increasingly need to examine alternatives that help ensure that energy is produced and consumed efficiently -- i.e., all social costs are incorporated into production and consumption decisions -- so as to minimize adverse environmental impacts. Market-based strategies that create economic incentives to reduce adverse environmental impacts can help provide society the flexibility to maximize its diverse goals. Creative organizational, as well as technological, solutions can be applied. In addition, a credible and efficient long-term mitigation strategy will promote the economically efficient goals of sustainability, waste minimization, and recycling.

Specific market-based strategies include emissions fees, tradeable emissions rights, alternative utility rate structures, targeted economic subsidies when price signals are

inadequate, regulatory reform, informational and moral suasion programs, and improved government procurement policies. Other strategies to consider include broadened utility planning process that include alternative environmental/economic perspectives, utility plant and end-use efficiency and emission standards, and basic research, technology transfer, and full-scale demonstration programs.

Since most utility regulation and many other important energy and environmental decisions and actions occur at the state level, an appropriate federal role, especially for an agency such as the EPA, is to develop working partnerships with regional, state, and local policy makers and program administrators. EPA and other federal agencies can serve as conduits of information and expertise and collaborate with state and local decision makers as they grapple with important environmental problems and craft mitigation strategies.

Specific areas for further collaboration include:

- Quantification of the externalities of energy production, transportation, and consumption; i.e., quantification on a full fuel-cycle basis.

- Technical assistance in assessing supply curves for energy efficient end-use capital equipment, i.e., "conservation supply curves." Analysis could include a market assessment (as distinct from an assessment of technical potential) covering topics such as consumers' decision making process, product positioning, marketing techniques, etc.

- Analysis of the benefits of alternative customer rate designs, i.e., marginal cost pricing or time-of-day/time-of-year pricing.

- Analysis of the benefits of alternative energy-sector industrial organizations; i.e., analysis of deregulation of the electricity generation sector, analysis of increased horizontal or vertical integration (redefinition of traditional energy services markets), and analysis of barriers to entry in demand-side services.

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DATA REQUIREMENTS FOR VALUING EXTERNALITIES - THE ROLE OF EXISTING PERMITTING PROCESSES

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DATA REQUIREMENTS FOR VALUING EXTERNALITIES - THE ROLE OF EXISTING PERMITTING PROCESSES

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State regulators and utility officials are paying increasing attention to the issues of externalities associated with new electricity resources. A growing number of states are requiring utilities to factor externalities, particularly residual environmental damages, into their decision-making processes for new resources. The assessment of such externalities, whether on a qualitative or quantitative basis, requires regulators and utilities to acquire and analyze a wide range of data and information. Resource developers, whether they are utilities or entities selling power to utilities, also will have to collect and provide data through processes specified by utilities or regulators. These requirements will undoubtedly impose new burdens on all parties involved in the development of electricity resources.

While the assessment of externalities, or residual impacts, will place new demands on regulators, utilities, and developers, existing processes already require certain data and information that may fulfill some of the data needs for externality valuation. This paper examines existing siting, permitting, and other processes and highlights similarities and differences between their data requirements and the data required to value environmental externalities. It specifically considers existing requirements for siting new electricity resources in Oregon and compares them with the information and data needed to value externalities for such resources. This paper also presents several observations about how states can take advantage of data acquired through processes already in place as they move into an era when externalities are considered in utility decision-making. It presents other observations on the similarities and differences between the data requirements under existing processes and those for valuing externalities. This paper also briefly discusses the special case of cumulative impacts. And it presents recommendations on what steps to take in future efforts to value externalities.

VALUATION OF EXTERNALITIES--STATUS AND DATA REQUIREMENTS

Externalities are those impacts of one activity on other activities that are not priced in the marketplace. According to Baumol and Oates (1975) an externality is said to exist when two conditions hold: 1) the utility or operations of one economic agent, A, include nonmonetary variables whose values are chosen by another economic agent, B, without regard to the effects on A and 2) B does not pay A compensation equal to the incremental costs inflicted on A.

By definition, the persons or firms bearing the costs associated with an externality absorb them without compensation. The costs are the result of impacts that can include fairly tangible damages, such as increased health care or depressed property values, and less tangible effects, such as reduced attractiveness of a scenic vista. Many of the latter type of impacts fall into the category of non-market values since they include effects on resources and goods that are typically not bought and sold in markets.

Electricity generation involves a wide range of potential and actual environmental impacts. Legislative, permitting, and regulatory requirements directly or indirectly control certain environmental impacts, implicitly causing them to become internalized in the cost of electricity generation. Electricity generation, however, often produces residual environmental impacts that meet the definition of an externality.

Importance of Externalities to Utilities and Regulators

Ottinger (1990) suggests two reasons why utility regulators should require and will increasingly require consideration of environmental externalities in utility resource planning. First, utility service has historically been regarded as imbued with the public interest. Utility commissions oversee the fulfillment of that obligation. Second, the future is likely to hold more stringent legislative and regulatory environmental controls. Since such controls may apply to existing resources, it would be imprudent to permit utilities to make investments now that would be subject later to substantial and costly retrofits to meet future, more stringent requirements. While regulators and utility policy makers have many options for incorporating environmental externalities in the planning and ratemaking processes, the fundamental question they face is what is the correct value to assign to the uncompensated damages resulting from the externalities.

Externality valuation has the objective of determining the total economic cost of the damages imposed on society by a specific activity. In the case of powerplants, as in many situations, this can be a difficult task for a number of reasons. First, probably not all the damages can even be identified. Second, interactions occur among the pollutants and other kinds of primary environmental disruptions caused by a powerplant. For example, air pollutants from a single powerplant interact with one another and may affect the final damages caused. Third, it is unlikely that specific individuals can be identified who will be damaged by the plant and unlikely that the extent of their damages can be predicted accurately. This issue leads to considerations of risks and probabilities, rather than deterministic predictions of the actual damages that will occur. Fourth, environmental externalities should not be considered only during the electricity generation process, but during all stages of what has been termed the "fuel cycle," or all steps leading up to, during, and after electricity generation from a plant throughout its life cycle (Callaway and Currie 1989). In actual practice, approaches have been simplified for valuing externalities in the face of such imposing difficulties.

Valuation Approaches

Buchanan (1990) identifies three general approaches for valuing externalities. One approach is the complete listing and quantification of economic costs associated with each type of damage caused by the residual environmental effects. This is typically the most difficult and complex approach. The second approach is determining the cost to mitigate each residual effect. And the third approach is determining the costs of placing controls on the source that would prevent residual impacts. This approach is usually the least difficult and complex.

Using the third approach, quantifying control costs, reflects the assumption that the marginal costs society has elected to impose through emission (and other environmental disruption) regulations equal the marginal benefits that society receives from avoiding environmental damages. If pollution control regulations were driven strictly by economic optimization criteria, then the marginal cost of the required controls *would* equal the marginal benefits of reducing emissions by one additional unit. Under these conditions, the marginal value of the residual damages associated with an externality would be simply the marginal control cost. There are, however, many obvious and not so obvious reasons why this approach is unlikely to give an accurate estimate for the value of residual damages.[2] Nevertheless, for practical reasons this approach has been used in almost all cases by states that have attempted to value externalities so far.

Experiences of Key States

Three states have taken the lead in specifying numerical values to be used by utilities in valuing environmental externalities: New York, Wisconsin, and Vermont (Foley and Lee 1990). Wisconsin and Vermont use a simple adder to account for the differences in externalities produced by different resources, such as combustion and non-combustion (demand-side management) resources.

Other states have taken various steps to address powerplant externalities. Without prescribing exactly how to proceed, Oregon has ordered utilities to consider external costs when

they are evaluating the cost-effectiveness of alternative resources. Although California has no mechanism in place yet for utilities to follow, the state has conducted the most comprehensive analysis of the issues surrounding the valuation of externalities.

In addition to state activities, the Bonneville Power Administration (Bonneville) has made significant progress in addressing externalities. Seminal studies sponsored by Bonneville have attempted to quantify the damages associated with environmental impacts (for example, ECO 1986). In a resource acquisition planned for fall 1990, Bonneville will include the costs associated with environmental externalities (BPA 1990) in accordance with the guidelines provided by the Northwest Power Planning Council (NWPPC 1986).

Of all the states, New York, through its Public Service Commission (NYPSC), has gone the farthest in prescribing a quantification approach and the parameters that will be used. Massachusetts has developed a similar approach, but there the utilities have taken the lead in making it operational. The approaches used in both states rely on a point system that assigns scores to various environmental externalities. In New York, air, water, and land impacts are included. The NYPSC has identified several attributes of each type of impact that are to be assigned points depending on the magnitude or qualitative measure of their severity. Weights are assigned to each attribute based on 1) the relative cost of controlling or mitigating each attribute or 2) the damages attributable to the residual impacts. The weights are multiplied by the points for each attribute, and the resultant scores are summed for each proposed resource. For air emissions, the NYPSC derives appropriate weights based on pollution control costs estimated for coal plants.

Though many states have started to address externalities in utility resource planning and acquisition, approaches so far have been quite simplified. As a result, many deficiencies, such as those listed below, remain in the current approaches:

- No approach has looked at the entire fuel cycle. This gap may be critical for some resources.
- In state approaches, the effects of geographic location on impacts are accounted for only on a limited basis, if at all.
- Little recognition is given to the fact that marginal and average impacts differ and both values are subject to change over time.
- Cumulative effects have not been explicitly incorporated.

Comprehensive valuation of environmental externalities would improve upon existing valuation processes by filling these four gaps.

Externality Valuation Information Needs

The purpose of powerplant environmental externality valuation is to place an economic value on the damages that a powerplant will cause, after all required control and mitigation measures have been implemented. Valuing the resulting externalities requires analyzing several steps in a complex process. This process typically consists of four steps.

The first step is the primary disruption to the environment. This step includes the release of air pollutants, discharge of water pollutants, disruption of a scenic vista, and so on.

The second step involves the linkage between the primary disruption and affected systems. In the case of air emissions, this step may include dispersion of the plume from a powerplant and the chemical reactions in that plume that convert initial pollutants or precursors into the pollutants that affect humans, animals, materials, production processes, etc.

The third step is the actual effect of the environmental disruption on affected systems and their responses. Such effects and responses include physical damage to materials and organisms, health damages, changes in market prices, and changes in behavior.

The final step is the translation of the effects into quantified economic costs.

Each of the four steps requires analysis and quantification. Models have been developed for several externalities to characterize these steps and quantify their effects. In all cases, data, information, and models used should be specific to the powerplant and location being considered.

For all resources, information should be obtained on land use, fish and wildlife, water quality, air quality, and solid and hazardous waste impacts. Primary impacts (such as pollutant emissions) need to be determined for each resource, in each of these impact areas, as the first step in quantifying the economic costs of resultant externalities.

Additional information and data may be required for specific resource types. For example, municipal solid waste plants might produce certain air pollutants that would not be produced by other powerplants.

In addition, it may be important to obtain information on additional stages in the fuel cycle for specific powerplants. For example, potential impacts during decommissioning of a nuclear powerplant may be significant; whereas, they might be negligible during decommissioning of many other powerplants.

Using Information from Other Siting/Permitting Processes

New powerplants are subject to numerous approvals prior to construction and operation. Table 1 shows the variation in permit requirements for 12 types and sizes of new powerplants in Oregon. The requirements range from three possible or probable permits for a 10-MW photovoltaic plant to 14 permits for a 50-MW geothermal plant.

Existing permitting and other processes can be useful sources of information for valuing externalities. The remainder of this paper looks in more detail at what the permitting requirements are in a single state, with the intent of identifying potential sources of information for externality assessments and gaps in those sources. Recognizing potential overlaps and gaps in the data required by different processes is the first step in developing a coordinated approach that can minimize the burden on resource developers, utilities, and regulators alike.

EXISTING PERMITTING AND SITING REQUIREMENTS IN OREGON

We use Oregon as an example to illustrate the kinds of information typically required by existing permitting and siting processes. Requirements will vary by state, however, so other states need to be studied on a case-by-case basis. The information presented here is limited to requirements at the powerplant site; therefore, information on other parts of the fuel cycle is not presented.[3] Impacts from nongenerating stages in the fuel cycle tend to be more generic, anyway, and often do not require site-specific assessments.

The following discussion is based on Hendrickson et al. (1990) and sources discussing specific regulations and requirements. It focuses on general environmental and siting requirements first; then discusses land, air, and water requirements; and finally, discusses requirements that are powerplant-specific.

The Council and Bonneville

Oregon and other states in the Pacific Northwest are greatly influenced by the activities of the Northwest Power Planning Council (Council). The Council was established by the Pacific Northwest Electric Power Planning and Conservation Act (Regional Act) to "set forth a general scheme for implementing conservation measures and developing resources . . . with due consideration by the Council for (A) environmental quality . . . [and] (C) protection, mitigation, and enhancement of fish and wildlife and related spawning grounds and habitat . . . ." The Council's policies are directed primarily at Bonneville, the region's federal power-marketing agency. Bonneville, which supplies 48 percent of the region's power (Bain 1989, p. 69), has a major influence on the entire electricity-generating system in the Pacific Northwest.

As noted earlier, Bonneville will conduct a competitive acquisition for new generation resources in the fall of 1990 (BPA 1990). Given Bonneville's federal status, this acquisition will trigger the environmental review requirements of

TABLE 1. Oregon Permit Requirements

License/Permit	50 MW Geothermal	10 MW Wind	10 MW MSW Incinerator	10 MW PV	10 MW Hydro	683 MW Coal	197 MW Fluidized Bed Coal	139 MW Single cycle CT	428 MW Combined Cycle CT	10 MW Wood Cogen	10 MW Gas Cogen	428 MW Coal gasif. Combined Cycle
NEPA EIS or EA	P	P	P	P	Y	P	P	P	P	P	P	P
SEPA EIS	N	N	N	N	N	N	N	N	N	N	N	N
Certificate of Convenience and Necessity	N	N	N	N	N	N	N	N	N	N	N	N
State siting agency approval	Y	N	N	P	N	Y	Y	Y	Y	N	N	Y
Local land use approval	P	Y	Y	Y	P	Y	Y	Y	Y	Y	Y	Y
Optional FERC QF certification	Y	Y	Y	Y	Y	N	N	N	N	P	P	N
FERC hydroelectric license	N	N	N	N	Y	N	N	N	N	N	N	N
State hydroelectric permit(s) related to bed, banks, and diversion	N	N	N	N	P	N	N	N	N	N	N	N
Federal geothermal lease	P	N	N	N	N	N	N	N	N	N	N	N
State geothermal permit(s)	P	N	N	N	N	N	N	N	N	N	N	N
State/local emission permit	P	N	Y	N	N	Y	Y	Y	Y	Y	Y	Y
Nonattainment permit	P	N	P	N	N	P	P	P	P	P	P	P
PSD permit	P	N	P	N	N	P	P	P	P	P	P	P
NESHAPS permit	N	N	P	N	N	N	N	N	N	N	N	N
NPDES permit	P	N	P	N	N	Y	P	P	P	P	P	P
UIC or state underground injection permit	Y	N	N	N	N	N	N	N	N	N	N	N
Corps permit for structure in navigable water	N	N	N	N	Y	P	P	N	P	P	P	P
Corps dredge and fill permit	P	P	P	P	Y	P	P	P	P	P	P	P
FUA certification to DOE	N	N	N	N	N	N	N	P	P	N	P	N
State/local MSW incinerator permit	N	N	Y	N	N	N	N	N	N	N	N	N
State/local permit for ash/waste disposal	P	N	Y	N	N	Y	Y	N	N	Y	N	Y
Water acquisition permit	Y	N	P	N	Y	Y	Y	N	Y	P	P	Y

Key: Y = probably yes; N = Probably not; P = Possibly

Source: Hendrickson et al. (1990)

NEPA, the National Environmental Policy Act (see following discussion). A wide range of environmental data and information will have to be obtained on proposed generation resources under the NEPA requirements. In addition, the Council has spelled out a 10-step process that the Bonneville Administrator is to use to quantify all environmental externalities directly attributable to a resource (NWPPC 1986).

The details of the methods and data Bonneville will use to assess externalities are not available at this time. Clearly, however, resources developed in Oregon under this acquisition will have to meet both the NEPA data requirements and the requirements of Bonneville's externality assessment process.

NEPA

NEPA is the basic national charter for protecting the environment. Its requirements are directed specifically at federal agencies, but its implementation has led to requirements likely to affect new powerplants in every state. NEPA requires federal agencies to prepare an environmental impact statement (EIS) for major federal actions significantly affecting the quality of the environment. An EIS is not a permit, but can be the major process to reveal and address potential environmental impacts. An EIS is a detailed report comparing environmental impacts of alternative options for achieving specific purposes and needs. The need for an EIS can be triggered through actions related to siting a powerplant, such as issuance of a federal license or permit, transfer of federal lands, or federal financing.

Though many states do, Oregon does not have a state environmental policy act to implement NEPA. In Oregon, NEPA is applied only when federal agencies or funding are involved, which is often true of large-scale hydroelectric plants and generators, such as geothermal plants, that are located on federal land.

Perhaps the most important step in the NEPA process is choosing which environmental impacts to focus on. All powerplants are likely to result in some environmental effects. The nature and magnitude of these effects is very much dependent on specific project features, such as the fuels and technologies employed and the location of the project. NEPA stipulates that all significant environmental effects must be assessed. NEPA states that significance requires consideration of both the context and the intensity of an impact (40 CFR 1508.27). Intensity refers to the severity of the impact. Context means the setting in which the impact occurs.

In judging which impacts are significant and clearly insignificant, decision-makers must consider a number of factors when assessing the intensity of an impact within its unique context. Uncertainty of intensity or context is usually resolved by assuming a reasonably foreseeable extreme (Alton, Dowty and Schmidt 1989). A great deal of scientific uncertainty or substantial controversy about an impact tends to bring about a conclusion of significance. Other factors that should be considered include potential effects on human health; possible effects on unique geographical features, such as nearby cultural or historic resources, parklands, prime farmlands, wetlands, or wild and scenic rivers; whether seemingly insignificant individual actions result in a significant impact when taken cumulatively; and potential adverse effects to endangered or threatened species.

Thus, NEPA assessments are comprehensive in their treatment of environmental effects. However, specific information needs are dependent on site and plant characteristics. NEPA requires the information to complete an assessment to be the best available. If information that is essential to making a reasoned decision is not available, but the costs of obtaining it are not exorbitant, federal agencies are to include the information when preparing an EIS (40 CFR 1502.22).

Another key NEPA provision is the requirement to include cumulative impacts in environmental impact assessments. NEPA regulations define cumulative impacts as those that result from the incremental impact of an action when added to impacts of other past, present, and reasonably foreseeable future actions (40 CFR 1508.7).

The regulations go on to state that "Cumulative impacts can result from individually minor but collectively significant actions taking

place over time." When evaluating proposed energy projects, analyses of cumulative impacts may require three perspectives:

- The inclusion of all present and potential emitters or polluters in relation to a particular resource (e.g., new powerplant).
- The inclusion of all portions of the fuel cycle related to the generating plant, rather than the generating portion only.
- The interactive impacts between a new powerplant and the existing power generation system. For example, in the Pacific Northwest, the development of new thermal plants is likely to affect the operations of the Columbia River hydro system; thus, Bonneville's EISs include analyses of system-wide impacts.

An EIS may be structured to include an analysis of the value of environmental externalities. NEPA does not specifically address externalities, but EISs are currently being prepared that incorporate these values. NEPA states that if a cost-benefit analysis is relevant to choosing among environmentally different alternatives, such an analysis shall be incorporated by reference or appended to the document (40 CFR 1502.23). When such an analysis is prepared, the EIS must contain a discussion of the relationship between the analysis and any analyses of unquantified impacts, values, and amenities. However, comparisons of varying alternatives within an EIS need not be displayed in a monetary cost-benefit analysis and should not be when there are important qualitative considerations (40 CFR 1502.23).

Powerplant Siting Laws

Many of Oregon's environmental impacts data requirements are imposed through the general siting process. In Oregon, the need for a powerplant site certificate is triggered when a powerplant with a generating capacity greater than 25-MW or solar collecting facilities covering more than 100 acres of land are going to be constructed. For cogeneration plants fired by agricultural or wood waste, a certificate is required if the plant has a capacity of 50-MW or more. The certificate is issued by the Oregon Energy Facility Siting Council (EFSC). The EFSC implements a one-stop siting process for energy facilities. Through this process, a wide range of issues is addressed including public health and safety, water rights, socio-economic impacts, environmental impacts, historic and cultural resource impacts, and others. In accordance with the one-stop requirement, all other state and local agencies must issue the appropriate permits, licenses, and approvals once the EFSC has issued its site certificate (Bain 1989, p. 79).

Chapter 345 of the Oregon Administrative Rules (OAR) presents the rules followed by the EFSC. OAR 345 Division 40 provides guidance to powerplant developers by specifying areas of the state that are "suitable," "less suitable," and "unsuitable" for powerplant siting. Areas are categorized both according to whether they meet certain criteria and are in specific regions of the state. These specifications, along with EFSC's one-stop siting mission, alleviate some of the potential burdens on developers.

For large powerplants (more than 200-MW), except combustion turbine and geothermal plants, proposers must file a Notice of Intent (NOI) at least 12 months before making a siting application (OAR Ch. 345, Div. 20). The NOI includes plant location, land area, status of decisions regarding filing for the site certificate and construction permits, plans for a study of environmental impacts, and the sources of cooling water. The NOI also partially addresses the fuel cycle by requiring a description of the method for disposal of waste heat, wastes, and spent nuclear fuel.

The actual site permit application varies by powerplant type. For biomass and fossil-fuel plants, applicants must submit, among other information, the following (OAR Ch. 345, Div. 111):

- a description of the facility
- a description of the site and existing environment
- a description of construction and operation processes and their attendant environmental impacts

- a description of required decommissioning or waste disposal sites and methods.

As in the NOI, the requirements include stages in the fuel cycle other than just construction and operation.

For nuclear plants, similar requirements apply. In addition, the applicant must provide a cost analysis that includes mitigation costs for identifiable social, health, safety, and environmental impacts (OAR Ch. 345, Div. 76). Nuclear plants also are required to develop a plan for decommissioning in accordance with Nuclear Regulatory Commission rules (OAR Ch. 345, Div. 26).

The most detailed requirements are specified for hydroelectric and geothermal plants. These are discussed in later sections.

Land Use Approval

As in most states, approvals related to land use in Oregon originate primarily at the local level. Oregon is fairly unique in that the Oregon Land Conservation and Development Commission (LCDC) plays a significant role in establishing overall land use policies that can affect powerplant siting.

In Oregon, each county is required to have a comprehensive land use plan. The local plan must be consistent with the 19 Statewide Planning Goals (ODOE 1985). One goal requires an inventory of 12 resources, including lands for open space, wildlife areas and habitats, historic areas, and cultural areas. Conflicts between protection of these resources and other uses must be identified and resolved. Other goals concern specific areas such as estuaries, beaches and dunes, and coastal shorelands. Local governments are to translate these goals into implementing ordinances regulating land use.

Local land use permits require reviews to ensure protection of public health, safety, and general welfare; to comply with statewide planning goals; and to comply with city or county comprehensive plans. Local governments are required to consider special purpose zoning, such as historic preservation sites; water quality; soils suitability; fish and wildlife; and noise. Although requirements vary by county, the processes used by each county to issue required permits are likely to identify most of the land impacts that would have to be analyzed to assess powerplant externalities.

Powerplants and appurtenances on federal land, however, are not typically subject to local land use requirements. When powerplants or associated facilities or access roads are to be constructed on federal land, the agency administering the land must approve. The approval may be through a use permit, authorization, lease, or an easement. This process is one mechanism for triggering the NEPA requirements.

Clean Air Act Requirements

The Clean Air Act requires the U.S. Environmental Protection Agency (EPA) to establish national primary and secondary ambient air quality standards for air pollutants "which may reasonably be anticipated to endanger public health or welfare" (Clean Air Act). Ambient air quality standards have been established for several air pollutants produced by powerplants. States are required under the Act to classify areas into one of three categories, by pollutant, depending on whether pollutant levels are worse than the primary or secondary standards, are better than the standards, or cannot be classified because of insufficient data or information.

States are required to develop state implementation plans (SIPs) that provide for attainment of the national standards. States are permitted to develop requirements that are stricter than the national ones and Oregon has done so in some areas.

Under the Clean Air Act requirements, four permits could be required for a new powerplant: 1) a state emission permit, 2) a nonattainment permit, 3) a prevention of significant deterioration permit, and 4) a permit for construction approval under a program related to hazardous air pollutants for which no ambient air quality standard is applicable.

Nonattainment permits are required for new plants proposed for areas where ambient air standards are not being met. One condition of

these permits is use of emission control designated as providing the lowest achievable emission rate (LAER), i.e., the most stringent emission limitation in any SIP.[4] A prevention of significant deterioration (PSD) permit is required for proposed powerplants in areas that meet ambient air standards. This permit requires the applicant to employ the best available control technology (BACT), which is basically the best control, given considerations of cost, energy, and environmental impacts. The permit also requires a fairly comprehensive analysis of the probable air quality, visibility, soils, and vegetation impacts of the plant if areas such as national parks or wilderness areas may be affected.

In Oregon, any person intending to establish a new or modified source of air contaminant emissions must obtain an Air Contaminant Discharge Permit from the Department of Environmental Quality (DEQ) or a local air pollution agency (OAR Ch. 340, Div. 20). Specific information requirements for this permit vary depending on the quantity and type of pollutants, and the plant location. The following information is generally required from applicants:

- a description of the nature, location, design capacity, and typical operating schedule of the source, including specifications and drawings showing its design and plant layout
- an estimate of the amount and type of each air contaminant emitted by the source in terms of hourly, daily, seasonal, and yearly rates, showing the calculation procedure
- a construction schedule
- information needed to determine that BACT or LAER technology, whichever is applicable, would be applied
- when needed, an analysis of the air quality and/or visibility impact, including meteorological and topographical data, and specific details of models used
- when needed, an analysis of the air quality and/or visibility impacts, and the nature and extent of commercial, residential, industrial, and other source emission growth in the affected area that has occurred since January 1, 1978.

Air quality/visibility analyses are required when sources exceed preestablished emission rates for specific pollutants (OAR, Ch. 340, Div. 20). These rates range from 100 tons per year of carbon monoxide to 1 ton per year of vinyl chloride. The regulations do not cover carbon dioxide. If modeling demonstrates that emissions would exceed significant rates, then BACT must be employed. If the source still does not meet the standards, a more detailed analysis of emissions may be used to demonstrate compliance. If it is clear that the standards will be exceeded, the developer may challenge the requirements and conduct his or her own risk assessment. However, this last step has rarely been invoked in Oregon.

Issuing a new permit may require a public hearing. For energy facilities, the hearing may be consolidated with the hearing requirements for site certification conducted by the Oregon EFSC.

Clean Water Act and Other Water Pollution Requirements

The Clean Water Act (CWA) authorizes federal and state control of pollutant discharges into U.S. waters and municipal sewer systems. In Oregon, a person responsible for such discharges must obtain a permit (CWA Section 402) from the Oregon DEQ, Water Quality Division. Specific standards must be met to obtain such a permit. The technology-based standards reflect the nature of the pollutants. For conventional pollutants (suspended solids, fecal coliform, oil, etc.), best pollution control technology (BCT) is required. BCT is defined in terms of costs and benefits. For toxic and nonconventional pollutants, best available control technology economically achievable (BAT) is required. Definition of BAT is based on considerations of cost, but not cost-benefit analysis.

In Oregon, the DEQ has established 19 water basins with their own water quality goals and regulations. Permits are considered on a case-by-case basis, and the size of the receiving stream is considered (Miles, Craig, and Greene 1984). The DEQ uses standard permit application forms developed by the EPA. Form 1 requests general information about the facility including its

location, a topographic map extending at least one mile past the property boundaries, and characteristics of the discharge. Applicants for powerplants that discharge process wastewater must complete Form 2D. The following is part of the information and data required:

- location and name of water body receiving the discharge
- operations that contribute to each point source, average flows, and treatments applied to each wastewater
- frequency of discharges, maximum and minimum flow rates, and duration
- maximum and average flows of specific pollutants including biochemical oxygen demand, chemical oxygen demand, total organic carbon, total suspended solids, ammonia, and pH
- maximum and average flows of nearly 150 other pollutants, if present
- a listing of toxic and hazardous pollutants, from a list of over 350, which are expected to be discharged.

For powerplants that discharge only nonprocess wastewater, such as noncontact cooling water, applicants must complete Form 2E. This form requires in part the following information:

- location and name of receiving waters
- maximum mass and concentration in effluent of biochemical oxygen demand, total suspended solids, total residual chlorine, oil and grease, chemical oxygen demand, total organic carbon, ammonia, discharge flow, pH, and winter and summer temperatures
- description of seasonal and intermittent flows
- description of treatment systems.

These data requirements are fairly comprehensive and should be adequate for the initial step in valuing water-related externalities, that of quantifying relevant discharges. However, the lack of modeling or risk assessment requirements in the standard permitting process means that little other information is produced for valuing externalities.

Intentional discharges to groundwater are regulated primarily by the federal Underground Injection Control (UIC) Program (Section 1421 of the Safe Drinking Water Act). Under the Act, EPA has issued regulations for underground injection programs that are administered by Oregon, primarily by the DEQ.

Finally, a permit is required from the Army Corps of Engineers for dams or dikes constructed in navigable waters (see later discussion). If a hydroelectric project is licensed by FERC, the requirements are usually included in the FERC license. For projects exempt from the FERC process, the Corps requires a separate permit. Other facilities associated with powerplants may require FERC licensing if they are in or affect navigable waters. In addition, discharges of dredged or fill materials generally require permits from the Corps.

FERC Certification of Qualifying Facilities

Sections 201 and 210 of the Public Utilities Regulatory Policies Act (PURPA) create a special class of power generating facilities designated as qualifying facilities (QFs). QFs are typically cogeneration facilities and small powerplants. PURPA exempts such facilities from several federal acts and most state public utility regulations.

In turn, however, owners of hydroelectric QFs must provide special information to the Federal Energy Regulatory Commission (FERC). Developers must submit an Environmental Report that includes the following information (18 CFR Ch. I, Sec. 4.41(f)):

- a description of federal and state recommended measures to protect and improve water quality; an explanation of why any measures were rejected; and a description of the applicant's alternate measures
- a description of groundwater impacts and measures proposed to mitigate them.

In addition, the applicant must submit information essentially the same as that discussed in the following section on FERC hydroelectric licensing.

Licensing of Hydroelectric Facilities

FERC imposes special requirements on hydroelectric generating plants. The Federal Power Act requires developers of hydroelectric facilities that do not qualify for an exemption to obtain a license from FERC prior to construction. The applicant must prepare a detailed environmental report, and FERC will normally prepare an EIS for newly constructed hydroelectric facilities.

For hydroelectric plants of greater than 5-MW capacity regulated by FERC, applicants must submit detailed information on the project. Permit applicants must provide the following environmental information required to assess environmental impacts (18 CFR Part 4, Subpart E):

- the location and description of the relevant water body
- minimum, mean, and maximum stream flows at plant intake and a description of the baseline water quality
- a description of the affected environment
- construction and operation impacts on water quality including quantification of effects on downstream temperature, turbidity, and nutrients
- mitigation and enhancement measures proposed to address water quality impacts
- a report on fish, wildlife, and botanical resources
- expected impacts on fish, wildlife, and botanical resources
- mitigation, enhancement, and protection measures proposed for fish, wildlife, and botanical resources and the costs of mitigation measures
- similar information on historic, archeological, recreational, and aesthetic resource impacts; socioeconomic impacts; and mitigation measures
- a description of current and proposed land use.

Similar, but less detailed, information is required by FERC for smaller hydroelectric plants.

For dams located on navigable waters, a permit must be secured from the Army Corps of Engineers. A set of policies applies to the permit requirements including the following (33 CFR Part 320.4):

- Probable impacts, including cumulative effects, must be evaluated.
- The evaluation must consider economics, aesthetics, general environmental concerns, wetlands, fish and wildlife, land use, and water quality.
- Mitigation is deemed to be an important part of the review process and it can include avoiding, minimizing, rectifying, reducing, or compensating for resource losses.

Under the FERC regulations, proposers also must consult with all appropriate federal and state agencies before applying to FERC. In Oregon, the applicant must consult with the Oregon DEQ. The applicant must also explain the proposed project's consistency with relevant state, local, and regional plans including the Northwest Power Plan and the Columbia Basin Fish and Wildlife Program. As noted, exemptions and reduced requirements are available to applicants proposing relatively small projects.

Federal law requires FERC hydroelectric licensees to comply with state water laws. Oregon has developed extensive, comprehensive policies and requirements for hydroelectric development. This is one area in which Oregon is quite unique.

Oregon has taken several steps to coordinate activities related to hydropower projects. The Strategic Water Management Group was established in 1985 to coordinate state responses to FERC hydroelectric actions. It comprises

representatives from state agencies such as the Water Resources Department, Department of Fish and Wildlife, ODOE, Economic Development Department, Department of Land Conservation and Development, Department of Forestry, and others. One duty of the Group is monitoring applications related to hydroelectric projects. A Hydro Task Force was also created to ensure that other relevant state agency concerns are brought up. The Task Force also serves as staff to the Group on FERC project licensing matters (Bain 1989, p. 104-105). The Task Force has instituted a process for state approval of new projects that outlines the steps developers must follow.

The Water Resource Commission develops relevant policies and the Water Resources Department (WRD) implements them. These policies affect the data requirements and procedures of the EFSC in its powerplant siting activities.

Oregon law sets stringent minimum conditions for siting hydroelectric plants, including the following (NERA 1990, p. 25):

- a project cannot be approved that may result in *mortality or injury to anadromous salmon and steelhead resources* except when the applicant proposes to modify an existing facility to restore or enhance anadromous fish populations within that river system
- any hydroelectric activity shall be consistent with the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program for the protection and enhancement of regional fish and wildlife resources
- the project may cause no net loss of wild game fish or recreational opportunities unless proposed mitigation measures are approved
- water quality, wildlife, scenic and aesthetic values, historic, and other sites shall be maintained or enhanced.

Cumulative impacts are considered in the case of hydroelectric facilities. If the EFSC determines that pending, approved, or existing hydroelectric facilities could have cumulative impacts, it must conduct a consolidated review of the applications. Resources covered in the review include anadromous salmon and steelhead; recreational opportunities; water quality; soils; scenic and aesthetic values; wildlife; threatened or endangered species; wetlands; agricultural and forest lands, etc. If cumulative impacts are probable, then the EFSC must conduct a study of individual and cumulative impacts. If the impacts violate minimum standards, then the EFSC refuses one or more pending facilities until the impacts are below the minimum standards (OAR Ch. 345, Div. 79).

Geothermal Resource Permitting Requirements

The federal government has special provisions for geothermal resource development on federal lands. Under the Geothermal Steam Act of 1970 the Department of the Interior (DOI) is given the authority to execute leases for geothermal resource development on most federal lands. A permit is required for exploration prior to execution of a lease and specific rules are laid out for all stages of development. Many of the rules focus on environmental impacts (43 CFR Part 3260).

The DOI's Bureau of Land Management prepares an Environmental Assessment (EA) that includes a description of the project, evaluation of the environmental impacts, descriptions of alternatives, and mitigation measures applied. The information in the EA is used to determine whether an EIS is required. The lessee may be required to provide data on the quantity and quality of the geothermal resource and water, including heat and fluid flow data. The lessee is required to submit for approval an operation plan that identifies areas of potential disturbance; methods for waste disposal; a description of environmental protection measures; and provisions for collecting data on existing air and water quality, noise, and ecological systems.

In Oregon, in addition to the EFSC's general powerplant siting and permitting requirements, permit requirements exist for drilling geothermal wells on non-federal lands. Drilling permits must be obtained from the Department of Geology and Mineral Industries (DOGAMI) for certain resources (high-temperature resources or deep wells). For wells not regulated by DOGAMI, a groundwater appropriation permit must be

obtained from the Oregon Water Resources Commission (NERA 1990, p. 29).

Geothermal well drilling permit applications to the DOGAMI must include the following information (OAR Ch. 632, Div. 20):

- location and elevation of the floor of the proposed derrick
- estimate of the depths to be drilled
- nature and character of the resources sought
- other information as may be required.

The DOGAMI circulates the application to several other state agencies including the Water Resources Department, DEQ, Department of Fish and Wildlife, Department of Land Conservation and Development, and ODOE (NERA 1990, p. 28).

A permit is also required from the DOGAMI if reinjection is planned. Conditions on the permit include that reinjection shall not pollute state waters, create a public nuisance, impair beneficial water uses, or degrade the habitat of aquatic life. The permit requires an explanation of the system used; a map; fluid characteristics including quality, quantity, chemical contents, reactivity, toxicity, and temperature; and characteristics of the injection zone, hydrology of the surrounding area, and subsurface maps (OAR Ch. 632, Div. 20). Reinjection requirements are based on federal regulations (40 CFR Subpart D, Sec. 146.34).

Summary of Oregon Requirements

Table 2 summarizes the preceding discussion of information collected in Oregon that could be used to analyze externalities. The table depicts information collected through both state and federal processes. Requirements related to water and air environmental impacts in Oregon derive largely from federal laws. For land impacts, Oregon has comprehensive statewide land use policies that are implemented at the local level. The existing requirements are likely to produce essential data for determining the amount of primary environmental disruptions associated with externalities, but in only certain cases will they produce data and information relevant to other steps in the process required to value externalities.

CUMULATIVE IMPACTS - A SPECIAL CASE

The analysis of cumulative impacts deserves special attention here because it cuts across several issues related to the valuation of externalities and corresponding data requirements.[5] As the previous section illustrates, cumulative impacts are not addressed in a comprehensive and consistent way in Oregon and probably most other states. This section briefly discusses the role of cumulative impacts in externality valuations.

Intuitively, pollution controls on new facilities should be tightest in regions where existing pollution levels are the highest. The Clean Air Act and Clean Water Act exemplify this concept through their tiered control technology requirements. For example, the Clean Air Act requires use of best available control technology in attainment areas, but requires control to the stricter lowest achievable emission rate in nonattainment areas.

This approach can be justified on theoretical grounds as illustrated in Lee et al. (1990)[6] for air pollution. The theoretical argument is based on the assumption that environmental impacts should be controlled to their economically efficient level, taking into account both control costs and the damage costs of uncontrolled impacts. Marginal control costs increase and the marginal benefits of each additional reduction in environmental damages decrease as tighter and tighter controls are imposed. To satisfy the economic efficiency criterion, controls should be required up to the point where the marginal control cost equals the marginal benefits of reduced damages. For a single powerplant in isolation, the intersection of the marginal control cost curve and marginal benefits curve for that plant determine the optimum control level.

When all existing sources of environmental damages are taken into account, however, different requirements emerge. For example, in the case where four identical powerplants exist and a fifth is being added, the combined marginal

TABLE 2. Availability of Data and Information in Oregon for Valuing Externalities

Component of Valuation	Type of Resource		
	Land	Water	Air
Baseline conditions	Yes; through local permits	Yes, for hydro plants; through state and federal requirements	Some information; through federal and state requirements
Quantities of primary disruptions	Yes; through local permits	Yes; through state and federal requirements	Yes; through state and federal requirements
Linkage of disruptions to affected systems	No	Yes, for hydro plants; through state and federal requirements	No, except for modeling required in special cases; through state requirements
Effects on systems	Some; through local permits	Yes, for hydro plants; through state and federal requirements	No, except for special cases; through state requirements
Economic impacts	No	No	No
Fuel cycle	Some; through local permits	Yes, for decommissiong and waste disposal in some cases; through state and federal requirements	No
Cumulative impacts	No	Yes, for hydro plants; through state and federal requirements	Only through prescribing controls on environmental impacts; through state and federal requirements

control cost and benefits curves would capture the combined effects of all five plants. This represents a situation where cumulative impacts are taken into account. Under these circumstances, it can be shown that the optimal control level is tighter for the new plant than if it were analyzed in isolation.

This result suggests that where existing pollution levels are higher, tighter controls on new plants are justified and the societal benefits are higher. This theoretical finding is supported empirically by recent arguments in California that certain out-of-state air quality damages should be valued at one-tenth their in-state value (CEC 1989).

Since the incremental cost of damages caused by each new powerplant depends on the existing level of environmental damages, externality valuations should take such cumulative effects into account. In Oregon, only state permitting requirements for hydroelectric plants require cumulative impacts assessments. In almost all other cases, except those where NEPA is triggered, the processes focus on meeting specific pollution standards with no, or only indirect, consideration of cumulative impacts. Consequently, there is likely to be limited information available through existing processes that can be applied to studies of cumulative impacts. Collecting such information and data could improve current siting and permitting processes as well as provide the basis for comprehensive externality valuations.

CONCLUSIONS AND OBSERVATIONS

Information for just a single state provides many useful insights into how other states can best take advantage of current processes in their efforts to value powerplant externalities. Driven largely by federal laws, states have in place many mechanisms to identify, quantify, and mitigate environmental impacts. These mechanisms, however, do not necessarily produce information on residual impacts, that is, externalities. This section presents observations and conclusions about 1) the match between the data collected under existing processes and those data needed to value externalities and 2) gaps that need to be filled.

Federal Requirements--Primary Environmental Disruptions

Major federal laws regulate the environmental impacts of new powerplants. The Clean Air Act, Clean Water Act, and NEPA can affect the major types of pollutants produced by powerplants. These laws and others impose their requirements either through direct federal processes or processes delegated to the states.

How states implement the federal requirements varies. Generally, the federal requirements provide a good starting point for determining what individual states will do.

As a rule, it appears that the federal laws as implemented by the states should lead to good information and data on the amounts of primary environmental disruptions, particularly in the area of air and water pollution. Because federal laws focus primarily on reducing externalities to specified levels, they lead to quantitative information about the quantities of primary environmental disruptions, such as the amounts of air pollutants emitted. These quantities comprise the first of the four quantification steps required in valuing externalities. Information on the other three steps, however, is less likely to be available.

Other Steps in the Valuation of Externalities

The approaches implemented by states that have valued externalities so far have been shortcuts to convert the amount of primary environmental disruptions into economic costs. Ultimately, accurate and credible valuation approaches will require more complete analyses of 1) the linkage between the primary disruption and affected systems, 2) the actual effect on such systems and their responses, and 3) the economic costs.

Current data requirements under federal laws address the first and second items only in certain circumstances under NEPA and, possibly, in the case of air quality impacts. In Oregon, air quality permits require plume dispersion modeling and risk assessments for powerplants under certain circumstances.

To determine the economic costs of externalities, control and mitigation cost data have been used in some cases as measures of the societal costs of externalities. Federal processes require some information on control and mitigation measures. Because the requirements are not designed for valuing externalities, however, they are inconsistent and incomplete.

Overall, existing procedures require little of the information necessary to address the three steps listed above in the externality valuation process.

State Diversity

We have presented some of the unique process requirements in Oregon. This information suggests that individual states are likely to have special information and data requirements in place that reflect atypical state characteristics.

In Oregon, for example, hydroelectric projects receive special attention. The state requirements are driven by federal requirements, but also respond to regional interest in monitoring and preserving water resources. In states where air quality is a major issue, such as California and New York, environmental regulations and requirements and externality quantification methods focus on air quality impacts (Foley and Lee 1990). It is likely that other states already have in place special processes and requirements that can provide data for valuing externalities of special interest.

The Fuel Cycle

Both federal and state environmental processes focus principally on the electricity generation stage of the fuel cycle. Existing externality valuation methodologies are also oriented toward impacts during generation.

Oregon siting requirements, however, partially address other portions of the fuel cycle. In most cases, siting certificate applicants must provide information on methods for disposal of spent nuclear fuel and wastes and on decommissioning. Nevertheless, a full valuation of externalities will require more complete data on other segments of the fuel cycle than are obtained under either federal or typical state processes.

Cumulative Impacts

As we have noted, the interactions among existing sources can be important in determining the value of damages caused by a new powerplant. Such cumulative effects are often overlooked or only implicitly recognized in externality valuations.

Federal and Oregon laws require assessments of cumulative impacts associated with hydroelectric resources. Other than the NEPA requirements applying to all federal actions, hydroelectric resources are the only ones for which explicit cumulative impact data and analysis are likely to be required in Oregon.

Coordination of Data Requirements and Submittals

Coordinated and centralized data requests can ease the burdens on resource developers who are required to submit information for valuing externalities. One-stop powerplant siting processes are an example of mechanisms to ease such burdens. Oregon's EFSC provides one example of a state agency with such authority. Other, but not all, states have agencies with similar authority. Because of their coordinating role, the federal NEPA process and state versions of the process also can reduce potential burdens on developers.

General Observations and Recommendations

Our analysis does not provide any insights about states with NEPA-like processes because Oregon does not have one. Nevertheless, it seems apparent that states that have their own NEPA-like process will be better prepared to set up procedures and data requirements for valuing externalities.

Our analysis of Oregon's processes and requirements demonstrates that existing processes in most states are likely to provide data and information adequate to partially assess powerplant externalities. States are likely to be best situated to collect information on primary environmental disruptions.

Major gaps, however, are probable in three areas: 1) parts of the fuel cycle other than electricity generation, 2) steps in externality valuation other than the primary environmental disruptions, and 3) cumulative impacts.

The valuation of externalities is a complex task. The success of state efforts to successfully include externality valuations in their utility planning and acquisition processes will depend to a large extent on the defensibility of their approach and the burdens that it places on developers. Based on our analysis, we present the following recommendations aimed at both minimizing the burdens of providing the necessary data and increasing the validity of the required analyses:

1. Agencies responsible for developing externality valuation procedures should inventory and assess current siting and licensing requirements that may provide some of the required information. Gaps in current requirements should be identified.

2. Steps should be taken to centralize and coordinate data collection. Externality valuation data collection might need to be incorporated in current processes or data collection under current requirements might best be incorporated in an overall integrated data collection process.

3. Alternative methods for valuing individual externalities should be assessed as the basis for determining the best approach for each externality and establishing appropriate data and information reporting requirements.

4. Procedures should be established for collecting information on control and mitigation costs and damages associated with all impacts.

5. Processes should be developed for collecting and analyzing data on cumulative impacts for all environmental impact types.

6. Processes and criteria should be developed for determining which stages of the fuel cycle to evaluate for various generating resources and what data to require.

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REFERENCES

Alton, C.C., P.M. Dowty, and O.L. Schmidt. 1989. *Commonly Asked Questions on the NEPA Process*. Bonneville Power Administration, Portland, Oregon.

Bain, D. 1989. *Development Framework for PURPA Resources in Oregon*. Oregon Department of Energy, Salem, Oregon.

Baumol, W.J. and W.E. Oates. 1975. *The Theory of Environmental Policy: Externalities, Public Outlays, and the Quality of Life*. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Bonneville Power Administration (BPA). 1990. *BPA Generating Resource Acquisition Process*. DOE/BP-1436, Portland, Oregon.

Buchanan, S.C. 1990. "Estimating Environmental Costs of Energy Resources." *The Electricity Journal*, V.3, N.6, Seattle, Washington.

California Energy Commission (CEC). 1989. *Valuing Emission Reductions for Electricity Report 90*, Staff Issue Paper #3R, Sacramento, California.

Callaway, J.M. and J.W. Currie. 1989. *A Framework for Incorporating Externalities into Least-Cost Planning Procedures in Massachusetts*. Battelle-Northwest Laboratories, Richland, Washington.

Clean Air Act. 42 USC 7401-7642.

Clean Water Act. 33 USC 1342, Sec. 402.

ECO Northwest (ECO). 1986. *Estimating Environmental Costs and Benefits for Five Generating Resources*. Prepared for Bonneville Power Administration, Portland, Oregon.

Foley, L.O. and A.D. Lee. 1990. "Scratching the Surface of the New Planning: A Selective Look." *The Electricity Journal*, V.3, N.6, Seattle, Washington.

Hendrickson, P.L., S.A. Smith, A.G. Thurman, R.L. Watts, and S.A. Weakley. 1990. *Preconstruction Schedules, Costs, and Permit Requirements for Electric Power Generating Resources in the Pacific Northwest*. PNL-7420, Pacific Northwest Laboratory, Richland, Washington.

Federal Power Act. 16 USC 812(b).

Geothermal Steam Act of 1970. 30 USC 1001-1025.

Miles, T.R., Jr., L.S. Craig, and W.T. Greene. 1984. *Guide to Oregon's Environmental Permits for Biomass Energy Projects*. Prepared for Oregon Department of Energy, Salem, Oregon.

National Environmental Policy Act (NEPA). 40 CFR 1500 - 1508.

National Economic Research Associates, Inc. (NERA). 1990. *An Evaluation of State Environmental Requirements and Permitting Procedures in the Bonneville Power Administration's Resource Acquisition Process*. Seattle, Washington.

Northwest Power Planning Council (NWPPC). 1986. *Northwest Conservation and Electric Power Plan, Volume Two*, Appendix II-A. Portland, Oregon.

OAR Ch. 345, Div. 20.

OAR Ch. 345, Div. 26.

OAR Ch. 345, Div. 76.

OAR Ch. 345, Div. 79.

OAR Ch. 345, Div. 111.

OAR Ch. 632, Div. 20.

Oregon Department of Energy (ODOE). 1985. *Regulation of Small Scale Energy Facilities in Oregon, Background Report Vol. 2*. Salem, Oregon.

Ottinger, R.L. 1990. "Getting at the True Cost of Electric Power," in *The Electricity Journal*, V.3, N.6, Seattle, Washington.

Pacific Northwest Electric Power Planning and Conservation Act (Regional Act). Pub. Law No. 96-501, Sec. 4.(e)(2), 94 Stat. 2706 (1980).

Public Utilities Regulatory Policies Act (PURPA). 16 USC 824a-3.

Safe Drinking Water Act. 42 USC 300h.

18 CFR Part 4, Subpart E.

18 CFR Ch. I, Sec. 4.41(f).

33 CFR Part 320.4.

40 CFR Subpart D, Sec. 146.34.

43 CFR Part 3260.

ENDNOTES

1. Pacific Northwest Laboratory is operated by Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830.

2. One obvious reason is that legislation and regulations set emission and other requirements through a political process, not through economic optimization. A less obvious reason is that even if the regulated marginal control cost did equal marginal benefits, it would be incorrect to simply multiply the marginal cost times the quantity of residual pollution to calculate total residual impacts because marginal benefits (avoided marginal damages) are likely to decrease as the amount of residual pollution declines.

3. The major permit and license requirements are included, but certain types of permits, such as building permits and special transportation permits, are not included.

4. This requirement is important because it illustrates a regulatory approach to require controls with marginal costs that are higher where marginal benefits of control are likely to be higher.

5. The term "cumulative impacts" can be interpreted differently in different settings. Here we mean total impacts, taking into account existing sources of environmental degradation and new sources.

6. Lee, A.D., M.C. Baechler, J.M. Callaway, L.O. Foley, and C.S. Glantz. 1990 (forthcoming). *Information for Bonneville's Quantification of Environmental Externalities*. Pacific Northwest Laboratory, Richland, Washington.

DATA AND INFORMATION FOR VALUING EXTERNALITIES IN OREGON

Valuation Component	Type of Resource: Land	Water	Air
Baseline Conditions	Yes, Local Permits	Hydro Plants, State/Federal Requirements	Some, State/ Federal Requirements
Primary Disruption Quantities	Yes, Local Permits	Yes, State/Federal Requirements	Yes, State/ Federal Requirements
Linkages	No	Hydro Plants, State/Federal Requirements	Only Special Cases, State Requirements

DATA AND INFORMATION FOR VALUING EXTERNALITIES IN OREGON (contd.)

Valuation Component	Type of Resource: Land	Water	Air
Effects on Systems	Some, Local Permits	Hydro Plants, State/Federal Requirements	Only Special Cases, State Requirements
Economic Impacts	No	No	No

DATA AND INFORMATION FOR VALUING EXTERNALITIES IN OREGON (contd.)

Valuation Component	Type of Resource: Land	Water	Air
Fuel Cycle	Some, Local Permits	Decommissioning/Waste Disposal in Some Cases, State/Federal Requirements	No
Cumulative Impacts	No	Hydro Plants, State/Federal Requirements	Only Through Prescribing Controls, State/Federal Requirements

RECOMMENDATIONS

- Inventory Current Processes and Requirements
- Centralize and Coordinate Data Collection
- Assess Alternative Valuation Methodologies
- Establish Data Collection Procedures for Valuing Externalities
- Collect and Analyze Data on Cumulative Impacts
- Determine Stages of Fuel Cycle to Assess

CONCLUSIONS

- Federal Requirements Focus on First Step in Externality Valuation
- State and Federal Requirements Are Inadequate For Quantifying
  - -Linkages Between Primary Disruption and Affected Systems
  - -Effects on Systems
  - -Economic Costs
- Diversity Exists Across States
- Existing Requirements Do Not Adequately Address Fuel Cycle

THE NEED FOR UTILITIES TO CONSIDER POTENTIAL REGRET IN EVALUATING OPTIONS TO MEET FUTURE ENERGY SERVICE NEEDS

By John S. Hoffman and Kathleen Hogan

Abstract

As utilities struggle to meet growing energy service needs, they would benefit from carefully evaluating the potential economic losses that would be associated with changing environmental requirements. Past failures to consider acid rain provisions and nuclear safety concerns have led to higher costs for some energy supply options. Failure to consider possible future limitations of greenhouse gases could have serious economic consequences for ratepayers and utilities. Explicitly considering risks of future limits on greenhouse gases and other environmental effects of various options to satisfy growing energy service needs can greatly reduce risks of future cost escalation due to future decisions to limit greenhouse gases. Because of the large number of economically attractive options available (conservation, alternative supply, and natural gas), reforms that are neutral to how energy services are met and consider environmental benefits can also lower costs as well.

A Least-Cost Strategy for CO_2 Reduction

by

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Abstract

In the summer of 1988 a group of scientists and policmakers met at the Aspen Institute to discuss the issue of global warming. They concluded that the evidence for concern about global warming was compelling enough to consider taking policy actions now to avert the likelihood of future warming. Yet because of the uncertainties about both the likely amount of warming and the potential damage that warming might cause, the consensus was that only policy measures that are "least cost"--that is, cost-effective or very low cost on their own merits (without taking into account the long-term costs and benefits of global warming)--should be considered at this time.

Focusing on the U.S. energy sector as a major contributor to global CO_2 emissions, there have been a number of studies that measure the potential reductions in emissions from alternative U.S. energy policy actions for reducing CO_2 emissions. The analysis was done as a part of a U.S. Department of Energy research project commissioned by Congress in 1989. A larger scale model of U.S. energy supply and demand, called FOSSIL2, was used to quantify the costs and potential CO_2 reduction from alternative energy policies. This model was developed in 1977 for DOE specifically to evaluate the long-term effectiveness of national policies, and to provide policy analysis for National Energy Strategy.

The paper concludes that conservation and reforestation are "Least-Cost" policies for reducing future CO_2 emissions. However, cost-effective conservation programs might reduce CO_2 emissions only about 10 to 20 percent--well below the reduction needed to keep CO_2 emissions from growing. Reforestation--especially in tropical areas--is both low in cost and has the potential for larger reductions in emissions. For example, a policy of offsetting CO_2 emissions for new power plants by growing enough trees to absorb their emissions might increase costs by less than 1 to 5 percent, and might keep total U.S. CO_2 emissions near today's levels.

A Least-Cost Strategy for CO_2 Reduction

I. INTRODUCTION

The issue of global warming has sparked debate among scientists and policy makers. Increased world-wide emissions of certain gases (carbon dioxide, methane, ozone, nitrous oxide and CFC's) may be changing the atmosphere in ways that could alter the global climate through increases in surface temperatures. Although the magnitude and timing of such temperature changes is uncertain, potential impacts include sea level rise, decreased rainfall in agricultural regions, disruption of ecosystems and increased violence of tropical storms. In short, increased concentration of these "greenhouse" gases could adversely affect a wide range of human activities.

The U.S. and other nations are spending large sums of money in an effort to better understand the causal mechanisms of climate change. Major research is focused on improving general circulation models that model the biosphere as a system. However, it will likely be years before the uncertainty in the magnitude and timing of global warming forecasts is substantially reduced. In the meantime, prudent scientists and policy makers have suggested that, given the potential severity of global climate change, mitigation strategies be studied immediately.

This paper reports on one such study. Congress in late 1988 mandated the U.S. Department of Energy (DOE) to conduct a study of energy technology and policy options to mitigate greenhouse gas emissions (1989 Energy and Water Authorization Bill). The study mandate is quite broad, allowing DOE to evaluate a comprehensive set of policies aimed at reducing emissions by 20 percent (from 1989 levels) by the year 2000 and 50 percent by 2010.

The focus of the study is energy technologies and policy; the U.S. energy sector is a major producer of greenhouse gas emissions, accounting for about 57 percent of U.S. emissions in the 1980's (EPA, 1989). A number of recent studies have attempted to assess the potential reduction in emissions from specific policy actions (Manne and Richels, 1989). However, no study to date has attempted to comprehensively assess a full array of policies or measure their costs.

The current DOE study is an attempt to assess the emissions reduction potential and costs of a broad set of technology as well as several individual and combinations of policies. It is expected to be the most comprehensive and detailed analysis of this issue to date and have a major impact on both domestic global warming policies and international treaty negotiations. The focus of this paper is on CO_2 reduction policies. CO_2 represents 70 percent of energy-related greenhouse gas emissions. Of the other greenhouse gases, methane and CFC's are not directly related to energy consumption, and although methane is tied to natural gas production and distribution as well as underground coal mining, policies to reduce methane emissions are not discussed here. Nitrous Oxide (N_2O) is not considered in the DOE study because of the uncertainty of the emissions coefficients.

This paper is a summary of some preliminary results of this study. It discusses the analysis methodology, the policies assessed, some draft results and policy insights gained. Several dozen policies and policy combinations are considered in the full DOE study. This paper focuses on a subset of eight cases.

II. THE FOSSIL2 MODEL

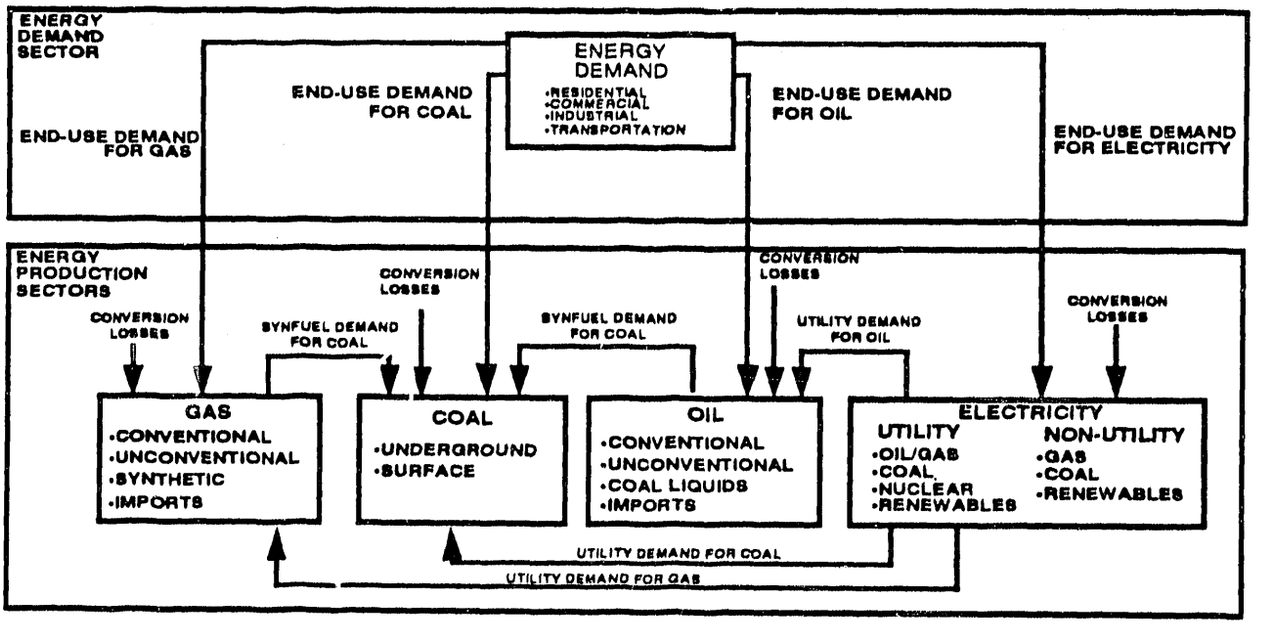
The principal analysis tool for this study is a large-scale system dynamics model of the U.S. energy system called FOSSIL2. FOSSIL2 is a technology simulation model that projects energy

production, imports, consumption and prices over a 40-year time period. It is used by the Department of Energy to analyze long-term energy policies and alternative energy futures.

The model can be characterized as an energy market equilibrium model, as energy markets clear over time through feedback among prices, demand and production capacity. The model is used in this study as an integrated analysis framework to incorporate a large set of assumptions generated by both the Department of Energy and the DOE national laboratories. The model is uniquely suited for long-term energy policy analysis because of its technology based structure, the integrated feedback of all sectors and fuels, and the inclusion of the long-term effects of resource depletion on fuel costs.

Figure 1 shows the basic interactions between energy producers and consumers included in the FOSSIL2 model. In the demand sector, energy consumers make decisions to utilize oil, gas, coal, or electricity based on both fuel prices and availability of fuels. Energy producers, in turn, choose

FIGURE 1
BASIC STRUCTURE OF THE FOSSIL2 ENERGY MODEL



to invest in the production technology that maximizes the industry's rate of return (or minimizes the average cost of production), subject to environmental constraints (for example, SO_2 restrictions or water availability).

Investment decisions by both end-users and energy producers accumulate through time as capital equipment is purchased. The existing stock of energy-consuming and energy-producing equipment largely determines the demand and production capacity for each fuel. If an imbalance develops between demand and capacity, then energy prices adjust to restore the balance, simulating the effect of market-forces.

Energy Demand

The FOSSIL2 model uses a "Least-Cost" analytical approach to model U.S. energy demand. Following this approach, the model first projects the demand for energy services (heat, light, steam, shaft power) and then calculates the share of specific end-use markets captured by energy-using technologies and fuels—including, for example, conservation, cogeneration, or conventional

energy-using technologies.

The concept of measuring energy services—not just fuel use—considers energy as a means of providing services to final consumers (for example, mobility, comfort, or industrial processes such as steam or machine drive). Fuel is only one necessary component in providing energy services—end-use equipment such as a furnace or air conditioner is also needed. Consumers do not simply choose fuels, but rather choose a combination of fuels and end-use technologies.

The demand sector uses a least-cost algorithm to project consumers' decisions to invest in end-use equipment. Costs of end-use conversion and conservation technologies are combined with fuel prices to meet projected energy service demands at the lowest possible cost. Generally, this involves a tradeoff between a capital investment (for example, an energy-efficient furnace or additional insulation for a home) and paying annual energy costs: adding capital can lower the annual fuel bill. The least-cost combination depends on the cost and efficiencies of the technology alternatives, as well as the expected price of fuels. As prices rise, consumers invest in more energy-efficient capital equipment in order to save on energy bills.

Historical evidence indicates that consumers tend to invest in energy-related decisions as if they had a relatively short payback period (two to five years), or a relatively high "hurdle rate" for energy efficiency investments. The cumulative effect of these individual investment decisions through time determines the U.S. energy-using stock and potential energy consumption. Utilization of existing equipment can be modified by short-term behavioral responses, such as changing thermostat settings or practicing energy management. Thus there is both an immediate as well as a long-term response of demand to changes in prices in the FOSSIL2 model.

In the FOSSIL2 demand sector, each of the major energy-using sectors—residential, commercial, industrial, and transportation—is represented separately. Within each end-use sector, energy demand is further disaggregated by service demand category. Consumers are assumed to choose the least-cost combination of conservation and fuels to meet new service demand or to modify existing equipment. The conservation options are represented in cost/efficiency curves with a specific curve for each fuel and service demand category. The curves describe the cumulative energy savings that customers can purchase in conservation investments as a function of their cost per Btu saved. The technologies that comprise the curves are arranged in least-cost order, assuming that customers invest in the most cost-effective technologies first. The amount of conservation investment is dependent on expected fuel prices and the consumer's discount rate (hurdle rate for energy investments). As energy prices rise, consumers "move up the curves" and purchase more conservation. However, the conservation supply curves all show diminishing returns, and at some level more investment produces too little incremental savings to make the investment worthwhile.

For most energy service categories, there are several fuels that can provide the required energy—in addition to "conservation." In a few cases, such as lighting and appliances, only electricity can be used. For those where there are choices of fuels, a least-cost algorithm is used in FOSSIL2 to determine the fuel market share categories for new energy equipment. To determine market shares, energy service costs for each fuel/technology combination are compared. This cost is the sum of the capital cost, which includes a base equipment cost and additional conservation costs, and the fuel cost, which takes into account the base efficiency and conservation savings. Because the costs faced by all consumers are not exactly the same due to regional and site-specific differences, the fuel choice algorithm is based on distributions of cost rather than on single point estimates (AES, 1986).

Energy Supply

The FOSSIL2 energy model has four major supply sectors: oil, natural gas, coal and electricity. Renewables that produce electricity are incorporated in the electricity sector; non-

electric renewables are included in each end-use sector. The discussion here focuses on the sectors most relevant to the global warming study: oil, gas and electricity. The coal production sector produces little direct CO_2 (most CO_2 comes from coal burned in industrial or electric utility boilers).

Petroleum and Natural Gas Supply

The oil and gas sectors of the FOSSIL2 model project petroleum and natural gas production and imports; natural gas wellhead prices are also estimated. These sectors capture the long-term dynamics of fossil fuel discovery, production and depletion as well as the transition of the oil and gas industry from conventional resources to unconventional resources and production technologies. The model includes structures that represent the exploration for new resources, development of new reserves and installation of new production capacity in response to demand (determined by the demand sectors) and industry return on investment. Wellhead gas prices are calculated based on market equilibration between gas supply and demand. Oil prices are determined in the world market and are therefore input assumptions, although the model adjusts the oil price in response to changes in demand. These prices are then used to calculate product prices, which in turn are fed back in each time period to the demand sectors in order to equilibrate supply and demand.

The oil and gas sectors allocate joint oil and gas industry investment among extraction and conversion technologies on the basis of marginal production costs and industry return on investment. For extraction technologies, investment is allocated between wildcat and development drilling. Wildcat drilling discovers resources and increases proven and probable reserves; development drilling increases proven and probable reserves. Investment in conversion technologies (e.g. coal liquids) results in construction of synthetic fuel facilities. Resource categories included in the model are listed in Table 1.

Table 1: Oil and Gas Categories

Oil Resources	Gas Resources
Conventional onshore	Conventional onshore
Stripper wells	Gulf of Mexico offshore
Gulf of Mexico offshore	Onshore associated
Thermal enhanced oil recovery	Gulf of Mexico offshore associated
Other enhanced oil recovery	Unconventional (coal bed methane, tight gas, Devonian shale and infill drilling)
Onshore natural gas liquids (NGL)	High Cost Unconventional (hydrates, very tight sands and deep gas)
Gulf of Mexico offshore NGL	Synthetic gas from coal
Tar Sands	Alaskan
Synthetic coal liquids	Pipeline imports
Alaskan	LNG imports
Imports	

Oil imports are equal to the shortfall in domestic supply. Natural gas imports (both pipeline and LNG imports) are determined on the basis of their cost and import capacity (EEA and AES, 1990).

Electricity Generation

The electricity supply sector of the FOSSIL2 model projects prices and the mix of electricity capacity and generation. It captures the long-term dynamics of capacity construction, use and retirement as well as the transition from more conventional fossil fuel capacity to advanced coal, nuclear and renewable generation technologies. The sector builds new capacity in response to expected future demand, dispatches capacity to satisfy current demand (determined by the demand

sectors) and sets electricity rates in accordance with utility rate regulations. These prices are then fed back to the demand sectors in order to equilibrate future capacity and demand.

The sector estimates the quantity of new electricity generation capacity required in each time period based on a forecast of load growth and the levels of generating capacity both existing and under construction. Utility and non-utility generators then compete for a share of the market for new capacity. The model includes costs and performance characteristics for 23 different generation technologies (listed in Table 2). In addition to the technologies listed, the model can explicitly "life-extend" oil, gas and coal steam plants, "repower" coal plants using the atmospheric fluidized bed (AFB) or integrated gas combined cycle (IGCC) technologies and convert gas combined cycle or turbine plants to coal by installing a coal gasifier.

In order to allocate investment in new capacity among the large number of technologies, the levelized cost per kilowatt-hour is calculated for each technology in each time period based on capital costs, operating and maintenance costs, fuel costs and design capacity factors. New capacity construction decisions are then made on a least-cost basis weighted by a market allocation function. The model uses a logit-based market share algorithm; "knife-edge" construction decisions are therefore avoided. Electricity rates are then calculated based on capital and operating costs of the resulting capacity mix. (Detailed information on the technology assumptions, market share algorithm and electricity rate algorithm is available in AES 1990).

Table 2: FOSSIL2 Electricity Generation Technologies

Coal	Oil/Natural Gas	Nuclear	Renewables
Coal Steam	Oil steam	Light-water reactors	Hydroelectric
Coal steam w/FGD	Gas steam	Advanced light-water reactors	Photovoltaics
Atmospheric fluidized bed	Gas combined cycle	Second generation nuclear	Solar thermal
Pressurized fluidized bed	Combustion turbines		Wind
Integrated gasification combined cycle (IGCC)	Steam injected turbines (STIG)		Geothermal
Coal gasification ISTIG	Intercooled steam injected turbines (ISTIG)		Biomass
Coal gasification fuel cells	Gas fuel cells		

A national-level annualized load duration curve together with operating costs determine the capacity dispatching order. In a given time period, technologies within the capacity mix are dispatched on the basis of fuel and variable operation and maintenance costs. This typically translates into a dispatch order that baseloads nuclear, a large amount of coal, some oil and gas, and renewables. "Intermediate" coal and "intermediate" oil and gas are used for cycling loads, and pumped storage hydro and combustion turbines serve peaking needs. Capacity factors are determined from this dispatching order.

III. GLOBAL WARMING POLICIES

Virtually every part of the U.S. energy system produces carbon dioxide; however, some sectors produce disproportionate emissions. In 1990 the electricity generation industry is estimated to produce 38 percent of total energy-related carbon emissions, although it is important to note that end-use consumers are in effect emitting that carbon by consuming the electricity. Petroleum use in transportation accounts for about 29 percent of emissions, while industrial fossil fuel use represents 21 percent and residential and commercial buildings account for about 12 percent. Policies to reduce carbon emissions should focus on the major CO_2-emitting sectors but also consider the fact that all sectors contribute to this problem.

Policies that address the rising rate of carbon emissions can take a number of approaches depending upon the availability of appropriate technology as well as the feasibility of implementation. Measures that decrease the carbon intensity of energy consumption seek to provide the same level of energy production at lower carbon levels. For example, the promotion of energy-efficient production technologies and energy conservation through standards causes users to use less fuel input for the same energy output. Financial incentives (such as fees or taxes) might also be used to discourage the use of carbon-intensive energy systems and encourage more environmentally benign ones. Such fees or taxes, based either on carbon content or the use of particular fuels or technologies would allow energy users to trade off the relative merits of paying the penalties versus adopting new fuels or technologies to avoid carbon emissions. If these fees are set appropriately, commensurate with the carbon content of the fuels, the market will pursue emission-reducing and economically efficient measures. In conjunction with reducing carbon emissions, sequestering those emissions by planting trees (or developing other carbon sinks) could prove worthwhile as well.

Our study seeks not to recommend a particular course of action, but rather to examine a wide range of policy options, to explore the potential costs of pursuing those options, and to identify feedback effects which could improve or offset the effectiveness of these policies. The FOSSIL2 model includes end-use technology costs as well as energy production costs, so it is able to account for the total energy service costs. Both capital and fuel components of costs are considered, so that new equipment, conservation investment and fuel price changes can be balanced as economic choices are made to invest in one or another technology. The costs of these policies can be compared with their effectiveness in reducing emissions to arrive at measures for policy cost-effectiveness. Relating these costs to their effects on the energy system and carbon emissions will give policy makers measures of the relative cost-effectiveness of alternative policy options.

Energy Efficiency Standards

Residential, commercial and industrial conservation investments in FOSSIL2 are made in each end-use category on the basis of fuel prices, consumer discount rates, and conservation equipment costs and efficiencies (represented in conservation "supply curves"). Given these parameters, each end use arrives at a least-cost matrix of energy conservation and fuel consumption in a given period. It is important to note, however, that the least-cost solutions for such consumers are often not the least-cost solution for society as a whole. For example, consumers who make decisions based on average energy prices and use a two to three year payback period are reluctant to invest one thousand dollars per kilowatt in energy conservation. However, utilities that see marginal prices and use a 30-year payback period may spend two to four thousand dollars per kilowatt on new capacity. Policies that could reduce energy consumption therefore also result in society-level least-cost solutions and are leading candidates for an effective CO_2 mitigation strategy.

Energy efficiency standards mandate higher conservation levels through efficiency standards for each end use. This is accomplished in the model by racheting up the conservation supply curves in 1990 to the standards levels. Thus the standards force new buildings and capital stock to meet the new efficiency levels. As a result, the capital costs rise substantially in the short term relative to the reference case without the standards; however, added fuel savings are realized in the longer term. Standards are incorporated similarly in the transporation sector. CAFE standards are specified over time and all new autos and trucks are required to meet the standards.

This paper reviews two standards cases that bound the buildings and industrial conservation potential in the conservation supply curves. The very high standards are set in the uppermost region of the curves; they represent extremely high but non-economic levels of conservation. The high conservation case represents approximate mid points on the curves between the reference and very

high conservation cases. Hypothetical extensions of vehicle CAFE standards in both cases are taken from recent work at Argonne National Laboratory. Average on-road auto fleet efficiency reaches 26 mpg by 2000, 32 mpg by 2010, and 48 mpg by 2030.

Carbon Taxes

The prices of fossil fuels do not reflect the carbon content of those fuels. In fact, the fuel highest in carbon (coal) has the lowest price ($/MMBtu). Policies that tax fuels proportional to their carbon content can adjust the energy prices seen by the end-user to better reflect the fuel's contribution to global warming. Such a pricing scheme would favor non-carbon emitting fuels over fossil fuels and natural gas over oil and coal. This tax would be applied based on the carbon content of the primary fuel, rather that actual carbon emissions. Ostensibly, an emissions tax would provide the user more flexibility in reducing carbon output, because of the additional option of removing carbon from the process before it is emitted. However, the present high cost of CO_2 removal and the lack of permanent CO_2 disposal possibilities make an emissions tax essentially no different than a carbon content tax from the end-user's perspective, and a tax based on carbon content is much more easily implemented.

Carbon taxes have already been proposed in a number of countries and are usually expressed in dollars per ton of carbon emitted. Finland has gone the furthest by introducing a $6/ton tax on fossil fuels in its 1990 Finance Act; Sweden is considering a much larger tax of $40/ton (The Economist, March 17, 1990). Even so, taxes of greater magnitudes will most likely be required to achieve the dramatic reductions called for by Congress. Our study explores four tax cases: $100/ton, $250/ton, $400/ton and $625/ton.

Coal Power Plant Efficiency Standards

Coal consumption in the electric utility sector represents over 85 percent of all U.S. coal consumption, and therefore the promotion of more efficient coal-fired generation should help to reduce carbon emissions. Included in our study is a set of coal power plant efficiency standards that imposes a penalty on the capital cost of new coal-fired power plants not meeting the standards. This penalty is based on the difference in conversion efficiencies between each coal technology and a chosen state-of-the-art technology. The best commercially available technology is considered the standard; this target changes as new clean coal technologies develop. Atmospheric fluidized bed issued as the most efficient available technology in 1990, but is then replaced by the Integrated Gasification Combined-cycle (IGCC) technology in 2000 and then by coal fuel cells after 2010. The penalty is $800 per 1000 Btu/Kwhr difference in the heat rates between the standard and target technologies; this translates into 30 to 50 percent increase in capital costs for the affected technologies.

Reforestation Offsets

The potentially high cost of limiting carbon emissions suggests that policies for removing carbon from the power plant emissions should be considered. Technologies exist to scrub carbon dioxide from the effluent stream of power plants, but costs are extremely high and disposal poses a substantial problem. Currently the most cost-effective method of "scrubbing" CO_2 after burning the fuel is the planting of fast-rotation trees and other forms of biomass. Carbon emitted by fossil fuel combustion can be "fixed" (i.e. removed from the atmosphere and stored in the biomass) during the growth cycle of such crops.

One reforestation offset case is considered in this paper. In this reforestation policy case, tree planting is mandated to fix the lifetime carbon output of all new fossil-fueled power plants and industrial boilers and cogenerators. Although such offsets are conceptually straightforward, major uncertainties are connected with the costs of such a policy (Moulton, 1989). This paper estimates

that 160 million acres of marginal agricultural land are available for reforestation in the U.S. and that carbon uptake with appropriate crops and climate conditions is about 2.5 tons/acre/year (Reilley, 1989). The acreage limit is assumed to be an economic rather than a absolute constraint; additional land is available, but only at a much higher cost. These costs start at about 10 dollars per ton of carbon removed, and rise as high as 90 dollars per ton removed (Moulton, 1989). This translates into into cost additions of up to a third of the capital cost of a new fossil-fueled power plant and almost double the cost of life extensions. In industry, the cost is 8 percent of a new boiler.

IV. RESULTS

With no major changes in policy, the annual rate of carbon emissions from the U.S. energy system is projected to grow from an estimated 1320 million metric ton per year (MMT/yr) in 1987 to 1772 MMT/yr in 2010 and 2267 MMT/YR in 2030--the 2030 rate being over 70 percent higher than in 1990. In this "business as usual" case, virtually all growth occurs in electricity generation and in transportation fuels.

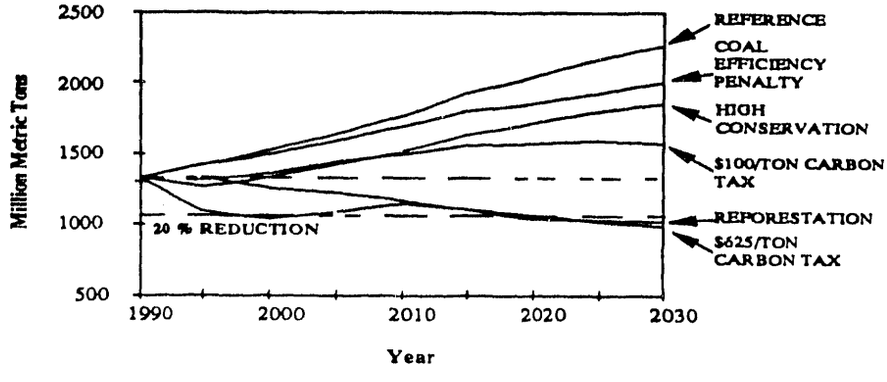
Our discussion first explores the CO_2 emissions reduction potential of the policy cases, then fuel switching and energy end-use implications, and finally discusses costs and cost-effectiveness. This set of policies illustrate that absolute reductions in carbon emissions are possible, but will not be easy.

Emissions

The eight policy cases examined involve significant changes in fuel use and technology choice and rely on consumers' responsiveness to higher prices. The substitution of more efficient technologies both at the end-use and in electricity production can help decrease our energy intensity, but the direct impact of efficiency improvements reduces greenhouse gas emissions only modestly. Significant carbon reduction comes about primarily through price-induced cutbacks in demand and wholesale switching towards carbon-free technologies.

Figure 2 illustrates annual carbon emissions for the reference case and selected carbon mitigation policies. Most notably, only the extreme carbon tax case ($625/ton) and the reforestation policy nears the goal of 20 percent reduction in total carbon emissions. Most of the reductions in emissions shown in Figure 2 occur in the electricity sector and to a lesser extent in industry. These not only represent the largest contributing sectors of carbon emissions, but are the sectors with the most technology and fuel alternatives. Conservation standards are the most effective means of reducing emissions in the residential and commercial sectors, whereas carbon taxes affect all sectors, (especially electric generation).

Figure 2: ANNUAL CARBON EMISSIONS

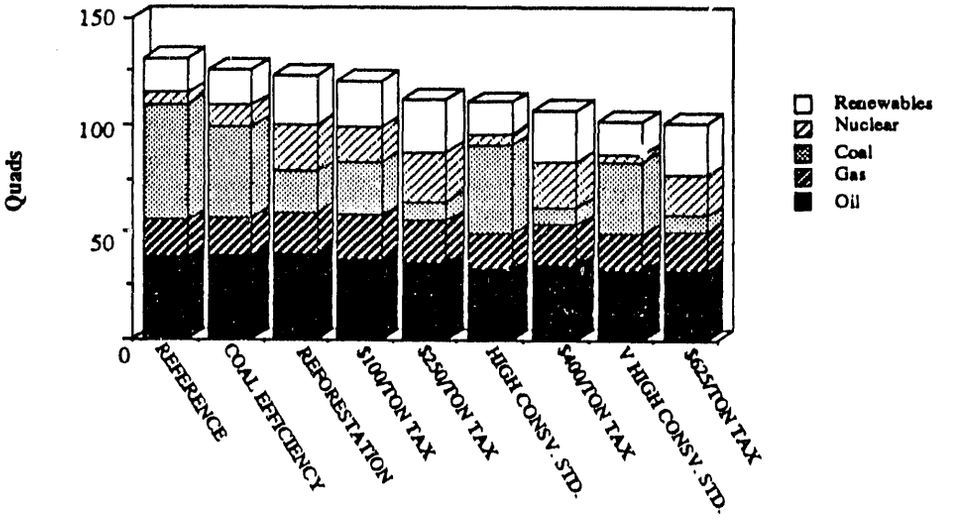


Reforestation is unique in offering sustainable carbon reductions. Because this policy fixes carbon output from all new generating plants, it decouples emissions from electricity demand. The potential reduction in emissions is quite large--emissions from electric generation represent 54 percent of total 2030 CO_2 emissions in the reference case but amount to only 5 percent with reforestation. With the prospect of increased electrification in the economy, this policy provides a potentially effective way to reduce emissions while maintaining growth in electricity usage, provided enough acreage is found to support the required biomass.

Energy Consumption

Since carbon emissions are closely linked to energy consumption, policies should be evaluated from this perspective as well. The goal of each policy in this context is to decrease the total fossil fuel consumption, and especially coal consumption, since coal emits twice as much carbon as natural gas. Figure 3 shows primary energy consumption in the year 2030 for each of the policies tested. Total oil and gas consumption in these cases is similar to the reference case, but total energy consumption as well as the mix of coal, nuclear, and renewables varies substantially. This model, prepared for the Department of Energy, assumes that over this 40-year time frame, viable "advanced" nuclear technology options will be developed. It is clear from Figure 3 that when coal use is cut back, these advanced nuclear technologies make up most of the difference, with some increase in renewable energy and conservation as well. This is logical since coal and nuclear power are assumed to be the two major energy sources which provide long-term, reliable and inexpensive baseload capacity for electricity generation. Natural gas provides a short-term solution (to the year 2000 or so), but as conventional gas resources are depleted, the energy system must rely on expensive unconventional supplies to meet gas demand. This causes the price of gas to rise substantially, making the nuclear option more economically attractive in the longer term.

Figure 3: PRIMARY ENERGY CONSUMPTION IN 2030



In the increased coal efficiency case, the average efficiency of coal power plants in 2030 increases from 40 percent to 45 percent. Although this change is relatively modest, the cost penalty associated with this policy substantially raises the cost of most coal-fired capacity and results in substantial shifts to nuclear, renewable and advanced high-efficiency coal capacity (e.g. coal gasification fuel cells) in the long term. Total coal use is reduced by almost 12 quads by 2030, 42 percent of which is due to increased efficiency; the remaining 58 percent is attributable to conservation and fuel switching (by both consumers switching away from electricity and electricity

generators switching to other fuels). In general, the end-use fuel mix in this scenario is not significantly different from the reference case, although coal use in industry increases slightly, thus mitigating some of the emissions reductions achieved in electric generation. This is in response to a decrease in the delivered price of coal resulting from reduced coal demand. This price-demand feedback effect has also been observed in other policies examined in the DOE study but not discussed here. In the end-use efficiency standards cases, end-use consumption for all fuels drops; by 2030, oil falls 15 percent, gas 8 percent, coal 50 percent and electricity 16 percent. The reforestation case shows a substantial switch from coal to nuclear and renewable energy in the long term, with some conservation as well. This adjustment is caused by the requirement to offset emissions with tree planting, which acts like a tax on coal-fired power plants and discourages coal use. In addition, a large portion (86 percent) of the carbon emissions from the remaining fossil fuel use is offset by this policy. The total energy consumption and fuel mix in the $100/ton carbon tax case looks similar to the reforestation case, but the more extreme carbon tax cases ($400/ton and $600/ton) show an even greater shift away from coal, with nuclear and renewables making up 43 percent of total fuel consumption in the $625/ton tax case, as compared to 16 percent in the reference case.

In order to understand the reasons behind the differences in fuel mix and levels of conservation in these different policy cases, it is helpful to look at the policies in terms of the energy consuming sectors which are being affected. Industry, transportation and electric generation consume the most energy: the electric sector uses 47 percent of total fuel consumption in the reference case in 2030, industry uses 22 percent, transportation uses 23 percent, and the remaining 8 percent is consumed by the residential and commercial sectors. Effective policies might focus on reducing energy consumption in each of the three energy intensive sectors, or encouraging a switch to non-fossil fuel sources of energy within these sectors. Table 3 below shows each policy and the sector or sectors affected by the policy. The coal efficiency case affects only the electricity producers, which explains why the policy is relatively ineffective. The reforestation case offsets emissions for both electric generators and industrial users, but does not affect the transportation sector. Both the conservation standards cases and the carbon tax cases affect all of the energy consuming sectors, and are generally effective at reducing total energy consumption as a result. The conservation standards cases, however, act upon each fuel equally, regardless of its carbon content. Since coal has the highest carbon content and the electric producers and industrial consumers use the greatest amount of coal (95 percent of total coal consumption in the reference case), these policies might be made more effective if higher conservation standards were placed on industrial coal boilers and electricity consuming end-uses (such as appliances). Therefore from an energy perspective, the carbon tax cases are the most effective in reducing emissions because these policy cases affect all energy consuming sectors and apply the tax based on the carbon content of the fuels.

Table 3: Energy Sectors Affected by Each Policy

Policy	Residential Commercial	Industrial	Transportation	Electric Generation
Coal Efficiency Penalty				√
Reforestation		√		√
Conservation Standards	√	√	√	√
Carbon Tax Cases	√	√	√	√

Note: Conservation Standards Cases act upon the electric generating sector indirectly by reducing electricity use by consumers.

Costs

The previous sections detailed the effects of the greenhouse policies on carbon emissions and

on energy consumption. This section focuses on the costs of those policies, using total energy service costs to determine cost-effectiveness of each policy. Energy service costs, which sum the end-use capital and fuel costs associated with using energy are calculated explicitly in FOSSIL2 and totals can be compared across cases. The cost of energy services varies depending on the fuels and technologies chosen and these costs feed back to overall economic output as measured by GNP.

Table 4 compares the average cost per ton of carbon reduction and the total amount of carbon reductions for each policy over the 40 year period. An effective policy would have a low (or even negative) cost of reduction and hopefully the potential to eliminate a large percentage of future carbon emissions. According to this analysis, the high conservation standards are the most cost-effective way to reduce CO_2 emissions. In fact, long term costs are negative. A negative cost suggests that consumers would be better off making the additional conservation investments anyway. That is to say, cost-effective conservation opportunities exist that would decrease energy usage, and hence emissions, without diminishing energy services or increasing long term costs. These opportunities are not pursued now, though, because of the short time horizons consumers have for calculating returns on investment. The very high conservation case mandates investments that are too expensive to be cost-effective even in the long term—the savings in fuel costs do not offset the high cost of

Table 4: Incremental Cost of Reduction

	Dollars/ton Removed*	Carbon Reduction (% from Reference)
Conservation		
High	negative	18%
Very high	280	28%
Reforestation Offsets	88	55%
Coal Efficiency Tax	260	12%
Carbon Tax		
$100/Ton	565	31%
$250/Ton	710	51%
$400/Ton	885	53%
$625/Ton	1100	57%

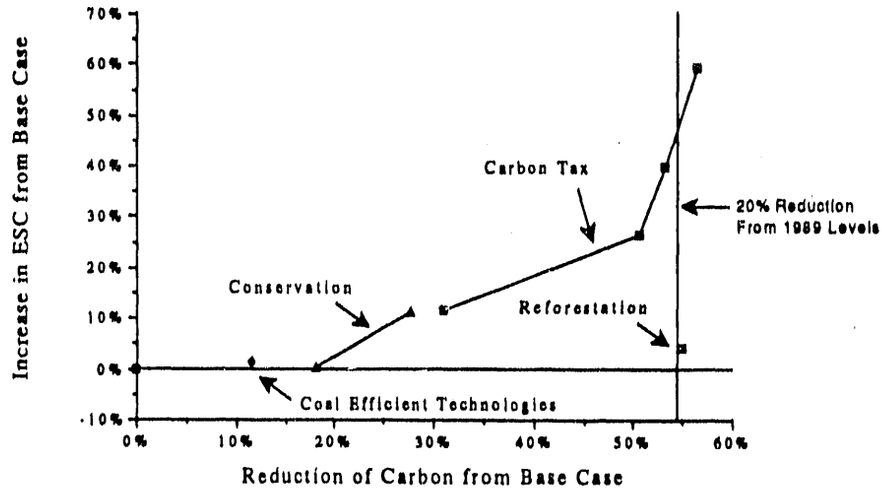
installing additional energy-saving devices. Reforestation offsets provide both a low cost carbon reduction policy and can achieve perhaps the highest absolute reduction in emissions (55 percent). The coal efficiency standards cost more than three times the reforestation case yet reduces emissions only 12 percent; although coal efficiency rises, large quantities of coal are still consumed in the electricity industry. The carbon tax cases have high costs of carbon removal and appear to have diminishing returns after the $250/ton case.

Incremental costs cannot explain the whole picture. Figure 4 is a "supply curve" of carbon reduction options. Both axes are relative to the reference case and compare the change in cumulative discounted energy service costs to changes in emission levels. Annual energy service costs are not simply summed over time, but are discounted based on a social discount rate of 3 percent. Expenditures in the near future are given more weight in this metric than are those further off in time, because money spent in the present is more highly valued than that spent in the future.

This analysis suggests that achieving the targeted level of reductions in carbon emissions can be expensive. The high conservation case is important because of its savings (negative cost) in total energy service costs relative to the reference case. But this level of conservation only achieves a 20 percent reduction relative to the 55 percent needed to meet the target. The reforestation case stands

out because of its ability to meet the target reduction level by 2030 at relatively low cost. In contrast, the $625/ton carbon tax also achieves the target, but only at a huge cost, with total cumulative energy service costs increasing by over 50 percent. Reforestation programs might increase total costs by about 5 percent (or perhaps less if non-U.S. acreage were used for planting), but has large and sustainable emission reduction potential. The practical effectiveness of this policy remains unknown because of uncertain costs and total acreage availability. Nevertheless, reforestation offsets show enough promise to warrant further consideration as an effective policy for carbon mitigation.

Figure 4: 2030 CARBON REDUCTION VS. ENERGY COSTS



V. CONCLUSION

This study has attempted to focus policy-makers on the cost and energy impacts of suggested measures to reduce carbon emissions. This discussion has seen reforestation emerge as a promising alternative to taxes or standards. More analysis and debate will be needed before an acceptable policy or combination of policies is found, and we hope to forward this search by presenting insights gained from the analysis presented here.

As has often been recommended, there are considerable opportunities for conservation to limit the growth of energy use and carbon emissions. Our analysis highlights possible cost savings (reductions in energy service costs) associated with at least one such case we tested (the "high conservation standards" case). It is clear that a policy that effectively promotes these cost-effective conservation measures would be worthwhile to implement and should be given a role in any global warming or energy policy strategy. A set of mandated efficiency standards is not necessarily the best method to advance these savings; a program that better informs people of conservation options and the potential savings from those options might go far in accomplishing the same result. More effort needs to go into understanding the non-cost related factors present in consumers' decisions and into addressing those factors in the design and sale of efficient equipment. Incentives (regulatory or otherwise) for manufacturers to develop and produce more energy-efficient equipment (such as CAFE standards) may also be necessary to achieve the desired level of conservation.

In the electricity sector, this analysis portrays a significant long-term switch from coal to nuclear power and renewables for many of our policy cases. An obvious key assumption in this conclusion is the existence of a viable, cost-effective nuclear option (here called "advanced nuclear generation"). Advanced nuclear plants are chosen as the inexpensive baseload technology to substitute for coal in the long-term. Natural gas provides a short-term solution for electricity generation, but it too is carbon-based and it is also a finite resource. The desire to reduce coal

consumption encourages gas use in the near term in this analysis which depletes gas resources and drives up the price of gas. Nuclear power and renewables then become the cheaper options in the long-term. Gas-fired generation, therefore, provides a transition from the present coal-dominated electricity sector to one in which nuclear power and renewables play an increasing role. Whether this future for nuclear power is realistic depends upon its cost and more importantly its public acceptability, but policy-makers will need to address the issue of finding an inexpensive, reliable and environmentally-benign fuel source to replace coal in electric generators.

The natural "feedback" interaction of energy supply, demand and price has illuminated another important insight regarding policy design. By having policies address only one sector and ignoring their ramifications on other sectors, unintended results may occur. For example, in the policy promoting coal efficiency, a penalty was assessed against inefficient coal plants. This resulted in a significant reduction in coal consumption by this sector. This reduction in demand brought down coal prices and made coal more attractive to industrial users. Policy-makers must concern themselves with this potential for policies to "backfire" in this manner.

Because of the limitations of most of these single policies to achieve significant reductions in a cost effective manner, policy-makers might need to seek a combination of policies that would be cost-effective and target the major carbon emitting sectors. One such combination would impose a carbon tax whose collection would be applied towards planting trees and increasing conservation investment and information. Other combinations might also be devised to take advantage of energy market interactions and consumer behavior.

A more thorough examination of policies and their results and insights can be found in the forthcoming DOE report to Congress. The global warming issue presents a significant challenge to both scientists and policy-makers, and system dynamicists are playing a role in providing important insights to both.

REFERENCES

Applied Energy Services (AES) Corporation and Energy and Environmental Analysis, Inc. *FOSSIL2 Energy Policy Model Oil, Gas and Coal Sector Documentation*, Arlington, VA 1990 (forthcoming).

Applied Energy Services (AES) Corporation, *FOSSIL2 Energy Policy Model Sector Documentation*, Arlington, VA 1986.

Applied Energy Services (AES) Corporation, *FOSSIL2 Energy Policy Model Electricity Documentation*, Arlington, VA 1990.

Manne, Alan S., and R.G. Richels, CO2 Emissions Limits: An Economic Analysis for the USA, *EPRI Journal*, July 1989.

Moulton, Robert and K. Richards, *Carbon Sequestration through Forestation*, Draft, Forest Service, 1989.

Reilly, John, *Economic Aspects of Carbon Reduction Through Forestation*, unpublished draft, U.S. Department of Agriculture, 1989.

Green Taxes: Where There's Muck There's Brass, In The Economist, March 17, 1990, pg 46-47.

U.S. Environmental Protection Agency, *Policy Options for Stabilizing Global Climate, Draft Report to Congress, 1989.*

FROM CONFLICT -- TO OPPORTUNITY -- TO A MORE SOCIALLY BENEFICIAL FUTURE?

By: Thomas J. Schneider

I. HISTORIC PERSPECTIVE: TWO DECADES OF SERIOUS CONTROVERSY ON RESOURCE ISSUES IN MONTANA

Energy resource decisions in Montana over the past two decades have been marked with serious and continuing controversy involving environmental, socio-economic, and integrated least-cost planning and acquisition issues -- long before such issues were in vogue on a national scale. The focus of the controversy has been upon Colstrip 3 and 4, two 700 MW minemouth coal plants and several hundred miles of associated transmission, owned by five investor owned utilities in the northwest. The continuing controversy occurred in a state with a legacy corporate domination as a resource colony. Importantly, Montana had taken a number of significant actions in the early 1970s to establish a more rational and environmentally sensitive future for its people and its natural heritage. For example, the new Montana Constitution, adopted in 1972, specifically provided in Section 1, Article IX -- Environment and Natural Resources, that:

> ... (1) The state and each person shall maintain and improve a clean and healthful environment in Montana for present and future generations.
>
> (2) The legislature shall provide for the administration and enforcement of this duty.
>
> (3) The legislature shall provide adequate remedies for the protection of the environmental life support system from degradation and provide adequate remedies to prevent unreasonable depletion and degradation of natural resources.

The new Constitution also established the Montana Consumer Counsel Office to represent consumers before the Montana PSC. Additionally, the Major Facility Siting Act, Coal Severance Tax, and a restructured Public Service Commission were also enacted by the legislature in the early 1970s to better assure that environmental, socio-economic, and consumer interest issues were reflected in resource and rate decisions.

A number of specific decisions flowed from the hotly contested regulatory and court actions concerning Colstrip 3 and 4:

(1) Approval to construct Colstrip 3 and 4 was ultimately granted by the Montana Supreme Court in 1979 after a four-year Siting Act battle;

(2) In 1984 the PSC entirely disallowed the Colstrip 3 as not "actually used and useful;"

(3) In 1985 after reversal in District Court and a new rate filing, a settlement agreement was approved for Colstrip 3 involving a five-year phase-in and deferral plan;

(4) Colstrip 4 was separately refinanced under a sale and leaseback arrangement to be competitively marketed off-system as a non-utility operation. However, because of the regional surplus MPC incurred a serious financial loss on Colstrip 4 for several years; and

(5) In 1989 the PSC rejected MPC's proposed sole source purchase of the remaining 74 MW from Colstrip 4, based upon the seriously flawed "contract" between MPC and its affiliated company. The case was extremely contentious.

Undoubtedly, the long-term resource decisions and controversy have had serious impacts upon all the stakeholders, i.e., ratepayers, investors, competitors, and society. The above recital of Montana's energy resource conflicts during the past two decades is obviously similar to those experienced in many states where baseload coal and nuclear plants were constructed during periods of: rampant inflation, unprecedented interest rates, the Three Mile Island incident, cost plus construction contracts and overruns, a severe recession, structural changes and plant closures in industry, conservation and price elasticity, implementation of the National Energy Act, and emerging competitive market alternatives. It is doubtful whether any of the stakeholders emerged unscathed from the debacles of the period -- except consultants. Clearly, then, responsible leadership is necessary to learn from these painful experiences and to establish standards for more socially beneficial resource future. In Montana and in many other states the stakeholders (e.g., regulators, utilities, environmental interests, and consumer groups) are engaged in processes designed to better assure that risk and uncertainty, environmental externalities, demand-side measures, and competitive market standards are incorporated into integrated least-cost resource planning and competitive acquisition processes.

II. MONTANA'S COLLABORATIVE PROCESS: INCORPORATING ENVIRONMENTAL EXTERNALITIES INTO INTEGRATED LEAST-COST PLANNING AND COMPETITIVE ACQUISITION

Montana's current efforts to incorporate environmental externalities into resource planning and acquisition strategies are embodied in a collaborative, advisory committee process for the Montana Power Company -- unique in its separation from direct involvement by the Montana PSC and the Montana Consumer Counsel. The Montana PSC and Consumer Counsel declined to directly participate in the process due to legal and philosophical concerns about pre-approval, complicity, and utility management responsibility.

The Montana collaborative process was initiated in October 1988 pursuant to a settlement between the Montana Power Company (the state's largest utility whose retail service is entirely within Montana), the Natural Resources Defense Council (Ralph Cavanaugh), and the District XI Human Resource Council (low-income agency represented by Dr. Thomas M. Power).

Montana Power Company received:

(1) Settlement of an environmental lawsuit by NRDC involving MPC's sale of 116 MW to Los Angeles DWP across the BPA transmission intertie to California; and

(2) Kept HRC from opposing MPC's proposed sole source purchase of 74 MW of Colstrip 4 from its affiliated operations.

NRDC/HRC received:

(1) Dramatic increase of utility-funded conservation commitments and expenditures, assuming acceptable PSC rate treatment; and

(2) Establishment of a utility-funded Conservation and Least Cost Planning Advisory Committee (Advisory Committee) made up of the most active energy conservation, environmental and low-income groups, the Montana Department of Natural Resources and Conservation (DNRC), Northwest Power Planning Council, industrial users group, and Montana Power Company.

Environmental and conservation issues are prominently reflected in the representation on the Advisory Committee, which includes the most aggressive, long-time critics of MPC's resource planning and acquisition practices. Environmental and conservation considerations are emphasized throughout the rationale and recommendations contained in the report of the Advisory Committee. It is important to recognize that the environmental externalities discussed herein are those remaining after applying Major Facility Siting Act mitigation requirements for air and water quality, land reclamation, socio-economic impacts (e.g., infrastructure; rural to industrial economy; boom-bust syndrome), demonstration of need, best available resource vis a vis alternatives, etc. Provided below is the text of the Advisory Committee's draft recommendations (to be finalized by 10/1/90) which relate most directly to incorporating environmental externalities into the resource planning and acquisition processes:

Environmental Costs and Integrated Least Cost Planning

Environmental costs which remain after controls and mitigation measures have been applied should be one of the major determinants in MPC's decisions on resource acquisition.

Recommendations

MPC should address environmental costs in its resource planning and acquisitions through the following actions:

(1) Quantify the costs of a range of environmental mitigation and controls and value the associated unmitigated environmental impacts, using best available methods for assessing environmental costs;

(2) Assess and disclose the risk resulting from the cost of future environmental mitigation that may be imposed on the company;

(3) Incorporate the uncertainty about the size and importance of environmental costs in the risk assessment analysis;

(4) To the extent that information is available, weigh and rank all resources on the basis of their environmental costs;

(5) In order to analyze the environmental costs of all resource alternatives in a consistent manner and minimize the environmental costs of the resources selected, incorporate environmental costs into resource planning and acquisition decisions by undertaking analysis on all resources similar to undertaking analysis on all resources similar to that specified in the decision standards of the Major Facility Siting Act Administrative Rules;

(6) Assess and disclose the associated uncertainty and risk associated with obtaining approvals from the Major Facility Siting Act decision standards related to environmental and socio-economic impacts of all resources;

(7) Assess and disclose the uncertainty and risk associated with ratemaking approval of all resources related to environmental and socio-economic impacts of all resources;

(8) Engage in a sensitivity analysis to determine whether significant reductions in environmental costs can be obtained at relatively small additional resource costs; and

(9) As a part of the sensitivity analysis, analyze the impact on the size of the conservation resource and the potential unrecoverable conservation expenditures due to regulatory action if marginal conservation measures are acquired at up to 115% of the avoided cost.

Interim Actions

Conservation is recognized as having generally benign environmental impacts. MPC should, therefore, undertake the following interim actions until the work of the Committee is completed and incorporated into MPC's resource planning and acquisition activities:

(10) Acquire marginal conservation measures at up to 115% of avoided costs to recognize the relative environmental and socio-economical cost advantage of conservation; and

(11) Request from the Public Service Commission the two percent rate of return differential authorized by Montana statutes for conservation expenditures.

Montana Public Service Commission Actions

The Committee recommends the Montana Public Service Commission (MPSC) take the following actions

that provide for rate recovery of expenditures associated with incorporating environmental costs into resource acquisition decisions:

(12) Formally recognize as a matter of regulatory policy consistent with the Montana Constitution that long-run environmental and safety costs associated with energy production pose significant costs, risks, and uncertainty to global society, utilities, and ratepayers;

(13) Allow rate recovery for resource acquisitions which are consistent with an integrated resource planning process which incorporates best available environmental cost criteria;

(14) Grant rate recovery of expenditures associated with the interim acquisitions of marginal conservation measures at up to 115 percent of avoided costs and grant the two percent of return differential for conservation expenditures on an interim basis.

It is important to recognize that the environmental and energy conservation emphases are pervasive in integrated least-cost planning topic areas addressed in the Advisory Committee report (e.g., definition, goal, risk and uncertainty, resource decision rule, cost effectiveness test, marketing, competitive acquisition, and regulatory/market barriers to conservation). The Advisory Committee will present its final report and recommendations to the Montana Power Company management in a two-day seminar scheduled for October 16-17, 1990.

III. NEED FOR NATIONAL AND INTERNATIONAL LEADERSHIP ON ENERGY AND THE ENVIRONMENT

National and international leadership is demanded to evaluate the multi-faceted strategy for evaluating utility resource choices for both the development of future facilities and operation of existing and future facilities. Obviously, the U.S. as largest (and certainly a relatively inefficient) consumer of energy must play a crucial leadership role in global environmental/energy issues. Absent comprehensive national and international standards relating to global environmental issues, serious equity, distribution of income, and competitiveness issues threaten those states or nations taking unilateral actions. For example, even the New York PSC in establishing an excellent multi-attribute framework for evaluating competitive bid resources, adopted a conservative, lower-range cost estimate for CO^2 (global warming) impacts in specific recognition of the relative competitiveness of New York with other states -- absent parallel actions by other states. However, that the "environmental President" has not yet acknowledged the problem of global warming -- let alone the seriousness of the threat -- bodes ill for the global society. The latest Persian Gulf crisis and its implications for the administration's likely energy and environment policy balance are distressing.

It is, therefore, crucial that individual states and utilities continue to take bold and progressive steps to fill that leadership vacuum, to tailor the implementation to the realities of the states, and to forge a more responsible resource future. Obviously, given the magnitude of the future resource requirements of populous, growing states, both the technical and political leaderships of the large states (e.g., New York, Wisconsin, Michigan, California, Pennsylvania, Texas, and Ohio) are critical in terms of relative global environmental impacts and political power.

Certainly, the national and private research labs, NWPPC, DOE, EPA, et al., will be called upon to provide the basic research, global technical data, mitigation/control alternatives, and quantification of environmental costs/impacts which will be incorporated by regulators.

Nevertheless, it is likely that smaller states with fewer technical resources will again play a crucial leadership role in developing and implementing innovative methods for incorporating environmental externalities into least-cost resource planning and acquisition processes. For example, Maine, Nevada, Idaho, Washington, Oregon, and Massachusetts have each taken leadership roles in conservation, competitive bid, and least-cost planning processes. Similarly, in Montana our efforts over the past twenty months have been to examine the most progressive approaches and information available on the range of environmental, conservation, integrated resource planning, and competitive acquisition issues. For example, I have personally contacted a large number of participants and speakers at this conference to obtain "state of the art" incite, documentation, and methods for incorporating environmental externalities in least-cost planning and acquisition decisions. Representation by the Northwest Power Planning Council has provided a substantial technical expertise and experience. I, therefore, submit that the Montana Advisory Committee report should be a particularly useful vehicle for other states to build upon.

IV. IMMEDIATE ACTION OR DEJA VU?

In the most significant action to date, the Advisory Committee on August 10, 1990, moved that the Commission suspend 1) long-term PURPA QF tariff options for resources in excess of 1 MW, and 2) further resource acquisitions until the integrated least-cost resource planning and competitive resource acquisition processes are implemented. Unfortunately, the request was necessary to avoid continuation of an outmoded and inefficient resource planning and acquisition process. The urgency involved imminent commitments by MPC to 1) its own planned hydro-upgrades, and 2) purchases from several significant PURPA cogeneration projects. Absent decisive action by the Montana PSC on the immediate suspension of future resource commitments, it is likely that the Advisory Committee's comprehensive, multi-attribute resource planning and acquisition criteria will be nullified to the long-term detriment of the global environment, society, ratepayers, and competition.

As a result (in large measure) of the Advisory Committee's letter petition, the Commission immediately issued an opportunity for interested persons to comment upon the petition. The Montana Commission also established a generic Notice of Inquiry (NOI) to address integrated least-cost resource planning, PURPA QF acquisition methods, and competitive acquisition procedures.

V. CONCLUSION

The ultimate success of the Montana collaborative process depends upon 1) the actions of MPC to implement the spirit of the principles and process recommendations reflected in the Advisory Committee recommendations; and 2) the regulatory policy and ratemaking treatment adopted by the Montana PSC. The PSC's recent Notice of Inquiry on the broad least-cost planning, competitive acquisition, and PURPA QF acquisition methods provides a substantive forum for addressing the fundamental resource policy issues in Montana.

I certainly expect that the Advisory Committee report and recommendations will play a substantial role in the regulatory policy and ratemaking standards for integrated resource planning and competitive acquisition. I further expect that the environmental, conservation, and low-income groups will play a continuing advisory role on technical and regulatory policy issues to assure that the spirit of recommendations are implemented. Vigilance, healthy skepticism, and perseverance by environmental, conservation, and consumer groups will most certainly be required -- in whatever forum or processes are appropriate. The opportunity exists for a dramatic and progressive change in the resource future of Montana. The extent to which corporate management and regulators seize upon the opportunity and spirit reflected in the Advisory Committee recommendations will determine whether society will reap the goals and benefits.

"State Regulatory Experiences in Attempting to Quantify and Incorporate Environmental Externalities"

"The Nevada Experience"

By

Cynthia Mitchell

Senate Bill 497

The 1989 Session of the Nevada Legislature passed into law Senate Bill 497 (SB 497) - Preference to Environmental and Indigenous Resources. Effective October 1, 1989, SB 497 amends Nevada's existing electric utility least cost planning statute to include consideration of the economic and environmental costs and benefits of resource options. The pertinent part of the Nevada Revised Statutes, NRS Section 704.746 now reads:

"...3. After the hearing, the commission shall determine whether:

c. The plan adequately demonstrates the economic, environmental and other benefits to the state and to the customers of the utility, associated with the following possible measures and sources of supply:

(1) Improvements in energy efficiency;

(2) Pooling of power;

(3) Purchases of power from neighboring states or countries;

(4) Facilities that operate on solar or geothermal energy or wind;

(5) Facilities that operate on the principal of cogeneration or hydrogeneration; and

(6) Other generation facilities.

d. The commission may give preference to the measures and sources of supply set forth in paragraph (c) that:

(1) Provide the greatest economic and environmental benefits to the state;

(2) Are consistent with the provisions of this section; and
(3) Provide levels of service that are adequate and reliable.

The Commission shall adopt regulations which determine the level of preference to be given to those measures and sources of supply.

Background

Nevada's least cost planning process dates back to the 1983 Session of the Nevada Legislature's passage of the Senate Bill 161 - the Utility Resource Planning Act. Initiated by the state's then recently created Office of Consumer Advocate, the legislation was a bold step on the road to ensuring theat the state's energy needs and that those future needs are fulfilled using the most practical and cost-effective means.

Nevada's least cost planning process has many procedural and substantive hurdles over the last seven years. The original Commission adopted-regulation has been twice amended to include provisions to deemed necessary to encourage fuller utility participation and support of least cost planning. The amendments provides balancing account cost-recovery for utility resource planning development and pilot demand-side management program implementation costs; and capitalization or expensing of fully-implemented demand-side management program costs. In addition, the Commission has an ongoing docket opened to consider additional provisions to provide increased financial incentives to encourage fuller utility participation in least cost planning.

The Nevada Regulation

The Commission began rulemaking proceedings this past summer. As of the time of this submittal, the first cut at a draft rule was released by the Consumer Advocate's Office, dated September 7,1990. The Commission will hold hearings in September and October on the draft rule. A final rule will be subsequently adopted by the Commission. The draft rule is attached.

Section 1. As used in sections 1 to 9, inclusive of this regulation, unless context otherwise requires:

1. "RIMS II multiplier" means a number which converts a direct change in demand to a total change, and is obtained from the Regional Input-Output Modeling System, localized for Nevada, and published by the Bureau of Economic Analysis in the United States Department of Commerce.

Section 2. NAC 704.934 is hereby amended to read as follows:

1. As part of a utility's plan, it shall submit a plan for conservation and load management.

2. The plan for conservation and load management must include:

(a) An identification of classes of customers and end uses for programs for conservation and load management.

(b) An assessment of technically feasible programs for conservation and load management, as determined by the utility. The programs must be ranked in a list according to the level of savings in energy or reduction in demand, or both.

(c) A quantification of the economic and environmental benefits to the state from technically feasible programs.

(d) An assessment of the technically feasible programs to determine which will produce benefits exceeding costs, based on a determination of the costs and benefits of particular programs to various classes of customers. The utility shall rank the programs on the basis of their overall relationship between benefits and costs and identify the programs or groups of programs whose benefits will clearly exceed their costs. The methods used for the assessment must be stated in detail, specifically listing the data and assumptions considered in the assessment.

(e) A list of proposed programs for reducing energy and demand.

(f) A determination of the reduction in the use of energy and the demand for energy which would result from the proposed programs, in

kilowatt-hours and kilowatt-savings per program. The programs must be listed according to their expected savings and their contribution to a reduction in energy and peak demand based upon a realistic penetration of the market.

(g) An assessment of the costs of the proposed programs and the savings in the utility's costs produced by the proposed programs, assuming a realistic level of penetration of the market. The assessment must include the savings in the costs of transmission and distribution and the economic and environmental benefits to the state from technically feasible programs.

(h) An assessment of the impact on load shapes of proposed and existing programs for conservation and load management.

(i) An assignment of priorities to the programs for conservation and load management on the basis of a more detailed analysis of the benefits and costs of each program as compared with other options. In assigning the priorities, the utility shall also take into account consideration of equity such as requiring one group of ratepayers to subsidize another group, which may result from putting into effect certain types of programs.

(j) A report on the status of all programs for conservation and load management. The report must include tables for each trial and full program showing, for each year, the planned and achieved reduction in kilowatt-hours, the reduction in demand in kilowatts, the cost of the program and the cost-effectiveness of the program.

Section 3. NAC 704.9365 is hereby amended to read as follows:

A utility's plan for supply must develop and document the origins of:

1. Its assumptions, data and projections used to calculate the costs and benefits of its options;

2. The costs, benefits and feasibility of power transactions with other utilities including nonfirm and firm energy and the costs of transmission;

3. Its basic economic limitations and availability of fuels;

4. Required controls to mitigate pollution at planned facilities when estimating the costs of the facilities for the plan;

5. Criteria selected for determining the reserve margin;

6. Assumptions for conventional generation;

7. Assumptions for renewable resources;

8. Assumptions for nonutility generators;

9. Estimates of the cost of, the requirements of time for and the feasibility of converting to the use of coal;

10. A statement of the limits on its import or export of power within its primary system of generation and transmission;

11. A statement of the utility's requirements for research and development;

12. A statement of potential projects for upgrading existing systems for transmission of new interties;

13. The criteria used by the utility in setting the dates for the retirement of its facilities; and

14. The quantification of the economic and environmental benefits to the state from each option for future supply.

Section 4. NAC 704.937 is hereby amended to read as follows:

1. A utility's plan must include a list of all existing and planned facilities for conventional generation, facilities for using renewable resources, nonutility generators, programs for reducing demand for and use of energy and other sources available as options to the utility for the future supply of electricity. The listing must include the capacity and projected loads of the facilities and resources for each year of the plan.

2. A utility shall identify the criteria it has used for the selection of its options for meeting the expected future demands for electricity and shall explain how any conflicts among criteria are resolved.

3. In comparing its options, the basic criterion which the utility shall use to select and rank its options for the supply of power is the present worth of future requirements for revenue. The quantification of economic and environmental benefits to the state must be added to the present worth of future revenue requirements for comparison of options. If an option selected by the utility as its preferred option fails to produce the lowest present worth of revenue requirements, the utility must fully justify its choice by setting forth the other criteria which influenced the utility's choice.

4. Other criteria which the utility shall consider are the avoidance of risk by means of:

(a) Flexibility;

(b) Diversity;

(c) Reduced size of commitments;

(d) Choice of projects which can be completed in short periods;

(e) Reliability; and

(f) Displacement of fuel.

5. The utility's selections must;

(a) Provide adequate reliability;

(b) Be within regulatory and financial constraints; and

(c) Meet the requirements for environmental protection.

Section 5. NAC 704.939 is hereby amended to read as follows:

1. A utility's plan must contain a list showing:

(a) All sources of electric power from which the utility has plans or potential opportunities to buy electric power during the 20 years covered by the plan; and

(b) The amount of electric power to be purchased from each source and the years for which delivery is contracted.

The nature and source of the purchase must be described (e.g. nonfirm electric power in winter months ~~only~~ from a combustion turbine fueled by natural gas). If a purchase is not from a specific source of supply then a mix of all resources of the seller must be described. The economic and environmental benefits to the state from each source or mix of resources must be quantified. Major new commitments for purchases of power must be documented and justified as economical options for supply of power.

Section 6. NAC 704.9395 is hereby amended to read as follows:

1. The estimated costs of construction, including:

(a) Annual flows of expenditures, in current dollars, without allowance for funds used during construction;

(b) Annual flows of expenditures, in current dollars, without allowance for funds used during construction;

2. The estimated costs of operation, including:

(a) Costs which are variable, in current dollars, per kilowatt-hour, with expenses for fuel and other items indicated separately;

(b) Costs which are fixed in current dollars, per kilowatt-hour; and

(c) Environmental and economic costs to the state which are otherwise external to the utility's revenue requirement.

3. The rates of escalation of cost, including:

(a) Capital costs;

(b) Costs which are variable and related to fuel;

(c) Operating costs which are variable and unrelated to fuel; and

(d) Operating costs which are fixed; and

4. The annual average cost per kilowatt-hour at projected loads in current dollars for each year of the plan for each facility, both existing and planned.

Section 7. NAC 704.9475 is hereby amended to read as follows:

1. A utility shall conduct an analysis of sensitivity for all major assumptions and estimates used in its plan. The analysis must include the:

(a) Forecast of load;

(b) Dates when proposed acquisitions will be in service;

(c) Unit availability;

(d) Costs of power plants;

(e) Price of fuel;

(f) Amounts of purchased power and corresponding costs;

(g) The schedule, impact and costs of programs for conservation and load management;

(h) Capacity of plants in megawatts;

(i) Discount rates;

(j) Rate of inflation;

(k) Cost of capital;

(l) Environmental benefit; and

(m) Economic benefit.

2. The utility shall state the ranges and consequences of uncertainty for each of the assumptions and methods of combining various uncertainties.

Section 8. Economic benefit quantification.

1. Economic benefits to the state must be quantified in the form of changes in the earnings of state residents due to both positive and negative changes which occur in all sectors of the state's economy from implementation of options for supply and demand.

(a) The utility should assume that all funds spent are derived from ratepayers of the utility.

(b) Spending should then be calculated both as an increase in spending by the industries, including the utility, involved in the construction and operation of each option for supply and demand in the years in which the spending is expected to occur, and a decrease in funds available to be spent by ratepayers on all other sectors of the state's economy.

(c) Only those changes that pay for in-state labor, and services and goods produced within the state shall be considered.

(d) In addition, for programs in demand-side management, reductions in energy usage, times applicable rates, shall be counted as increases in ratepayer incomes and as decreases in utility revenues.

2. To calculate the total impact from direct changes in revenues to businesses and households in the state and from indirect changes in funds respent throughout the state economy, the utility must use the most current set of applicable RIMS II multipliers. For residential customers, multipliers based on the best available data concerning major categories of household spending shall be used.

(a) The utility should compute a RIMSII multiplier for each category of spending which constitutes at least ten percent to the total spending for an option for supply or demand. Any category of spending which constitutes less than ten percent of the total spending may be combined with a category which most closely reflects the type of spending involved.

(b) The resulting RIMS II multipliers should then be applied to the positive and negative spending impacts of implementing utility supply and demand options for each major class of customers.

Section 9. Environmental benefit quantification.

1. The costs of environmental benefits to the state associated with operating and maintaining options for supply or demand must be quantified for air emissions, water and land use. Air emission factors should be quantified for each of the following pollutants: nitrogen oxides, sulfur oxides, total suspended particulates, carbon monoxide, volatile organic compounds, carbon dioxide, methane, nitrous oxide, hydrogen sulfide and ammonia.

2. The utility must use the general emission factors for a new option for supply from the tables below, unless the utility justifies a need for deviating from the tables below.

3. The utility must also utilize the valuation of cost impact for pollutants listed below unless the utility can identify site- and resource-specific marginal costs of control which justify the use of different costs per pound of emission.

9/5/90

Electric Facilities Emissions Factors

New Utility Facilities	lbs/MMBtu in										gals/MMBtu in
	NOx	SOx	TSP	CO	VOC	CO2	CH4	N2O	H2S	NH3	H2O use
Baseload											
1a. Combined Cycle NG	0.3933	0.0006	0.001	0.021	0.033	117	0.0019	0.0078	NA	NA	16.3
b. Combined Cycle NG w/SCR	0.079	0.0006	0.001	0.021	0.033	117	0.0019	0.0078	NA	0.0391	16.3
2a. Combined Cycle Distillate Oil	0.5	0.315	0.001	0.018	0.0165	163	0.0016	0.0325	NA	NA	NA
b. Combined Cycle Distillate Oil w/SCR	0.1	0.315	0.001	0.018	0.0165	163	0.0016	0.0325	NA	0.0391	NA
3a. Combined Cycle Residual Oil	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4a. Coal, Pulverized w/scrubbers	0.6	0.6	0.03	0.024	0.004	238	0.0015	0.0325	NA	NA	NA
5a. Coal, Atmospheric Fluidized Bed	0.5	0.6	0.01	0.15	0.0028	236	0.0015	0.0325	NA	NA	NA
6a. Coal, Integrated Gasificaton Combined Cycle	0.20	0.33	0.003	0.01	0.003	196	0.0015	0.0325	NA	NA	NA
7a. Geothermal, Flashed steam	0	0	NA	0	0	3.92	0	0	0.0025	0.91	0
b. Geothermal w/injection	NA	NA	NA	NA	NA	0.0300	1E-05	NA	0.00166	NA	NA
8a. Solar, Thermal	0	0	0	0	0	0	0	0	0	0	41.3
b. NG, Boiler back-up unit	0.150	0.0006	0.00290	0.036	0.0013	119	0.0002	0.028	NA	NA	16.7
c. NG, Boiler back-up unit with/LNB	0.075	0.0006	0.0029	0.036	0.0013	119	0.0002	0.028	NA	NA	16.7
9a. Solar, Photovoltaic	0	0	0	0	0	0	0	0	0	0	0
10a. MSW, Steam Boiler	0.308	0.36	0.4700	0.93	0.0300	165	0.001	0.033	NA	NA	NA
b. MSW, Steam Boiler w/FFB	0.308	0.36	0.00470	0.93	0.0300	165	0.001	0.033	NA	NA	NA
11a. Wood, Steam Boiler	0.155	0.0063	0.4662	0.221	0.0773	212	0.033	0.033	NA	NA	NA
b. Wood, Steam Boiler w/FFB	0.155	0.0063	0.00466	0.221	0.0773	212	0.033	0.033	NA	NA	NA
12a. Wind	0	0	0	0	0	0	0	0	0	0	0
13a. Small Hydroelectric	0	0	0	0	0	0	0	0	0	0	NA
14a. Purchases	Check source note.										
Peakers											
1a. Combustion Turbine NG	0.3933	0.0006	0.0133	0.1066	0.012	119	0.012	0.018	NA	NA	r 26
b. Combustion Turbine NG w/SWI	0.118	0.0006	0.0133	0.1066	0.012	119	0.012	0.018	NA	NA	0.26
2a. Combustion Turbine Distillate Oil	0.6	0.212	0.03	0.116	0.0359	164	0.0016	0.0211	NA	NA	NA
b. Combustion Turbine Distillate Oil w/SWI	0.2	0.212	0.03	0.116	0.0359	164	0.0016	0.0211	NA	NA	NA
3a. Reciprocating Engine, Diesel	3.3500	0.0557	0.2393	0.7266	0.2293	162	NA	NA	NA	NA	NA
b. Reciprocating Engine, Diesel w/SCR	0.5025	0.0557	0.2393	0.7266	0.2293	162	NA	NA	NA	0.0391	NA
4a. Pump-storage Hydroelectric	Check source note.										
5a. Purchases	Check source note.										

Electric Facilities Emissions Factors

New Utility Facilities	Heat Rate	lbs/MWhr out									gals/MWhr out
		NOx	SOx	TSP	CO	VOC	CO2	CH4	N2O	H2S	NH3	H2O use
Baseload												
1a. Combined Cycle NG	8140	3.2	0.005	0.01	0.17	0.27	952	0.015	0.063	NA	NA	149
b. Combined Cycle NG w/SCR	8140	0.64	0.005	0.01	0.17	0.27	952	0.015	0.063	NA	0.32	149
2a. Combined Cycle Distillate Oil	8140	4	2.56	0.01	0.15	0.13	1330	0.013	0.265	NA	NA	NA
b. Combined Cycle Distillate Oil w/SCR	8140	0.8	2.56	0.01	0.15	0.13	1330	0.013	0.265	NA	0.32	NA
3a. Combined Cycle Residual Oil	8250	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4a. Coal, Pulverized w/scrubbers	9400	6	6	0.3	0.23	0.038	2240	0.014	0.306	NA	NA	NA
5a. Coal, Atmospheric Fluidized Bed	10000	5	6	0.1	1.5	0.03	2360	0.015	0.325	NA	NA	NA
6a. Coal, Integrated Gasificaton Combined Cycle	9260	1.9	3.1	0.03	0.09	0.03	1840	0.014	0.302	NA	NA	NA
7a. Geothermal, Flashed steam	53000	0.00	0.00	NA	0.00	0.00	208	0.00	0.00	0.13	48	0
b. Geothermal, w/injection	40000	NA	NA	NA	NA	NA	1.20	0.0004	NA	0.0664	NA	NA
8a. Solar, Thermal	14600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	603
b. NG, Boiler back-up unit	11000	1.65	0.007	0.032	0.42	0.014	1310	0.002	0.31	NA	NA	184
c. NG, Boiler back-up unit with/LNB	11000	0.825	0.007	0.032	0.42	0.014	1310	0.002	0.31	NA	NA	184
9a. Solar, Photovoltaic	24000	0	0	0	0	0	0	0	0	0	0	0
10a. MSW, Steam Boiler	16800	5.17	6.4	7.896	16	0.504	2770	0.02	0.55	NA	NA	NA
b. MSW, Steam Boiler w/FFB	16800	5.17	6.4	0.079	16	0.504	2770	0.02	0.55	NA	NA	NA
11a. Wood, Steam Boiler	16740	2.59	0.14	8.139	3.7	1.29	3550	0.55	0.55	NA	NA	NA
b. Wood, Steam Boiler w/FFB	16740	2.59	0.14	0.08136	3.7	1.29	3550	0.55	0.55	NA	NA	NA
12a. Wind	7600	0	0	0	0	0	0	0	0	0	0	0
13a. Small Hydroelectric	3800	0	0	0	0	0	0	0	0	0	0	NA
14a. Purchases		Check source note.										
Peakers												
1a. Combustion Turbine NG	13100	5.152	0.006	0.174	1.434	0.16	1560	0.16	0.24	NA	NA	3.7
b. Combustion Turbine NG w/SWI	13100	1.55	0.006	0.174	1.434	0.16	1560	0.16	0.24	NA	NA	3.7
2a. Combustion Turbine Distillate Oil	13100	8	2.76	0.4	1.52	0.470	2150	0.021	0.276	NA	NA	NA
b. Combustion Turbine Distillate Oil w/SWI	13100	3	2.76	0.4	1.52	0.470	2150	0.021	0.276	NA	NA	NA
3a. Reciprocating Engine, Diesel	10000	33.500	0.557	2.393	7.266	2.293	1620	NA	NA	NA	NA	NA
b Reciprocating Engine, Diesel w/SCR	10000	5.025	0.557	2.393	7.266	2.293	1620	NA	NA	NA	0.39	NA
4a. Pump-storage Hydroelectric	4900	Check source note.										
5a. Purchases		Check source note.										

Explanatory Notes and Adjustment Specifications:

9/5/90

Control Devices.

Control levels can be adjusted on the facilities with control devices in place (affecting only the level of the controlled pollutant). The adjustment can be performed as follows:

$$E1 = E0 * (1-Y)/(1-X)$$

where E1 is the pollutant emission rate after desired control adjustment, E0 is the pollutant emission rate before adjustment, X is the original control level (in decimal form), Y is the desired control level (in decimal form). Refer to the explanatory notes for a reasonable range of control level. This adjustment should be made on both emissions per energy in and energy out.

Heat Rates.

The above emission coefficients per unit energy out can be adjusted if a different heat rate is desired. The adjustment can be performed as follows:

$$E1\ out = E0\ out * (HR1/HR0)$$

where E1 out is the pollutant emission rate after desired heat rate adjustment, E0 out is the pollutant emission rate before adjustment, HR1 is the adjusted heat rate, HR0 is the original heat rate.

Fuel Sulfur Content.

SOx emissions can be adjusted by changing the amount of sulfur present in the fuel. This adjustment can be made as follows:

$$SOx1 = SOx0 * (S1/S0)$$

where SOx1 is the adjusted SOx emission rate, SOx0 is the original SOx emission rate, S1 is the adjusted fuel sulfur percentage (in decimal form), and S0 is the original fuel sulfur percentage (in decimal form).

NH3 Emissions

Ammonia emissions are given in ADL, 1989 for existing energy producing facilities with SCR devices enabled. These emission rates ranged from .0157 lbs/MMBtu to .0777 lbs/MMBtu. An average of these emission rates was performed to achieve the NH3 emission level here. This value is approximate.

Non-System Offsets

1. COGENERATION: Electricity producing facilities that produce usable steam in addition to their output of electricity can displace emissions from steam producing devices. The expression for the net emission rate for a cogenerator can be expressed as follows:

$$En = Eg - Eb*(Sc/Sb)$$

where En is the net cogenerator emission rate, Eg the gross cogenerator emission rate, Eb the gross avoided boiler emission rate, Sb the steam efficiency of the displaced boiler (out/in), and Sc the steam efficiency of the cogenerating facility (=[1-3414/HR]*F, where HR is the electric heat rate and F is the fraction of waste heat captured for thermal uses). We recommend that the power developer quantify the offsets (i.e. Eb*(Sc/Sb)).

2. LANDFILL DECOMPOSITION OFFSETS: The use of municipal solid waste and wood waste in electricity generating facilities can displace emissions from decomposition in landfills. Average emissions from municipal solid waste landfills are 5 lbs/MMBtu and 12 lbs/MMBtu for CH4 and CO2, respectively. We recommend that the power developer quantify these offsets.
3. SUSTAINABLE WOOD YIELD OFFSETS: Live biomass respiration can displace some of the emissions of wood burning facilities. We recommend that the power developer quantify the offsets.

New Utility Facilities

Baseload

1a. Combined Cycle NG. The potential range for the CO control using oxidation catalyst is 80 - 90%. Source: CEC for control range.
b. Combined Cycle NG w/SCR. The potential range for CO control using oxidation catalyst is 80 - 90%. The potential range for NOx control using SCR is 80 - 90%. Source: CEC for control ranges.
2a. Combined Cycle Distillate Oil. The potential range for CO control using oxidation catalyst is 80 - 90%. Source: CEC for control range.
b. Combined Cycle Distillate Oil w/SCR. The potential range for CO control using oxidation catalyst is 80 - 90%. The potential range for NOx control using SCR is 80 - 90%. Source: CEC for control ranges.
3a. Combined Cycle Residual Oil.
4a. Coal, pulverized w/scrubbers.
5a. Coal, Atmospheric Fluidized Bed Combustion.
6a. Coal, Integrated Gasification Combined-Cycle.
7a. Geothermal, Flashed steam.
b. Geothermal, w/Injection.
8a. Solar, Thermal.
b. NG Boiler back-up unit.
c. NG Boiler back-up unit w/LNB. The potential range for NOx control using LNB is 25 - 65%. Source: CEC for control range.
9a. Solar, Photovoltaic.
10a. MSW, Steam boiler.
b. MSW, Steam Boiler w/FFB.
11a. Wood, Steam Boiler.
b. Wood, Steam Boiler w/FFB.
12a. Wind.
13a. Small Hydroelectric.
14a. Purchases.

Peakers

1a. Combustion Turbine NG.
b. Combustion Turbine NG. The potential range for NOx control using SWI is 70 - 82%. Source: CEC for control range.
2a. Combustion Turbine Distillate Oil.
b. Combustion Turbine Distillate Oil w/SWI. The potential range for NOx control using SWI is 70 - 82%. Source: CEC for control range.
3a. Reciprocating Engine, Diesel.
b. Reciprocating Engine, Diesel w/SCR. The potential range for NOx control using SCR is 80 - 90%. Source: CEC for control range.
4a. Pump-storage Hydroelectric.
5a. Purchases

VALUATION OF ENVIRONMENTAL EXTERNALITIES

Pollutant	Valuation (1990 real levelized dollars/lb)
Carbon Dioxide (CO_2)	0.011
Methane (CH_4)	0.11
Nitrous Oxide (N_2O)	2.07
Nitrogen Oxides (NO_x)	3.4
Sulfur Oxides (SOx)	0.78
Volatile Organic Compounds (VOC)	0.59[1]
Carbon Monoxide (CO)	
Ambient Air Quality +	0.43
Global Warming Contribution	0.03
Total	0.46
Total Suspended Particulates/ Particulate Matter (diam<10mm) TSP/PM_{10}	2.09
Hydrogen Sulfide (H_2S)	NA[2]

[1] The value for VOC has been adjusted to reflect the state of Nevada's status as attainment for VOC. This value is representative of an actual cost incurred in Nevada to control fugitive VOC emmissions from gasoline.

[2] A national marginal control cost for VOC in attainment areas would be approximately $0.9 per lb. (OTA, 1989). The valuation of H_2S in progress at this time.

EVALUATING FACTORS NOT EASILY EXPRESSED IN DOLLARS (NEEDS): Development of the Non-Quanitifiable Risk Assessment Worksheet

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For Presentation at the NARUC
National Conference on Environmental
Externalities in Jackson Hole, Wyoming

October 1-3, 1990

By:

Richard L. Prestin

Northern States Power Company

Overview

Northern States Power Company (NSP), like most other electric utilities, has historically conducted rigorous analyses of the economic costs and benefits of demand and supply side options. For major coal and nuclear projects, as well as related high voltage transmission lines, significant time and effort were spent on environmental assessments. In the early 1970's a quantitative approach was developed and utilized for assessing environmental factors which were not readily addressed in an economic setting. This approach consisted of developing an appropriate list of factors or criteria, assigning weights for each category and then compiling the "scores" for each alternative. This method was used for ranking potential power plant sites and transmission line routes.

Evolution From Quantitative to Qualitative Analysis

The quantitative approach, with the use of weighting and scoring, was utilized by NSP planners for nearly a decade. During this time, many of the projects being proposed by the company ran into extensive controversy, permitting delays, public opposition and ultimate disapproval by the regulators.

NSP planners took a step back and reevaluated their basic planning approach. After considerable internal discussion, NSP realized that it needed to first answer some basic questions:

1) Who are the real decision makers?

2) Are decisions being made objectively or subjectively (or a combination)?

3) What were the key factors being considered by the decision makers?

4) How could NSP planners address these factors in their analyses, in order to come up with more reasonable, acceptable proposals?

5) Why wasn't the quantitative method working (utilizing weights and scores for analyzing social/environmental issues).

Some Answers

#1) Decision Makers: NSP thought it made the important decisions, since it was NSP who was charged with analyzing and proposing alternatives. But as of the mid-1970's (Wisconsin Plant Siting Bill), NSP was wrong. The Public Service Commission (PSC) ultimately made the final decision on major projects, both for need and for siting. In reaching their decisions, NSP realized that there were a number of important decision influencers, who had an active role in the decision process. These influencers included:

* NSP
* PSC Staff
* Public
* Special Interest Groups
* Environmental Groups
* Potentially affected landowners
* Other regulatory agencies and officials

#2) Objective or Subjective Decisions: NSP realized that decisions were not going to be made solely on economic parameters.

There were other factors influencing decisions, which were not readily quantifiable or relatable to economic terms. In other words, decisions were being made using both objective and subjective factors. Decisions were being greatly influenced by quantitative factors, such as impacts to landowners, environmental impacts and other agencies' inputs.

#3) Key Factors: Although economics and system reliability continued to be important factors in reaching decisions, it became obvious that other less-quantifiable factors were also important:

* Health
* Safety
* Option Reliability
* Environmental Impacts
* Fuel Usage
* Social Impacts
* Political Uncertainties
* Local Economics
* Flexibility
* Technical Innovation

#4) Planning Using These Factors: At the time, no formalized system for analyzing these factors was being used by NSP at the planning stage. As a result, in 1987, NSP developed a Non-quantifiable Risk Assessment Worksheet, to be used at the planning stage to address the factors not easily expressed in dollars (NEED$). This worksheet has been refined in the past three (3) years and the latest version is included as Attachment 1 to this paper. The worksheet addresses the factors which influence decisions, in a manner which is best described as a combination of quantitative and qualitative techniques, with a special emphasis on reviewer comments and the potential for fatal flaws. The worksheet emphasizes quantifying factors whenever possible (Tons of emissions, acres of land affected, number of regulatory agencies involved, etc) but does not attempt to assign any weights nor develop any scoring mechanism.

The most important lessons learned in using the worksheet in the past three (3) years are:

1. The worksheet does not exactly or appropriately fit all resource options and is not intended to do so. No one worksheet could accomplish this.

2. The intent of the worksheet is to quantify where possible and to stimulate thought and discussion between planners and NSP management.

3. The value of the worksheet is the process of completing it, not the actual details on the forms.

4. The most important parts of the worksheet are the sections for comments and fatal flaw potential.

#5) Why was weighting/scoring not working:

What NSP realized after using the weighting and scoring techniques for about a decade was that the decision maker's and decision influencer's opinions on the weighting of particular factors were extremely diverse. As a result, the process served to polarize or alienate the various parties, drew attention away from the really important issues which deserved discussion and resulted in extensive delays and disapprovals. All efforts to try to quantify, tabulate and address the important factors, prior to weighting, were very useful. The problem with the system was the use of weighting and scoring to compare alternatives.

I think this problem can best be described using an analogy. Let us assume that we want to produce a painting of something (i.e. a decision) and attempt to get a consensus from a diverse group on what the painting is showing. First of all we get a canvas and frame and paint the basic background. This is the foundation for the painting (i.e. the economic parameters). Once the foundation is laid we can add the details using fine brushes and various colors to begin to bring out the various components of the painting (i.e. tons of emissions, safety factors, environmental, social, political attributes). If sufficient time and care is spent on these details, the painting really takes form and becomes recognizable to most, but not all people. In an attempt to put on the final touches, so that <u>everyone</u> will be able to see what the painting is about, we take out a six (6) inch wide house painting brush, dip it in a big bucket of black paint and proceed to apply a half dozen full-width passes over the entire painting (i.e. weighting and scoring).

Get the point! Things were proceeding fairly well (but not perfectly) up to a point. What we have to realize is that no system is perfect. Decision makers have based their decisions on somewhat subjective factors in the past and will continue to do so in the future. As planners, we need to recognize and accept this fact and attempt to conduct our planning in such a way as to give as much support and information to the decision makers as we can, without introducing additional confusion or foundation for alienating the various groups who influence their decisions.

NSP has found that the process it now uses works fairly well and most importantly promotes communication and discussion among groups. With this philosophy, NSP has become a utility industry leader for innovative projects such as:

* Demand-Side Management Implementation
* Major Hydro Plant Redevelopment
* Fluidized Bed Combustion
* Waste Wood Utilization
* Whole Tree Burning Research
* Wind Farm Research
* Refuse Derived (RDF) Utilization
* Transmission System Upgrades
* Development of a Small, Modular, Pre-engineered, Fluidized Bed Coal Plant

NON-QUANTIFIABLE RISK ASSESSMENT WORKSHEET **346** Version 6/90 Attachment 1
Northern States Power Company

Option Name/Description _____

_____

Evaluated By _____
Name Position Date

HEALTH

	None/ No	Slight	Moderate	Significant	Great/ Yes	Quantity
Particulate Emissions						
Toxic Emissions						
Carcinogenic Emissions						
Radon/Indoor Pollution						
Hazardous Waste Discharges						
Proximity to Population Centers						
Electromagnetic Fields						

FATAL FLAW? (Characteristic which could outweigh everything else)

Comments:

General Outcome
Negative ☐
Neutral ☐
Positive ☐

SAFETY

	None/ NO	Slight	Moderate	Significant	Great/ YES	Quantity
Potential for Fire, Explosion, or Electrocution						
Potential for Other Accidents - Type_____						
Exposure: Public						
Employee						

FATAL FLAW?

Comments:

General Outcome
Negative ☐
Neutral ☐
Positive ☐

RELIABILITY

	None/ NO	Slight	Moderate	Significant	Great/ YES	Quantity
Impact on Outage Rates						
Dependence on Customer Action						
Potential for Regulatory Delay						
Effect on Peak Demand						
Potential for Technical Failure						

FATAL FLAW?

Comments:

General Outcome
- Negative
- Neutral
- Positive

ENVIRONMENTAL

	None/ NO	Slight	Moderate	Significant	Great/ YES	Quantity
Wetland Impacts						
Forestry Impacts						
Agricultural Impacts						
Recreation Area Impacts						
Engangered Species Habitat Impacts						
Water Quality Impacts						
Surface						
Groundwater						
Acid Deposition Impacts						
Fish/Wildlife Impacts						
Aesthetic/Viewshed Impacts						
Noise Level Impacts						
Construction Impacts						

FATAL FLAW?

Comments:

General Outcome
- Negative
- Neutral
- Positive

FUEL

	None/ NO	Slight	Moderate	Significant	Great/ YES	Quantity
Renewable Availability:						
Present						
Future						
Price Stability						
Efficiency of Fuel						
Best Societal Use of Fuel						

FATAL FLAW?

Comments:

General Outcome
- Negative
- Neutral
- Positive

SOCIAL

	None/ NO	Slight	Moderate	Significant	Great/ YES	Quantity
Customers Creating Load are those Primarily Affected						
Loss of Agricultural Land						
Displacement of People						
Landowners Affected						
Public Lands Encroachment						
Negative Public Attitudes						
Impact on Customer Lifestyle						
Impact on Customer Comfort						
Public Goodwill Generated						
Jobs Created Locally						
Impact on Productivity						

FATAL FLAW?

Comments:

General Outcome
- Negative
- Neutral
- Positive

ECONOMIC

	None/ NO	Slight	Moderate	Significant	Great/ YES	Quantity
Jobs: Created						
Displaced						
Impact on Local Taxes:						
Increase						
Decrease						
Potential for Secondary Businesses						
Local Work Force Used						
Increased Rates						
Lost Revenue						
Economic Benefit: In State						
Out of State						
Potential to Delay Major Capital Investments						
Diversification Opportunities						
Customer Investment Required						

FATAL FLAW?

Comments:

General Outcome
- Negative
- Neutral
- Positive

POLITICAL

	None/ NO	Slight	Moderate	Significant	Great/ YES	Quantity
Difficulty Obtaining Permits						
Extent of Permitting Necessary						
Involvement of Other States						
Involvement of Counties						
Involvement of Townships						
Involvement of Federal Gov't						
Public Acceptance						

FATAL FLAW?

Comments:

General Outcome
- Negative
- Neutral
- Positive

FLEXIBILITY/RISK

	None/ NO	Slight	Moderate	Significant	Great/ YES	Quantity
Adaptable to Changes In:						
Load Growth						
Inflation						
Interest Rates						
Future Planning						
Ease of Dispatch						
Lead Time Required						
Modular Design						
Degree of Overall Risk						

FATAL FLAW?

Comments:

General Outcome
- Negative ☐
- Neutral ☐
- Positive ☐

TECHNICAL INNOVATION

	None/ NO	Slight	Moderate	Significant	Great/ YES	Quantity
New/Improved Method of Generation						
New Design for Transmission						
New Design for Distribution						
New Technologies for End Use Efficiency Improvements						
R & D Opportunities						
Value of Information Acquired						

FATAL FLAW?

Comments:

General Outcome
- Negative ☐
- Neutral ☐
- Positive ☐

NON-QUANTIFIABLE RISK ASSESSMENT WORKSHEET
Northern States Power Company

Option Name/Description_____

General Overview by Category

Category	Negative	Neutral	Positive	Fatal Flaw Potential (Minor/Major)
HEALTH				
SAFETY				
RELIABILITY				
ENVIRONMENTAL				
FUEL				
SOCIAL				
ECONOMIC				
POLITICAL				
FLEXIBILITY				
TECHNICAL INNOVATION				

The Commonwealth of Massachusetts

DEPARTMENT OF PUBLIC UTILITIES

SESSION: State Regulatory Experiences

TITLE: Implementing an Environmental Externality Evaluation Method for Electric Utility Planning and Resource Acquisition in Massachusetts

PRESENTER: Henry Y. Yoshimura, Director, Electric Power Division, Department of Public Utilities

DATE: August 31, 1990

PREFACE

The attached paper is an excerpt from the Environmental Externalities section of the Department of Public Utilities' Order in D.P.U. 89-239 (August 31, 1990). D.P.U. 89-239 was the proceeding through which the Department promulgated its final integrated resource management ("IRM", called Least-Cost Planning by some other states) regulations. The presenter was the director of the project leading to the promulgation of the final IRM regulations, and was the lead technical staff person responsible for the environmental externalities portion of the Department's Order.

ENVIRONMENTAL EXTERNALITIES

A. Introduction

The Department defines the cost of environmental externalities as the cost of environmental damages caused by a project or activity for which compensation to affected parties does not occur, regardless of whether the costs are imposed within Massachusetts borders or elsewhere.[1] In D.P.U.

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1 We assume that the cost of mitigating environmental damages required by federal, state, and local regulations are internalized in a resource developer's production costs and, therefore, in the prices bid by developers and electric companies. Any residual damages that occur after compliance with basic environmental regulations and standards are assumed to occur without compensation to affected parties and, therefore, constitute an external cost. D.P.U. 86-36-G, p. 77.

86-36-F, the Department required electric companies to include environmental externalities to the fullest extent practicable and quantifiable in their evaluations of C&LM programs and other resource options. Id., p. 22. In D.P.U. 86-36-G, the Department reaffirmed its decision to incorporate environmental externalities in the evaluation of alternative energy resources by finding that

> electric utilities' evaluation of alternate energy resource options must take into account environmental externalities to avoid the selection of resources that impose high costs not internalized in the prices bid by competing resource developers. In addition, explicitly incorporating the value of environmental externalities in resource decisions encourages resource developers to consider the value of environmental resources in project proposals and enables projects that are relatively environmentally clean to compete fairly with lower-priced energy projects that have high environmental impacts.

Id. pp. 79-80.

The Department stated in D.P.U. 86-36-G that it would establish a regulatory framework that takes environmental externalities into consideration and that does so through the application of either price or non-price criteria. Id., p. 80. We stated that utilities should identify and quantify externalities as thoroughly as is reasonable for purposes of comparing resources, but we also expressed our willingness to consider alternative regulatory schemes that either, (a) put externalities in dollar terms and add them to the price of the resource (i.e., a monetization approach), or (b) select a weight for environmental externalities and a method for ranking the range of externalities in much the same way that factors other than price (e.g., reliability) are handled within the framework of the Department's existing QF regulations (i.e., a weighting and ranking approach). Id.

B. Comments and Discussion on Environmental Externalities

Many of the comments submitted in D.P.U. 89-239 are devoted to the treatment of environmental externalities in the IRM process. There is a virtual consensus among commenters that including environmental externalities in the resource evaluation process is a positive development that would allow resources with varying degrees and types of environmental impacts to be compared more accurately. In addition, most of the commenters agree that environmental externalities should be evaluated using a

common framework and set of values for all utilities. Only BECo advocated giving each utility the flexibility to develop its own environmental scoring methodology (BECo Comments, 2/23, pp. 20-21).

The commenters, however, disagreed on a variety of issues involving the method of implementing an environmental component in the evaluation of energy projects. The issues raised by the commenters include:

- Using an impact-based versus a technology-based initial ranking system;
- Monetizing versus weighting and ranking externality values;
- Valuing externalities at the marginal cost of control versus cost of actual damages;
- Determining the weight of environmental externalities relative to other project selection criteria;
- Extending externality evaluations to site-specific factors;
- Extending externality evaluations to include entire fuel cycle costs;
- Extending externality evaluations to include economic and social externalities; and
- Finalizing the transitional policy for environmental externalities.

The first four issues concern the method by which environmental externality values are estimated and incorporated into the resource selection process. The next three issues concern the scope of the externality evaluation. In this section of the Order, the Department shall discuss issues with regard to the method and scope of estimating environmental externalities for use in the IRM process. The final issue, transition policy, will be dealt with more fully in the transition section of this Order. See Section IV.B, infra.

1. Estimating and Incorporating Environmental Externalities into the IRM Process

a. An Impact-based Versus a Technology-based Scoring System

In D.P.U. 86-36-G, the Department outlined three alternative methods for incorporating environmental externalities in the resource evaluation process. These methods included a

technology-based, impact-based,[2] and hybrid scoring systems. See Id., pp. 88-93, for a full description of these methods. Most of the commenters strongly favor an impact-based or a hybrid scoring system.[3] The commenters' main objection to a technology-based system is that it scores all projects using the same fuel or turbine/boiler configuration equally, regardless of a developer's attempt at mitigating emissions from a project. Many commenters state that under a technology-based scoring system, no incentive exists for the developer to invest in cleaner technology (Mass. Audubon Comments, 2/23, pp. 2-3; CLF Comments, 2/26, pp. 23-24; WMECo Comments, 2/26, pp. 42-44 and 5/4, pp. 21-22; Altresco Comments, 5/4, pp. 12-14).

The Department agrees that a project evaluation system that distinguishes energy project proposals by their particular expected emission levels is preferable to scoring systems that allocates fixed points based on technology types. Scoring systems based on impact levels recognize project-specific reductions of environmental impacts generally associated with energy projects of a particular turbine/boiler configuration and fuel type, and enables developers to evaluate more accurately the trade-offs between emission or resource-use levels, and the cost of controlling such emissions or reducing the level of resource use. Also, such a scoring system provides incentives for the development and procurement of cleaner technologies. Accordingly, the Department finds that electric companies should implement an environmental externality evaluation methodology that recognizes, to the greatest extent possible, the expected level of environmental impacts associated with particular project proposals. The following sections of this Order will discuss how the value of environmental impacts associated with particular energy projects should be estimated, including whether such values should be monetized, and whether these values should be based on the value of environmental damages or the cost of controlling emissions that cause damages.

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2 In this context, "impact" means emission or resource-use levels.

3 A hybrid system assigns general categories of technologies (e.g., coal, oil, gas, nuclear, renewable, C&LM) base environmental impact scores (as in a technology-based system), but allows each proposal to improve its base score by reducing impacts over several categories of environmental impacts (as in an impact-based system). D.P.U. 86-36-G, pp. 91-93.

b. Monetizing Environmental Externalities[4]

The commenters who support a monetization approach argue that placing dollar values on externalities makes the underlying judgments clearer and more understandable to the public. Although those that argue for a monetization scheme recognize that externality values are highly uncertain, they maintain that a weighting and ranking scheme simply obscures the monetary values implied by the scheme. In addition, these commenters oppose methods that assign a fixed weight to the externality category of the project selection criteria because such a method sets a cap on the maximum influence environmental externalities can have relative to prices bid by project developers (MassPIRG Comments, 2/26, pp. 14-15; MCSE Comments, 5/4, p. 1; DOER Comments, 3/2, pp. 12-13; CLF Comments, 2/26, pp. 33-35; Representative Alexander Comments, 5/18, pp. 6-7; The Department of Environmental Protection, Division of Air Quality Control ("DAQC") Comments, 5/25, pp. 3-5).

Several commenters support the weighting and ranking scheme proposed by MECo, with the environmental externality category accounting for 15 percent of the total project score (BECo Comments, 2/23, pp. 20-21; ComElectric Comments, 5/4, pp. 15; WMECo Comments, 5/4, pp. 21-22; Wheelabrator Comments, 3/8 Letter to MECo). Altresco supports the MECo plan, but with a 30 percent weight for the environmental externality category (Altresco Comments, 5/4, pp. 12-14); EECo supports the plan with a 10 percent weight for the environmental externality category (EECo Comments, 5/4, pp. 5-6).

The MIT Energy Lab asserts that monetizing intangible environmental impacts is an unnecessary complication of an already challenging analytic task (MIT Comments, 3/13, pp. 4-5). It asserts that lower costs, lower sulfur dioxide emissions, as well as increased employment and reliability are generally preferred. Accordingly, it argues that any strategies that perform better along all of these measures independent of any weighting and ranking scheme are better (id.). Accordingly, the MIT Energy Lab recommends that the Department adopt a system-based, multi-attribute evaluation technique (id., p. 2). The multi-attribute evaluation technique recommended by the MIT Energy Lab uses "distinct measures of cost, environmental

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4 We note our appreciation for the considerable assistance in developing methods and estimates of environmental externalities prepared by the commenters, especially Boston Gas Company ("BGCo"), DOER, MECo, and the MIT Energy Lab.

impacts, and reliability in the evaluation of resource portfolios to identify the full range of a strategies' impacts while avoiding controversy over the valuation of environmental and other externality effects" (id.).[5]

The Department finds that effective weighting and ranking approaches could be designed to account for the variation in environmental impacts among various energy resources. However, in order to design an effective weighting and ranking approach, environmental impacts and the value of those impacts would have to be estimated so that appropriate weights could be determined.[6] If weighting and ranking systems require

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5 The MIT Energy Lab states in its comments that resource strategies that focus exclusively on improving end-use efficiency perform poorly in reducing sulfur dioxide, nitrous oxides, and particulate emissions when compared to resource strategies that balance efficiency improvements on both the supply-side and the demand-side. According to research conducted by the MIT Energy Lab, it was found that resource strategies aimed at increasing combustion efficiency as well as end-use efficiency appear to be robust in mitigating local, regional, and global environmental impacts (MIT Comments, 3/27, p. 1). It states that these results appear to stem from the fact that over-subscribing to demand-side resources might lead to electric companies keeping older fossil-fueled generators (with high heat rates and emission levels) in service longer. Investing in new generation technology (with low heat rates and emission levels) allowed electric companies to retire old fossil-fired generation, thus reducing system-wide emission levels. The Department finds that the concerns raised by the MIT Energy Lab can be accommodated during the optimization phase of project evaluation and modification. Accordingly, the Department's final regulations require electric companies to optimize the ranking of proposals to take into account interactive effects between resources. The Department directs companies to expand the examination of interactive effects to include the interaction between new and existing resources, and to evaluate the collective environmental impacts of various committed and proposed resource combinations when preparing their draft initial resource plans and when optimizing the ranking of proposals.

6 The Department notes that, ultimately, this is true for all project selection criteria including those presently designated as "non-price" criteria.

quantification of externality values in order to determine the appropriateness of the weights, forming weights becomes unnecessary because the quantified externality values could be monetized and added directly to project costs to assist the determination of the mix of resources that minimizes cost and environmental impact simultaneously.

Accordingly, the comments in this proceeding convince the Department that externalities should be monetized to the greatest extent possible, and that such values would be added to direct resource costs (i.e., price bids of proposed resources, and the avoidable costs of existing and planned resources) for the purposes of evaluating and comparing alternative energy resources during Phase II. In categories of environmental impacts where estimates of externality values are absent, the utility must make its best effort to estimate monetary values with magnitudes appropriately weighted relative to better known values. These relative values must be estimated using the best information reasonably available.[7]

As we stated in D.P.U. 86-36-G, the Department realizes that monetizing externality values does not constitute the elimination of subjective judgments in the evaluation of externalities. We expect that as externality values are proposed by utilities and interested parties for use in the IRM process, that the proponents of such values reveal all assumptions and judgments so that their merit can be discussed in the appropriate public forum.

c. Cost-of-Control Versus the Value of Environmental Damages

In D.P.U. 86-36-G, the Department defined environmental externalities as the costs associated with damages caused by a project for which compensation to affected parties does not occur. Assuming that the cost of pollution controls required by

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7 All externality evaluations submitted to the Department in D.P.U. 89-239 omit environmental externalities associated with nuclear and renewable (most notably large hydro and waste-to-energy projects) energy production, and with load management programs. The Department directs each electric company to propose environmental externality values associated with nuclear and renewable energy production, and load-management projects, and to include such values in its first Phase I filing pursuant to the attached regulations.

government law, standards and regulation is internalized into the prices offered by alternative suppliers of generation, the value of environmental externalities equals the value of damages associated with residual emissions that manage to escape into the environment despite required pollution control technologies. For example, a conventional coal-fired power plant that just meets federal New Source Performance Standards for sulfur dioxide emissions will still emit significant and specific amounts of sulfur dioxide into the atmosphere. These residual emissions cause environmental degradation and, therefore, we find that these must be taken into account in an electric company's choice of energy resources.

The purpose of estimating environmental externality values is to enable decisionmakers to compare, on a consistent basis, the social costs associated with alternative energy resources offering different prices, environmental impacts, and non-price characteristics. To illustrate the value of externalities, assume a situation where there are two generating facilities that meet federal emission limits and are alike in all respects (e.g., price, reliability) except that one facility emits significantly less pollution than the other. Most would agree that the facility with lower emissions would be preferred. If the value of environmental externalities resulting from emissions permitted by federal statute were zero, we would be completely indifferent between these two generating facilities. Since we would not be indifferent -- that is, we would prefer the less-polluting generating facility -- externalities must have an economic value that we need to consider in our resource choices.

Moving from this example, consider a comparison of two facilities that each meet government emission and resource-use requirements, but one pollutes more than the other. The value of lower environmental externalities associated with the cleaner resource would equal the maximum difference in price between two resources (where the price of the dirtier resource is lower than the price of the cleaner resource) that would be acceptable before society preferred the dirtier resource. In theory, before society opts for the dirtier resource, the difference in prices (and presumably the costs) between the dirtier and cleaner resources (i.e., the amount by which the price of the dirtier resource is lower than the cleaner resource) must be greater than the value of the incremental environmental damages associated with the dirtier resource relative to the cleaner resource. If the value of the incremental environmental damage associated with the dirtier resource is smaller than the difference in price, it would be to society's net benefit to prefer the dirtier resource. However, if the value of the incremental environmental damage associated with the dirtier resource is larger than the price difference, society would be worse off with the dirtier resource. In this case, it would be

to society's net benefit to prefer the cleaner resource even though its internal price may be higher.

In order to compare different energy resources on a consistent basis, therefore, an estimate of environmental damage values associated with each resource would appear to be necessary. Given that the costs of environmental damages are difficult to estimate, methods other than direct damage cost assessments have been used to estimate externality costs.

Most of the commenters who support a monetization scheme state that using cost of actual damage values (e.g., health care costs, loss of natural resources, reduction in the quality of life) is the preferable method for valuing externalities, and argue that where these values are known, they should be used (CLF Comments, 2/26, pp. 37-39; DOER Comments, 5/2, pp. 6-8; DAQC Comments, 5/10, Preface; BGCo Comments, 5/18, Attachment 1, p. 4; MassPIRG Comments, 5/25, p. 3). In areas where damage costs are unknown or are uncertain, some of these commenters argue that a reasonable alternative to direct damage valuation is to use the marginal costs of control to reflect the values of environmental impacts implied by pollution standards set through other political processes (id.). These commenters argue that this approach provides conservative estimates (i.e., underestimates) of the externality costs and thus represent a proper starting point (id.).

MECo disagrees with the assumption that using the cost of control provides a conservative estimate of externality costs and asserts that cost of control methods for estimating the value of externalities should be rejected because it suffers from fundamental illogic (MECo Comments, 2/23, pp. 18-19). MECo asserts that the use of a cost of control method to estimate the value of externalities systematically tends to overstate the value of externalities (MECo Comments, 5/8, p. 2). MECo argues that society has already mandated restrictions on emissions such that the point has been achieved where the marginal cost of controlling emissions equals the marginal value of potential environmental benefits (id., pp. 4-7). Subsequently, MECo states that the marginal cost of abating any additional pollution must be greater than the marginal benefit society receives from such abatement (id.).

MECo also states that cost of control methods inappropriately equate two separate and distinct concepts, the cost of controlling emissions and the value of environmental externalities (id.). In addition, MECo claims that the cost of control varies widely between utilities and that selecting one estimate as representative of all utilities constitutes an arbitrary exercise unlikely to reflect a given utility's actual cost of control (id.).

The method proposed by BGCo and DOER to estimate the value of environmental externalities equates society's willingness to pay for pollution control (and hence, society's demand to avoid costly environmental damages) with the cost of controlling pollution to comply with government-mandated emission limits. The basic rationale for using cost of pollution control as a measure of the value of pollution reduction is that the cost of pollution controls required by the government provides an estimate of the price that society is willing to pay to reduce the pollutant (BGCo Comments, 1/5, p. 8; DOER Comments (Update), 5/18, pp. 4-6).

For example, if legislators, as society's representatives, require measures that cost four dollars to reduce a pound of emission, it seems reasonable to assume that the value or worth of reducing emissions is four dollars per pound. Presumably, society is willing to pay four dollars to avoid a pound of emission in order to avoid at least four dollar's worth of external environmental damages. Methods that estimate society's demand for pollution abatement using government-mandated emission limits are referred to as implied valuation methods.

As mentioned above, MECo states that implied valuation methods overstate the value of environmental externalities. MECo argues that the marginal cost of abating any additional pollution beyond that required by government regulation must be greater than the marginal benefit society receives from such abatement (MECo Comments, 5/8, pp. 4-7). Since marginal pollution control costs tend to increase and marginal pollution abatement benefits may tend to decrease with increasing levels of pollution control, MECo asserts that to control emissions significantly beyond the intersection of the marginal cost and marginal benefit curves of pollution control theoretically would diminish net societal benefits. Accordingly, MECo requests that the Department reject the implied valuation method.

However, the Department finds that MECo's argument is not relevant to the problem that the implied valuation method is attempting to address. Implied valuation methods attempt to use a proxy to estimate the value of residual pollution so that the societal cost associated with various energy resources (e.g., fossil-fuel generation, renewable-resource generation, nuclear generation, C&LM) can be compared on a consistent basis. MECo's argument implies that pollution emitted by resources meeting government-mandated emission limits cause no loss to net societal values and, therefore, need not be taken into account in the comparison between alternative energy resources. Clearly, this is not true (and MECo does not assert it is). As discussed above, if society were presented with the option to purchase either a relatively dirty or a clean resource (assuming that both resources comply with government-mandated emission limits), and these resources were alike in all other respects,

society would prefer the cleaner resource to avoid costly incremental environmental damages. If we were to accept MECo's argument to its logical conclusion, we would be unable to compare the differing levels of environmental externalities caused by different energy resources that comply with government emission standards.

As a theoretical matter, MECo is correct to state that controlling emissions significantly beyond the intersection of the marginal cost and marginal benefit curves of pollution control could diminish net societal benefits.[8] The Department, however, disagrees with MECo's assumption that the decisions that have led to the setting of government standards for controlling emissions or natural resource use are based solely on economic considerations of marginal costs and benefits. The level of pollution control presently mandated by legislation is based on many considerations besides an assessment of the economics of environmental damages, and, therefore, may not necessarily represent society's willingness to pay for controlling environmental damage. We acknowledge that because of the difficulties of measuring the value of environmental damages directly, it is unlikely that the level of pollution control mandated by legislation reflects society's willingness to pay to control environmental degradation. Absent better evidence, however, it is through the political process that government-mandated levels of pollution control provides a reasonable, rough proxy for of what society is willing to pay to avoid environmental externalities.

Further, we disagree with MECo that the implied valuation method overestimates the value of environmental externalities and, thus, would force power-plant developers to install pollution control equipment costing more than the benefit of abating the additional pollution. Economic theory posits that it is appropriate to value the avoidance of environmental externalities at the intersection of the marginal cost and marginal benefit curves of pollution abatement. It is at the intersection of the marginal cost and marginal benefit curves of

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8 As a practical matter, the level of pollution associated with energy resources used to serve Massachusetts electricity demand represents a very small amount of global environmental externalities. Even if MECo's analysis and assumptions were entirely correct, and a large amount of pollution associated with Massachusetts electricity consumption was abated, the amount by which the incremental cost of pollution control exceeded incremental benefits would be very small when viewed from a global perspective.

pollution control where societal value is maximized and, thus, defines the market-clearing price or equilibrium value of avoiding environmental externalities.[9]

At quantities of pollution abatement greater than the quantity at which the marginal cost and benefit curves intersect, the amount society is willing to pay for pollution control is lower than the marginal cost of controlling that amount of pollution. In this case, societal value is enhanced by lowering the quantity of pollution control.[10]

In the IRM process, project developers installing pollution controls whose actual cost per unit of reduced emissions is greater than the per unit dollar value associated with avoiding environmental externalities would incur costs higher in comparison with any credit they would receive for having reduced emission levels. In this situation, the overall economic value of the project would be reduced and the project would receive a lower score in the IRM process. Valuing environmental externalities at the marginal cost of control would enable power-plant developers to make decisions about fuels and pollution controls in the overall context of competing with other project developers on price, environmental, and non-price variables.

The purpose of estimating the value of environmental externalities is to allow consistent comparisons between various energy resources with differing prices, environmental impacts, and non-price features. This is especially important when comparing energy conservation resources that have relatively little or no environmental externalities against generation resources that have significantly higher externalities. But it is also essential for comparing different generating facilities

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9 The implied valuation method serves as a proxy to establish the point of intersection between the marginal cost and marginal benefit curves of pollution abatement, even though the actual control costs may not be at the intersection of such curves given our assumption that other factors besides marginal costs and benefits of pollution abatement entered into the determination of government pollution-control standards.

10 Conversely, at quantities of pollution abatement less than the quantity at which the marginal cost and benefit curves intersect, the amount that society is willing to pay for pollution control is higher than the marginal cost of controlling that amount of pollution. In this situation, societal value is enhanced by increasing the quantity of pollution control.

whose fuel and technological differences lead to significantly different pollution impacts. Estimating environmental externalities using the implied valuation method and using such values in the IRM evaluation process would give developers of generation technologies the incentive to design generation systems[11] that decrease emission levels at costs lower than the value of environmental externalities. If residual emissions allowed by government regulation were valued at zero, there would be little economic incentive for innovation of this type.

Without reasonable estimates of environmental damage costs, we cannot know with precision that the marginal cost of control at levels mandated by the government under- or overestimates society's demand for a cleaner environment. However, based in part on the comments in this case, it does not appear that using the results of the implied valuation method as a proxy has a significant risk of overestimating the costs of environmental externalities. Given the ongoing movement to make environmental standards more stringent rather than less stringent, and given the increasing sensitivity of the public to environmental issues, it is more likely that the marginal costs of controlling pollution are below marginal benefits at the present level of pollution control mandated by the government. As a consequence, using the cost of control as a proxy for the value of externalities is most likely a conservative estimate of society's willingness to pay for controlling externalities.

Since cost of control estimates, using the implied valuation method, is the best available proxy at this time (and clearly a better estimator of damage costs than the current assumption that the value of such damages is zero), we direct electric companies to use such control-cost estimates as a proxy for environmental damages in the absence of comprehensive damage cost estimates. In this record, both BGCo and DOER estimated the value of environmental externalities associated with various pollutants using the implied valuation method (BGCo Comments, 1/5, p. 13; DOER Comments (Update), 4/18, p. 33). For SO_x, CO_2, and particulate emissions, both BGCo and DOER estimated similar environmental externality values. For NO_x and CH_4 emissions, however, BGCo estimated significantly higher externality values compared to DOER.[12]

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11 That is, systems that use various combinations of fuels, fuel treatments, combustion configurations, and pollution control technologies.

12 BGCo estimates the value of externalities associated with NO_x and CH_4 emissions to be about $4.00 and $0.84 per pound, respectively (BGCo Comments, 4/13, Exhibit 1, pp. 12-14). In comparison, DOER estimates the value of these externalities to be about $3.25 and $0.11 per pound, respectively (DOER Comments (Update), 4/18, pp. 12 and 29).

With regard to BGCo's estimate of the value of externalities associated with NO_x emissions, it appears that BGCo misinterpreted NO_x emission reduction data associated with selective catalytic reduction technology (i.e., the marginal technology needed to attain a 9 ppmv emission standard) (BGCo Comments, 4/13, Exhibit 1, p. 14; DOER Comments (Update), 4/18, p. 12). The difference between BGCo's and DOER's estimate of the value of CH_4 externalities results from the method by which the impact of rapid global climate change was factored into the analysis (BGCo Comments, 4/13, Exhibit 1, pp. 11-13; DOER Comments (Update), 4/18, pp. 29-31). Although DOER is not convinced that the discounting method used by BGCo is the correct way to account for the impact of rapid global climate changes, DOER acknowledges that the rate of climate change may have comparable importance to overall climate change (DOER Comments (Update), pp. 30-31). Since DOER did not take the rate of climate change into account, its estimate of externalities associated with CH_4 emissions is probably understated. At this time, however, the Department will accept DOER's estimate of externality values associated with CH_4 emissions as a baseline value absent better evidence. In future cases, the Department expects parties to develop and propose more reasonable methods to account for the impact of rapid global climate change resulting from greenhouse gas emissions.

At this time, the Department will accept DOER's estimates of environmental externality values. Accordingly, the Department directs electric companies to use the environmental externality values proposed by DOER in this case for all electric company filings involving resource cost-effectiveness tests (including, but not limited to, preapprovals of utility C&LM and generation programs, QF RFPs, power purchase agreements, third-party C&LM contracts, IRM filings), unless it can be demonstrated in subsequent proceedings that other values for these or for other environmental externalities are more reasonable. See Table 1, infra. Electric companies may update such values, subject to Department review, on a case-by-case basis. Our ultimate objective, however, is to use comprehensive damage costs as the basis for environmental externalities where feasible.

d. Application of the Price/Externality Criterion

In D.P.U. 86-36-G, the Department stated as one of its goals that all companies use consistent categories and weights of environmental impacts because the relative value to society of global environmental impacts is not generally a matter subject to utility-by-utility variation. Id., pp. 86-87. Given that the Department has found that environmental externalities should be monetized to the greatest extent possible, the value of externalities relative to prices bid by resource developers would be consistent across all electric companies. The

Department's finding, however, opens the question of how to set the weight of the combined price/externality category relative to the weight of the other, "non-price" ranking criteria such as reliability and system compatibility.

In order to evaluate and rank various resource proposals, monetized externality values could be directly added to the price bid by the resource proponent to determine a project's direct costs to society. If price and monetized externalities were the only criteria by which to rank projects, those projects with the lowest price, including externality cost, would be given the highest ranking. As other project selection criteria are recognized and are assigned weights to reflect their importance to the electric company, projects with positive non-price features (e.g., highly reliable projects) may be given preference over those projects with low price/externalities.[13]

In addition, the relationship between the combined price/externality criterion and all other criteria that have not been monetized (i.e., non-price criteria) may vary across electric companies under a weighting and ranking scheme. For example, an electric company that generates a high proportion of its electricity from oil may wish to pay a higher price for new resources that do not use oil, as compared to a company that generates its electricity from a diverse set of fuels. As a result, the weight of the price/externality component of the scoring system relative to the fuel diversity component would differ between these two companies; we believe such a difference could be appropriate.

The Department finds, therefore, that monetizing externality values, placing them on a consistent basis with price, and then allowing the relative weights of the price/externality and non-price criteria to vary in accordance with an electric

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13 Although the Department views the monetization of environmental externalities as a priority over monetizing other resource attributes, the Department also sees merit in efforts to monetize other "non-price" factors. Although the Department directs electric companies to monetize environmental externalities to the greatest extent possible, the Department will welcome, but not now require, efforts to quantify the dollar values associated with other resource evaluation criteria (e.g., reliability, security, risks or benefits associated with fuels or fuel diversity) that presently are incorporated in the initial ranking formula using a weighting and rating scheme.

companies' actual circumstances and incremental needs,[14] is more appropriate than fixing the weight of the externality component, or the price/externality component, at any particular level vis-a-vis other non-price factors for all electric companies. By fixing the weight of the externality component to achieve consistency between utilities (e.g., 20 percent of total project score), the relationship between externalities, price and non-price factors could be severely distorted leading to inappropriate resource choices. In addition, fixing the weight of the externality component to a fixed percentage of total score may systematically under- or overestimate the real value of the externality component relative to price and other non-price criteria.

Rather than directing electric companies to use environmental externality weights that are equal across all companies, the Department will seek consistency in the monetary values used by electric companies to estimate the value of environmental externalities. Accordingly, the Department's final regulations do not require the weight of the combined price/externality category as a percentage of a project's total score to be equal across all electric companies. The final regulations allow the electric companies to propose, and for the Department to review, the weights of the various categories of project selection criteria. The weight of the combined price/externality category could vary between different electric companies as the values of the non-price criteria vary relative to the price/externality category. Although a decision by the Department on externality values for use by a company in a single case will have precedential value for that and other companies on a going-forward basis, electric companies and interested parties will have the opportunity to propose such values on a case-by-case basis.

2. Determining the Scope of Environmental Externalities

a. Site-specific Externalities

The commenters were divided on the question of whether site-specific externalities (e.g., visual, noise, and wetland impacts) should be considered in the IRM process. Some argue that site-specific factors should be included, otherwise local community groups will be alienated because the issues with which they are most concerned would not be addressed (Representative Alexander Comments, 5/18, pp. 13-14; MassPIRG Comments, 2/26,

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14 Of course, the Department would review and determine the appropriateness of the particular weights used in the project evaluation criteria.

pp. 10-11; MCSE Comments, 2/23, p. 5; Mass. Audubon Comments, 2/23, pp. 2-3). Others argue that site-specific factors should not be included in an externality scoring scheme. Some claim that site-specific factors will determine whether a project can be licensed and financed, and that such factors would be internalized by resource developers when developing bids (Altresco Comments, 5/4, p. 10; WMECo Comments, 2/26, pp. 40-41). DOER argues that although it would be desirable in principle to include all impacts within the resource evaluation process, it becomes increasingly difficult in practice to evaluate such impacts as the focus shifts from global to local effects (DOER Comments, 3/2, p. 4).

In D.P.U. 86-36-G, the Department proposed that the environmental externality criteria in the IRM structure focus primarily on the impacts of a proposed facility that occur regardless of the characteristics of the site where it was proposed to be located. Id., p. 87. The Department agrees with DOER that adding local, siting-specific environmental impacts into the evaluation process would be infeasible at this point. At the time a project proponent submits a project proposal to the utility for consideration in the IRM process, it may be impossible to assess site-specific factors for all project proposals because project developers may not have acquired sites before a power sales agreement is finalized.[15] In addition, site-specific environmental impact issues associated with large generating facilities would be investigated by the EFSC with a full and fair opportunity for local communities to voice their concerns. Accordingly, the Department will not consider site-specific environmental externalities in the IRM resource evaluation process.

b. Fuel-Cycle Externalities

Some of the commenters recommend that costs associated with the entire fuel cycle (i.e., fuel extraction, fuel transportation, facility construction, plant operation, waste disposal) should be included in the resource evaluation process (MassPIRG Comments, 2/26, p. 11; MCSE Comments, 5/4, p. 2; Mass Audubon Comments, 2/23, pp. 1-2; Representative Alexander Comments, 5/18, p. 16). Others state that it is appropriate to limit the examination of environmental externalities to externalities directly associated with plant operation (WMECo Comments, 2/26, pp. 40-41).

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15 Additionally, for generating facilities at least 100 MW in size and proposed to be located in Massachusetts, the EFSC's statute requires consideration of, and a specific proposal for, an alternate site.

The Department finds that ideally, all environmental externalities associated with energy production and use should be incorporated in the resource evaluation process. It would be difficult, however, at least at the present, for the Department to estimate externalities associated with early stages of the fuel cycle (i.e., externalities incurred before plant operation). To complicate the problem, externalities associated with early stages of the fuel cycle for each fuel type have varying degrees of site-specific attributes (e.g., different mining techniques such as deep mining and strip mining, local geology, land reclamation practices and land use practices, will influence the level of externalities associated with coal and uranium mining; the cost implications of potential oil spills may vary with each shipping lane).

Given the sizable task of estimating environmental externalities associated with power-plant operation, the Department finds that it would be unnecessarily burdensome and complicated at this time to require an estimate of environmental externalities associated with early phases of the fuel cycle. The Department finds that a priority should be placed on estimating environmental externalities that are the direct result of power-plant operation including all downstream effects (e.g., solid-waste disposal, waste-water disposal). The Department directs electric companies to consider in the project evaluation process all impacts resulting from plant operation[16] including air, water, solid waste and spent fuel disposal impacts, and resource use.

As we gain more experience and confidence with estimating externality values directly associated with power plant operation, the Department will consider proposals to expand the scope of the kinds of externalities so as to include those associated with earlier stages of the fuel cycle.[17]

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16 Such impacts should include, to the extent practicable, those environmental externalities resulting from the possibility of accidents associated with plant operation.

17 BGCo estimated the value of environmental externalities associated with oil spills at $0.20 per MMBTU (BGCo Comments, 1/5, Appendix A, pp. 85-87; 4/13, Exhibit 1, p. 16). While the Department acknowledges that environmental externalities associated with oil spills are potentially substantial depending on the nature of the spill, significant environmental externalities may exist for other major fuel types (e.g., environmental

c. Economic and Social Externalities

Some commenters argue that it is hard to create a level playing field for different resource options unless the full extent of economic and social factors are included. These costs include government subsidies (e.g., research and development, military support, tax benefits, clean-up support), economic development factors, and resource depletion. In addition, many commenters assert that special consideration should be given to projects which aid in the creation of local jobs (MassPIRG Comments, 2/26, pp. 12-14; MCSE Comments, 2/23, p. 6; Mass Audubon Comments, 2/23, pp. 1-2; Representative Alexander Comments, 5/18, p. 16).

Most of the comments received in D.P.U. 89-239 with regard to economic and social externalities request that the Department give special consideration to resources that promote local job creation as a source of external value. In Cambridge Electric Light Company and Commonwealth Electric Company, D.P.U. 89-242/246/247 (1990), the Department treated economic and social externalities (e.g., local job support) primarily as transfer payments rather than as resource costs. Id., pp. 19-20.[18] Accordingly, and consistent with our decision to

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externalities associated with coal and uranium mining, and gas drilling). In order to avoid possible uneconomic fuel preferences in the resource evaluation process by including the environmental externalities associated with some fuels and omiting those of other fuels, environmental externalities associated with early stages of the fuel cycle should be estimated for all major fuel types. We will consider environmental externalities associated with early stages of the fuel cycle on a case-by-case basis.

18 Constructing a power plant in Massachusetts supports local employment and reduces employment opportunities in other states and in Canada where power plants otherwise could be built to serve Massachusetts ratepayers. Since supporting local employment most likely means a reduction of employment opportunities in other regions, net employment gains may be negligible. Id. Similarly, although there may be direct employment differences between the types of resources implemented, a global perspective requires that direct, indirect and induced jobs be included in the net employment analysis. From a global perspective, therefore, the net employment difference, including indirect and induced employment, between resources requiring differing numbers of direct employees may be smaller than it might appear.

consider environmental externalities on a global perspective, the Department finds that local job creation should not be accounted for in the resource evaluation process.

At the same time, the Department recognizes that some economic and social externalities, including a portion of economic development costs and benefits, which represent resource costs and benefits rather than transfer payments should ultimately be accounted in the resource evaluation process (e.g., resource depletion costs not incorporated in price). For now, there is insufficient information available to order their inclusion in the resource evaluation process.[19] Rather, we will permit RFPs to include such externalities in the resource evaluation process if, on a case-by-case basis, the existence and level of such costs can be determined.

C. Summary of Findings and Directives on Environmental Externalities

The following summarizes the Department's findings and directives with regard to environmental externalities:

1. The Department agrees that a project evaluation system that distinguishes energy project proposals by their particular expected emission levels is preferable to scoring systems that allocates fixed points based on technology types. Scoring systems based on impact levels recognize project-specific reductions of environmental impacts generally associated with energy projects of a particular turbine/boiler configuration and fuel type, and enables developers to evaluate more accurately the trade-offs between emission or resource-use levels, and the cost of controlling such emissions or reducing the level of resource

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19 We note that BGCo estimated the value of economic externalities associated with oil imports at $2.26 per MMBTU (BGCo Comments, 4/13, Exhibit 1, p. 19). This figure was estimated to reflect the vulnerability of the United States to supply disruptions and price fluctuations (id.). It is not clear to the Department whether risks associated with oil imports should be reflected in the resource evaluation process as a monetized externality, or as a component of the fuel diversity selection criteria. Rather than deciding this matter at this time, we will consider issues related to oil imports on a case-by-case basis. We encourage electric companies to address this issue explicitly in their first IRM filing.

use. Also, such a scoring system provides incentives for the development and procurement of cleaner technologies. Accordingly, the Department finds that electric companies should implement an environmental externality evaluation methodology that recognizes, to the greatest extent possible, the expected level of environmental impacts associated with particular project proposals.

2. The MIT Energy Lab states in its comments that resource strategies that focus exclusively on improving end-use efficiency perform poorly in reducing sulfur dioxide, nitrous oxides, and particulate emissions when compared to resource strategies that balance efficiency improvements on both the supply-side and the demand-side. The Department finds that the concerns raised by the MIT Energy Lab can be accommodated during the optimization phase of project evaluation and modification. Accordingly, the Department's final regulations require electric companies to optimize the ranking of proposals to take into account interactive effects between resources. The Department directs companies to expand the examination of interactive effects to include the interaction between new and existing resources, and to evaluate the collective environmental impacts of various committed and proposed resource combinations when preparing their draft initial resource plans and when optimizing the ranking of proposals.

3. The comments in this proceeding convince the Department that externalities should be monetized to the greatest extent possible, and that such values would be added to direct resource costs (i.e., price bids of proposed resources, and the avoidable costs of existing and planned resources) for the purposes of evaluating and comparing alternative energy resources during Phase II. In categories of environmental impacts where estimates of externality values are absent, the utility must make its best effort to estimate monetary values with magnitudes appropriately weighted relative to better known values. These relative values must be estimated using the best information reasonably available. The Department also directs each electric company to propose environmental externality values associated with nuclear and renewable energy production, and load-management projects, and to include such values in its first Phase I filing pursuant to the attached regulations.

4. Since cost of control estimates, using the implied valuation method, is the best available proxy at this time (and clearly a better estimator of damage costs than the current assumption that the value of such damages is zero), we direct electric companies to use such control-cost estimates as a proxy for environmental damages in the absence of comprehensive damage cost estimates. At this time, the

Department will accept DOER's estimates of environmental externality values. Accordingly, the Department directs electric companies to use the environmental externality values proposed by DOER in this case for all electric company filings involving resource cost-effectiveness tests (including, but not limited to, preapprovals of utility C&LM and generation programs, QF RFPs, power purchase agreements, third-party C&LM contracts, IRM filings), unless it can be demonstrated in subsequent proceedings that other values for these or for other environmental externalities are more reasonable. See Table 1, infra. Electric companies may update such values, subject to Department review, on a case-by-case basis. Our ultimate objective, however, is to use comprehensive damage costs as the basis for environmental externalities where feasible.

5. The Department finds that monetizing externality values, placing them on a consistent basis with price, and then allowing the relative weights of the price/externality and non-price criteria to vary in accordance with an electric companies' actual circumstances and incremental needs, is more appropriate than fixing the weight of the externality component, or the price/externality component, at any particular level vis-a-vis other non-price factors for all electric companies. Accordingly, the final regulations allow the electric companies to propose, and for the Department to review, the weights of the various categories of project selection criteria. The weight of the combined price/externality category could vary between different electric companies as the values of the non-price criteria vary relative to the price/externality category. Although a decision by the Department on externality values for use by a company in a single case will have precedential value for that and other companies on a going-forward basis, electric companies and interested parties will have the opportunity to propose such values on a case-by-case basis.

6. The Department agrees with DOER that adding local, siting-specific environmental impacts into the evaluation process would be infeasible at this point. Accordingly, the Department will not consider site-specific environmental externalities in the IRM resource evaluation process.

7. The Department finds that a priority should be placed on estimating environmental externalities that are the direct result of power-plant operation including all downstream effects (e.g., solid-waste disposal, waste-water disposal). The Department finds that a priority should be placed on estimating environmental externalities that are the direct result of power-plant operation including all downstream effects (e.g., solid-waste disposal, waste-water disposal). The Department directs electric companies to consider in the

project evaluation process all impacts resulting from plant operation including air, water, solid waste and spent fuel disposal impacts, and resource use. As we gain more experience and confidence with estimating externality values directly associated with power plant operation, the Department will consider proposals to expand the scope of the kinds of externalities so as to include those associated with earlier stages of the fuel cycle.

8. Consistent with our decision to consider environmental externalities on a global perspective, the Department finds that local job creation should not be accounted for in the resource evaluation process. At the same time, the Department recognizes that some economic and social externalities, including a portion of economic development costs and benefits, which represent resource costs and benefits rather than transfer payments should ultimately be accounted in the resource evaluation process (e.g., resource depletion costs not incorporated in price). For now, there is insufficient information available to order their inclusion in the resource evaluation process. Rather, we will permit RFPs to include such externalities in the resource evaluation process if, on a case-by-case basis, the existence and level of such costs can be determined.

TABLE 1

SUMMARY OF ENVIRONMENTAL EXTERNALITY VALUES[20]
TO BE USED BY COMPANIES IN EVALUATING THE
EMISSIONS OF ENERGY RESOURCE OPTIONS

All Costs are in 1989 Constant Dollars

Northeast United States

		$/ton	$/lb
1.	Nitrogen Oxides (NO_x)		
	Ambient Air Quality	$6,500	$3.25[21]
	Greenhouse	$ 0	$0.00
	Total	$6,500	$3.25
2.	Sulfur Oxides (SO_x)	$1,500	$0.75
3.	Volatile Organic Compounds	$5,300	$2.65
4.	Total Suspended Particulates	$4,000	$2.00
5.	Carbon Monoxide (CO)		
	Ambient Air Quality	$ 820	$0.41
	Greenhouse	$ 50	$0.02
	Total	870	$0.43
6.	Carbon Dioxide (CO_2)	$ 22	$0.011
7.	Methane (CH_4)	$ 220	$0.11
8.	Nitrous Oxide (N_2O)	$3,960	$1.98

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20 DOER Estimates (DOER Comments (Update), 4/18) based on estimates prepared by Bernow and Marron, Valuation of Environmental Externalities for Energy Planning and Operations, May 1990 Update. Tellus Institute, May 18, 1990.

21 For NO_x externality estimates, the summary table on page 33 of the above-mentioned study contained a typographical error. The corrected value that appears in this Order was taken from pages 11 and 12 of the above-mentioned study.

JOINT COMMENTS OF

THE NATURAL RESOURCES DEFENSE COUNCIL AND

THE PACIFIC GAS & ELECTRIC COMPANY

ON THE U.S. DEPARTMENT OF ENERGY'S

NATIONAL ENERGY STRATEGY

July 16, 1990

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TABLE OF CONTENTS

		PAGE
Executive Summary		i
I.	Introduction	1
II.	The Purpose of a National Energy Strategy: Supporting Environmentally Preferable Least-Cost Energy Decisions	2
III.	Energy Efficiency is America's Largest, Least Costly. Untapped Resource Option	5
IV.	PG&E's Strategic Plan is Dominated by Energy Efficiency. and Environmentally Preferable Renewable Energy Resources	9
V.	Policy Reforms are Needed to Ensure that Energy Efficiency. and Energy Production Can Compete on Equal Terms	11
A.	Pervasive Market Barriers Block Cost-Effective. Efficiency Improvements Throughout the Economy	11
B.	Removing Regulatory Barriers Will Encourage Utility. Investment in Cost-Effective Energy Efficiency	13
C.	Upgraded Government Efficiency Standards are an. Essential Part of Any National Energy Strategy	16
D.	PG&E Programs Establish the Foundation for a National. Initiative to Promote Construction of Appliances that Substantially Exceed Current Federal Efficiency Standards	19
E.	The U.S. Department of Energy Should Substantially. Expand R&D Support for Energy Efficiency and Environmentally Preferable Renewable Energy Resources	21

TABLE OF CONTENTS (Cont'd)

		PAGE
F.	Auction Systems for Acquiring Electrical Energy. . . . . Resources Should be Integrated with Utilities' Least-Cost Resource Plans and Should Accommodate Environmental Costs and Benefits	24
G.	The IRS Should be Prevented from Imposing Taxes on. . . Energy Efficiency Improvements	25
H.	National Energy Strategy Can Promote Customer. . . . . Energy Efficiency and Non-Fossil Resources as a Hedge Against the Potential Environmental Impact of Greenhouse Gases	26

JOINT COMMENTS OF
THE NATURAL RESOURCES DEFENSE COUNCIL AND
THE PACIFIC GAS & ELECTRIC COMPANY
ON THE U.S. DEPARTMENT OF ENERGY'S
NATIONAL ENERGY STRATEGY

Executive Summary

Through these comments, a major environmental organization and the world's largest investor-owned energy utility present their recommendations on the treatment of energy-efficiency issues in the U.S. Department of Energy's National Energy Strategy. This joint statement of the Natural Resources Defense Council (NRDC) and the Pacific Gas & Electric Company (PG&E) is symbolic of a growing consensus on how to meet U.S. energy needs at the lowest possible economic and environmental cost.

We begin by recommending a framework for the DOE Strategy, based on least-cost energy planning methods that have evolved at the state level over the past ten years. The goal is to ensure that market forces and regulatory processes provide energy services at lowest cost, including recognition of environmental effects. Least-cost planning recognizes that energy savings created on a predictable schedule are energy resources, just like generators or oil fields or gas wells. If we see a need for additional energy supplies, we should be weighing our energy-efficiency options against our production technologies and picking the best buys first.

It is in energy savings that both NRDC and PG&E see America's largest, least-costly untapped resource option. The efficiency gains of the last two decades, while considerable, have not come close to exhausting the full potential for saving energy more cheaply than producing it. Studies undertaken for the DOE Strategy basically confirm this point, but, we believe, significantly underestimate the national energy-efficiency resource.

In addition, these studies did not attempt to answer what NRDC and PG&E both deem a crucial resource planning inquiry: What mix of efficiency and production investments would minimize the economic and environmental costs of the energy services needed to sustain a healthy economy? And, if we took advantage of all feasible options for saving energy more cheaply than producing it, how much would our need for new production facilities be reduced?

PG&E's own investigation of those issues dramatizes the importance of the efficiency resource: At least three-fourths of the company's planned increase in electricity capacity through the end of the century will be met by investing in efficiency improvements, covering all sectors of electricity use. Comparable assessments are needed at the national level.

Also required are major policy reforms to ensure that energy efficiency and energy production can compete on equal terms throughout the United States. Price strategies alone will not yield a least-cost national energy future, even assuming substantial changes in current policies regarding rate structures and the internalization of environmental costs. Regulatory and market barriers must be removed before more accurate price signals can function as intended.

For example, extensive evidence has emerged of a structural bias toward consumption, and against efficiency, throughout the energy marketplace. That bias leads prospective investors in efficiency routinely to decline or ignore opportunities with returns far better than those that energy companies can earn on production facilities. Utilities that try to level the field by investing directly in efficiency typically face unintended regulatory barriers; in most states, successful utility-financed efficiency programs are automatically unprofitable, because utilities' net revenues are tied directly to their sales volumes.

To address these and related issues, NRDC and PG&E join in the following specific recommendations for the National Energy Strategy:

- DOE support for regulatory reforms comparable to those in place or under development in California, which neutralize the adverse effects of efficiency gains on net revenues, and tie utilities' earnings in part to their success in promoting cost-effective efficiency improvements;

- Upgraded federal efficiency standards for appliances, manufactured housing, and federal buildings, with utility-financed programs helping to bridge the gap between existing standards and cost-effective technological advances that the standards may not yet incorporate;

- DOE support for nationwide expansion of a PG&E initiative to promote construction of appliances that substantially exceed current federal efficiency standards;

- Greater DOE support for research and development for energy efficiency and environmentally preferable renewable energy resources, including joint ventures with PG&E;

- Widespread use of "all-source" bidding systems for acquiring electrical energy resources, which are integrated with utilities' least-cost resource plans and accommodate both untapped energy-efficiency options and environmental values;

- Removal of the threat of a discriminatory federal tax on utilities' energy-efficiency investments; and

- Use of hedging strategies that anticipate the potential environmental effects of greenhouse gases, including enhanced energy-efficiency measures, further support for renewable energy development, and other efforts to reduce the environmental and economic uncertainties associated with continued dependence on fossil fuels.

JOINT COMMENTS OF THE NATURAL RESOURCES DEFENSE COUNCIL AND THE PACIFIC GAS & ELECTRIC COMPANY ON THE U.S. DEPARTMENT OF ENERGY'S NATIONAL ENERGY STRATEGY

I. Introduction

This statement presents the comments of the Natural Resources Defense Council (NRDC) and the Pacific Gas & Electric Company (PG&E) on the role of energy efficiency in the U.S. Department of Energy's (DOE's) National Energy Strategy. Our ability jointly to prepare and endorse these recommendations is symbolic of a growing national consensus on the most promising routes to a cost-minimizing energy future.

NRDC is a national, nonprofit environmental organization with more than 130,000 members and a fifteen-year-old Energy Program that has won several major national and regional awards. PG&E is the world's largest investor-owned energy utility, with annual revenues of approximately $9 billion; the company is also the world's largest private institutional investor in energy-efficiency improvements. As a result of a recently concluded collaborative process (hereafter "the California Collaborative"), NRDC and PG&E have forged a partnership on energy-efficiency issues that includes design of expanded systemwide programs, a rigorous test of a variety of state-of-the-art efficiency measures in

combined applications, and the construction of a major new efficiency demonstration facility.[1]

II. The Purpose of a National Energy Strategy: Supporting Environmentally Preferable Least-Cost Energy Decisions

The National Energy Strategy should provide a framework that ensures market forces and state and local regulatory processes deliver reliable energy services at lowest cost, including recognition of environmental effects. Currently, new technologies are providing expanded opportunities for improving energy efficiency. The strategy should target technological, market and regulatory barriers to rapid deployment of new ways to save energy more cheaply than producing it.

One of the clearest lessons of the last 15 years is that energy supply can be expanded either by finding more fuel supplies or by using more efficiently the supplies we already have. For purposes of meeting the needs of a growing economy and population, energy savings created in large quantity on a predictable schedule are energy resources, just like generators or oil fields or gas wells. If we see a need for increased supply or for replacing output from obsolete facilities, we should be weighing our conservation options against our production technologies and picking the best buys first.

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[1]The process is described, and its results are summarized, in Report of the Statewide Collaborative Process, An Energy Efficiency Blueprint for California, (January 1990), available from Pacific Gas & Electric Company, (415) 973-2092.

This crucial principle has yet to guide national energy policy. The federal government has tried pursuing essentially all energy options simultaneously (1973-1980) and endorsing sole reliance on the marketplace (1981-1988). Neither approach responds to current budgetary and environmental imperatives.

A promising alternative has emerged in California and numerous other states. In the course of long-standing regulatory relationships, many states and utilities have jointly acquired extensive experience in minimizing the cost of meeting future electric power needs. The resource-equivalence of conserved and produced power is now well understood, and techniques for comparing ways to do both have evolved under the rubric of "least-cost energy planning."

To its now numerous practitioners, this term implies in part that the public should not be asked to invest in new energy production until its representatives have explored and exploited less-costly energy savings. If electrical demand threatens to outstrip the current resource base, for example, least-cost planners investigate whether efficiency improvements in residences, commercial buildings and industries could meet these needs at a lower cost per kilowatt-hour delivered than additional power generation. Costs are evaluated over the anticipated life cycles of the competing conservation and power plant options, from design through construction and operation to retirement.

It is not enough simply to identify hypothetical savings, of course; means must be found to convert opportunities into tangible efficiency

improvements. The last decade has produced a wealth of concrete experience with the use of efficiency standards and incentive payments to acquire cost-effective conservation. Rather than paying one group of people to produce electricity or natural gas, utilities increasingly are paying a much larger group of people to save it.

For purposes of such efforts, minimizing society's costs means more than just comparing the projected dollar outlays for various resources, including conservation. Also important are considerations of flexibility: How long does a resource take to complete? How susceptible is it to mid-course corrections if conditions change? Can it be built up gradually in small amounts, or does it create an enormous "all or nothing" proposition? In an era of rapidly changing economic conditions, these considerations carry growing weight. And at least some least-cost planners have recognized that environmental costs and benefits also belong in the balance.

At the national level, these analytical techniques provide the most promising ways to develop energy policies capable of winning broad support. A least-cost planning inquiry would allow winners and losers to emerge on their merits. As we demonstrate in greater detail below, this emphatically is not a call to produce an intrusive regulatory program out of step with current political realities. The goal of a national energy policy is to help obstructed markets work better, not replace them, and to ensure a rational allocation of the public resources that are already committed to energy development.

III. Energy Efficiency is America's Largest, Least-Costly Untapped Resource Option

By finding ways to extract more work and wealth out of less energy, Americans expanded their economy by more than 35 percent from 1973 to 1986 without increasing their energy consumption.[2] If energy needs had simply kept pace with economic growth, more than 40 percent of our consumption would have had to be met with imports by the close of that period (compared with 26 percent at the height of the 1973-1979 "energy crisis").[3] Instead, total energy imports for 1986 were lower in relative terms than those for 1973.[4] California's efficiency record was even stronger than that of the nation as a whole.[5]

By the federal government's reckoning, an uninflated dollar of U.S. economic growth required 27 percent less energy in 1986 than in 1973.[6] A 1988 Scientific American analysis pegged the resulting reductions in the

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[2]See, e.g., Testimony of Donna R. Fitzpatrick, Assistant Secretary for Conservation and Renewable Energy, before the Committee on Energy and Commerce, Subcommittee on Energy and Power of the U.S. House of Representatives, at 1 (December 2, 1987).

[3]The calculations assume that consumption would have reached 101 quadrillion BTUs ("quads"), exceeding domestic production actually recorded for 1986 by 37 quads. See U.S. Energy Information Administration, Monthly Energy Review, at 3 & 12 (May 1989).

[4]U.S. Energy Information Administration, Monthly Energy Review, at 3 (May 1989) (import shares for 1973 and 1986 were 20 percent and 19 percent of total energy consumption, respectively).

[5]California Energy Commission, Conservation Report, at 24 (1988). (For example, from 1973-1985, the amount of energy required to produce a dollar of California goods and services dropped by 35 percent.)

[6]Id. 12

national energy bill at $150 billion per year, which represented nearly $2,000 for every household.[7] In large measure, the general abundance of energy supply and weakness of energy prices reflect that achievement.

Nonetheless, NRDC and PG&E agree that certainly California and most likely the nation's largest cost-effective efficiency gains still lie in the future. Since 1986, total U.S. energy consumption has begun growing again in seeming lockstep with gross national product -- nine percent in just three years -- as energy-efficiency efforts have flagged throughout much of the nation.

The efficiency assessment prepared for the National Energy Strategy by several of the National Laboratories -- "Energy Efficiency: How Far Can We Go?" ("Assessment") -- is a good first step in identifying unexploited efficiency opportunities, particularly given the time and resource limits that constrained the work. However, it is simply not possible to determine "how far we can go" in a two- or three-month study. The Assessment limits itself to energy-efficiency trends in selected sectors; it shows that large savings are available at modest cost, but does not inquire whether much larger savings are worth pursuing as well. What all would identify as extremely promising opportunities are addressed superficially or not at all;[8] these include commercial lighting (arguably the largest and cheapest

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[7]Rosenfeld & Hafemeister, Energy-Efficient Buildings, 258 Scientific American, at 78 (April 1988).

[8]See, e.g., Oak Ridge Laboratory, Energy Efficiency: How Far Can We Go? (January 1990) at 16: "Improvements to lighting may also yield substantial savings, but these were not estimated for either the residential or commercial sectors because of modeling limitations."

efficiency resource), residential lighting, improved voltage regulation, transportation mode shifts (particularly urban transit, high-speed passenger rail, and convertible truck trailers/rail cars), use of waste heat to generate electricity, and energy-supply efficiency increases. As for appliances, limitations on analytical resources prevented the Laboratories from going beyond the record compiled in earlier DOE administrative proceedings; the result is unsatisfactory even as a measure of current efficiency opportunities, let alone those that may be expected over the next 20 years.[9]

Most important, the Laboratories do not attempt to answer what NRDC and PG&E both deem a crucial resource planning inquiry: What mix of efficiency and production investments would minimize the economic and environmental costs of the energy services needed to sustain a healthy economy? And, if we took advantage of all feasible options for saving energy more cheaply than producing it, how much would our need for new production facilities be reduced? This is precisely the type of assessment that PG&E is undertaking for its own service territory; the nation continues to await and need a more global inquiry.

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[9]According to "How Far Can We Go?", efficiencies for refrigerators and electric water heaters top out at 590 kWh per year and 97 percent, respectively. We believe that those figures should at minimum be halved and doubled, respectively; (heat pump technology would readily allow 200 percent efficiencies for water heating). The electric clothes dryer projections exclude microwave and heat pump clothes dryers; the treatment of electric ranges and ovens leaves no place for bi-radiant and related technologies. No savings are projected for televisions, computers or gas clothes dryers (where substantial heat-recovery savings clearly are available).

Also unavailable in the Laboratories' report to DOE is any discussion of efficiency-oriented fuel switching options; just substituting high-efficiency gas water heaters for the 60 million electric units now projected for 2010 could save more than 1.8 quads of energy.[10] DOE is likely to overlook such opportunities, however, if it relies on the anomalous price forecasts of the U.S. Energy Information Administration. These forecasts anticipate 20 years of flat electricity prices coupled with natural-gas prices that increase by 85-175 percent net of inflation.[11]

Finally, we are also concerned about the Laboratories' use of a relatively high discount rate -- 7 percent net of inflation -- in evaluating efficiency improvements, which effectively discriminates against the demand side of the nation's resource option inventory. From an accounting perspective, costs of energy-efficiency programs are typically charged in full to the year in which they are incurred. By contrast, the costs of generating resources usually are spread over the life of the project. In both cases, the benefits are discounted over the productive life of the resource (whether efficiency or generation). Hence, in evaluating energy-efficiency projects, a discounted stream of benefits is compared to a first-year expensed cost, while in evaluating generation resources, both costs and benefits are discounted. Higher discount rates, therefore, make

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[10]The calculation uses DOE's equipment efficiency assumptions, which yield 2.75 quads of resource energy for the electric water heaters and 0.9 quads for the high-efficiency gas replacements.

[11]See Energy-Efficiency: How Far Can We Go?, at 53, Table B-1, citing U.S. Energy Information Administration, Annual Energy Outlook 1989. (For example, from 1988 to 2010, projected real increases in industrial energy rates for electricity and natural gas are 3 percent and 178 percent, respectively; the comparable figures for the residential sector are 2 percent and 85 percent.)

energy-efficiency projects relatively less attractive by reducing benefits relative to costs, but may not impact supply-side evaluations, since both benefits and costs are discounted at the higher rate. Under this methodology, for example, improvements in air conditioner efficiency would be rejected if their initial costs exceeded $513 per kw, even though a utility would have to pay substantially more for equivalent new generating capacity.[12]

IV. PG&E's Strategic Plan is Dominated by Energy Efficiency and Environmentally Preferable Renewable Energy Resources

PG&E's current strategic resource plan is a successful example of one utility's efforts to achieve a least-cost plan integrating supply and demand resources. The company's strategic plan for the 1990s relies on customer energy efficiency to provide 2,500 of the expected 3,300 MW need for additional resources. At least two elements of this strategic plan and its development could serve as a model within the National Energy Strategy. First, in PG&E's least-cost integrated planning approach, substantial amounts of energy efficiency turned out both to be the most cost-effective resources for the company, and to provide substantial environmental and economic benefits for its customers. Second, the details of the expansion of energy-efficiency programs were developed in an open, Collaborative Process of negotiation with a diverse group of environmental and consumer groups, whose involvement has both assured the programs' acceptance and sped their implementation.

[12]The calculation assumes an equipment lifetime of 15 years and savings of 750 kWh/year at 7.5 cents per kilowatt-hour.

PG&E's efforts are also focused on maintaining a corporate commitment to environmental quality. This commitment features improving the efficiency of electricity generation, transmission and end-use, enhancing the environmental compatibility of operations, and accelerating renewable energy technology development to provide us with both economical and environmentally preferred options to choose from at the time generating additions will be needed to continue to meet the needs of our growing economy.

The strategic plan builds on PG&E's experience as a world leader in promoting customer energy efficiency and the use of renewable energy. PG&E's extensive experience in energy efficiency is providing the foundation for the steady increases in program expenditure which are part of the strategic plan for the 1990s. The company has invested over $1 billion in energy efficiency and load management since the mid-1970s, and estimates that its programs have produced results equivalent to 1,800 MW (a typical new coal-fired power plant is rated at 250-500 MW). Through the Collaborative procedures described earlier, PG&E has joined forces with environmental groups, energy-efficiency experts, and regulators to deepen the company's commitment to energy efficiency through the expansion of existing programs and the development of new ones. Spending on efficiency programs is to increase to $150 million per year by 1991, an increase of more than 50 percent from 1989. The company expects a steady expansion of programs and expenditures for the rest of this century.

The potential availability of each supply alternative and of efficiency improvements will vary from one utility to another. However, the PG&E strategic plan would suggest a model for the National Energy Strategy in its careful analysis of alternatives on an equivalent basis, its reliance on energy efficiency, and the involvement of interested outside parties in its development.

V. Policy Reforms are Needed to Ensure that Energy Efficiency and Energy Production Can Compete on Equal Terms

The eight subsections below all support one overriding conclusion: Price strategies alone will not yield a least-cost national energy future, even assuming substantial changes in current policies regarding rate structures and the internalization of environmental costs. Regulatory and market barriers must be removed before more accurate price signals can work to ensure a fair competition between efficiency and production options.

V-A. Pervasive Market Barriers Block Cost-Effective Efficiency Improvements Throughout the Economy

Extensive evidence has emerged of a structural bias toward consumption, and against efficiency, throughout the energy marketplace.[13] That bias leads prospective investors in efficiency routinely to decline or ignore opportunities with returns far better than those that energy

[13] See e.g., sources cited in National Association of Regulatory Utility Commissioners, Volume 2, Least-Cost Utility Planning Handbook, at II-1 to II-15, (December 1988); Cavanagh, Responsible Power Marketing in an Increasingly Competitive Era, 5 Yale Journal on Regulation 331, 342-43 (1988); Massachusetts Department of Public Utilities, D.P.U., 86-36-F (Nov. 30, 1988).

companies can earn on production facilities. Consumers and businesses typically expect long-lived efficiency improvements to repay their full costs in three years or less, a return of more than 35 percent per year (sometimes more than 100 percent) on the money invested.

Such expectations contrast sharply with those of investors in energy production. Many large-scale energy projects do not even begin earning income for a decade or more after cash begins to flow into the planning and construction process. Investors here typically can expect returns of 15 percent or less. The discrepancy puts energy efficiency at an enormous and unjustified disadvantage.

There are many rational explanations for the conservers' apparent stinginess. For example, efficiency decisions often are made by people who will not be paying the ensuing energy bills, such as landlords or developers of commercial buildings. Other selections may be made under extreme pressure, with little opportunity for life-cycle cost assessments, as everyone knows who has ever replaced a broken water heater or refrigerator or leased an office. Unassisted "conservation shopping" often involves significant time commitments, inconvenience and uncertainty, which understandably are resisted by those whose primary business lies elsewhere.

As a result, according to analyses commissioned by the National Association of Regulatory Utility Commissioners, energy prices would have to increase more than seven-fold to overcome the gap that typically emerges in practice between the perspectives of investors in energy

efficiency and production, respectively.[14] The sections that follow outline a more palatable and promising route to a least-cost energy future.

V-B. Removing Regulatory Barriers Will Encourage Utility Investment in Cost-Effective Energy Efficiency

The National Energy Strategy should include initiatives both to overcome existing regulatory barriers which inhibit utility pursuit of energy efficiency and to provide incentives which make energy-efficiency investments at least as attractive to utilities as traditional supply investments.

Several aspects of the regulatory system in most states impede active utility involvement in customer energy efficiency. The most important is that, for most utilities, reducing demand through efficiency runs counter to the short-term interests of shareholders by lowering net revenues. These net revenues decline because they are tied to total sales, as an unintended but inevitable consequence of traditional ratemaking practice.

The first step, therefore, in improving the regulatory system is to decouple net revenues and profits from total sales. This was the step taken in California beginning in the late 1970s, and it has been essential to PG&E's renewed commitment to efficiency programs. Under this system, the company's net revenues are insulated from fluctuations in sales,

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[14] See National Association of Regulatory Utility Commissioners, note 13 above, at II-10 to II-12.

whether due to efficiency improvements, weather or unexpected demand growth. This is accomplished through accounting mechanisms called the Electric Revenue Adjustment Mechanism (ERAM) for electricity, and the Supply Adjustment Mechanism (SAM) for gas. By adjustments made through ERAM and SAM, the utility is made largely indifferent to either increases or decreases in total sales of electricity or gas.

But utilities must be moved from neutrality to aggressive support of customer energy efficiency. The ERAM/SAM system alone is not enough. Some incentive mechanism is needed to provide the strong signal that will lead utility planning in the right direction. Unfortunately, the traditional regulatory system has rewarded utilities only for supply investments by allowing a rate of return on capital invested in generation and transmission facilities. Utilities can, of course, be required to carry out customer efficiency programs, and expenses from these programs can be fully recovered through rates. But, as in any private enterprise, the attention, enthusiasm and expertise of the company's management will be focused on those activities that provide clear benefits to shareholders. We cannot expect the creativity and marketing skills of the utilities to be focused consistently through time on areas where there is no return for their owners.

The answer is to develop an incentive for demand-reducing programs which can begin to match the incentives already available for traditional generation. If such incentives are structured properly, the utility will invest in customer efficiency improvements which reduce long-run utility costs and ratepayer bills.

No single incentive system is clearly the best for all utilities. Each state and each utility needs to develop incentives which fit their particular circumstances. But recent California experience suggests that to be successful in the long term, an incentive system for the utility needs regulatory stability and legislative support. Frequent revisions in such systems would undermine the management commitment needed to make utility efficiency programs successful.

The particular incentive mechanism which PG&E has proposed to the California Public Utilities Commission (CPUC) will provide substantial benefits to customers, shareholders and the environment. The proposal has two components: First, for programs providing concrete resource value, PG&E proposes that the expected savings be shared between customers and the utility. Using assumptions fixed in advance, the net value[15] of the energy-efficiency measures actually installed through utility programs will be calculated. Of the resulting net dollar savings, 85 percent would be passed on to the ratepayers in the form of reduced rates, and 15 percent of the savings would flow to shareholders. This mechanism would not only begin to redress the balance between supply and demand programs within the company, it would also provide an incentive to the utility for vigorous marketing and careful cost control.

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[15]The net value is the difference between the costs of new power plants ("avoided costs") and the cost to the utility of the efficiency programs. Both costs are calculated as net present values per kWh and per kw over the appropriate life-cycle. Efficiency program costs include utility administrative and rebate costs.

Second, there are certain programs which are either undertaken for more reasons than efficiency alone, or which have energy benefits which are particularly hard to quantify. For example, PG&E continues to carry out substantial programs for weatherizing the homes of its low-income customers, and to provide on-site information and advice to all customers on the benefits of energy efficiency. To assure that these programs retain their priority, the company has proposed that these programs be subject to a second incentive mechanism. As long as those programs meet performance standards agreed upon with the CPUC, the company would recover 105 percent of the program cost, with the extra five percent flowing to shareholders.

V-C. Upgraded Government Efficiency Standards are an Essential Component of Any National Energy Strategy

Rational energy pricing and vigorous utility programs can help encourage production of efficient new homes, buildings and appliances. But efficiency opportunities not captured at the time of installation can be recovered only at substantially higher cost. Strong and timely government standards are by far the most effective way -- and the most cost-effective way -- to capture what otherwise would be very substantial "lost opportunities." We encourage the Department of Energy (DOE) to include in the National Energy Strategy a commitment to strengthening such standards (at the national or state level, as appropriate) for residential appliances and for all new construction.

Two of the key areas in which market barriers obstruct efficiency are new construction and residential appliances. In situations where the builder of a new structure will not be the occupant (and often even when builder and occupant are the same), the primary motivation of the builder is minimum first cost. Even where the eventual occupant (whether commercial or residential) is concerned about future energy consumption, information about energy efficiency is difficult to obtain, and a structure's other characteristics will often be more important in the purchase decision.

Similarly, the purchasers of residential appliances tend to place higher priority on other product characteristics, such as color and brand identification. In all these cases, the owner's financial criteria typically emphasize short-term benefits more than would either the utility or society as a whole. Efficiency improvements not captured at the time of sale are either much more expensive or not feasible later in the life of the building or appliance.

NRDC and PG&E support and encourage the DOE's efforts to establish and improve economically-justified minimum efficiency standards for residential appliances. We equally support the California Energy Commission's (CEC's) standards for new construction, and would encourage other states to adopt equally effective measures.

Utility efficiency programs can also reinforce and accelerate government efficiency standards. The efficiency which can be achieved by standards is limited since they must cover very diverse situations and are achieved through a complex process of political negotiation. It would also

be unwise for efficiency standards to require the use of products or materials which have not been well tested in the marketplace. Utility efficiency programs can both achieve substantial additional savings, and support the long-run standard-setting process by speeding the development and acceptance of new products. As agreed in the California Collaborative, "... utility programs should help bridge the gap between existing standards and cost-effective technological advances that the standards may not yet incorporate."[16]

Low-emissivity glass, for example, is a product with significant potential in both residential and non-residential buildings. Costs are still high, however, at least in California, and many customers are reluctant to try new, unfamiliar window systems. We expect utility rebates for such products to lower costs by increasing production, and to speed their widespread market acceptance. Once such products are well-known and produced by mature industries, incorporating them into building standards will be more acceptable and cost-effective.

In addition to rebate programs for homes that exceed state standards, PG&E is initiating the formation of CHERS, Inc. (California Home Energy Rating System, Inc.). This non-profit organization includes major California utilities, regulators, and building, lending, and real estate interests working in partnership to develop a statewide uniform home energy rating system. Providing information on whole house efficiency with a uniform energy-

[16] An Energy Efficiency Blueprint for California, note [1] above, at 72.

efficiency rating will help builders of highly efficient homes with their marketing and allow lenders to justify higher loans or stretched income/debt loan qualification ratios for homes where fuel bills will be reduced. Utilities benefit through reduced load growth, the state's standard-setting process will be accelerated as new technologies are given a market, information to consumers is increased, and homes become more affordable. CHERS, Inc. should be considered as a model for voluntary, market-reinforcing cooperation to promote home energy efficiency.

One additional role for federal and state agencies is to advance new technologies through improvements to their own facilities. As with utility programs, federal and state purchases can enhance market acceptance of advanced efficiency technologies, and provide a market to sustain early, high-cost production cycles.

V-D PG&E Programs Establish the Foundation for a National Initiative to Promote Construction of Appliances that Substantially Exceed Current Federal Efficiency Standards

Through national efficiency standards supported by NRDC and PG&E, the federal government has acted to remove the least efficient residential appliances from the marketplace. But technical options abound for substantially improving upon even the most demanding of the federal standards. This creates a continuing dilemma: Until standards become more stringent, manufacturers have little reason to invest in research and new production facilities to support dramatically higher efficiencies; yet

until new designs have been demonstrated in the marketplace, the federal government is reluctant to tighten standards.

With NRDC's strong support, PG&E has assumed a national leadership role in creating market-based solutions to the appliance dilemma. The vehicle is a PG&E commitment to provide substantial rebates for the first group of super-efficient refrigerators to appear in the marketplace over the next several years. PG&E's target is a 25 percent improvement on the federal government's refrigerator efficiency standard for 1993; initially, qualifying units would earn a PG&E payment of $300. Such "market-pull" rebates should receive a broad base of utility support throughout the nation; they represent highly cost-effective resource acquisitions and should be an important element of the National Energy Strategy.

Environmental as well as economic values are at stake in a nationwide campaign to promote more efficient household appliances, which account for more than one-fifth of U.S. energy consumption. For example, the New York Times of July 1, 1990,[17] provides a forum for the latest in a series of claims that protecting the ozone layer will result in higher electricity needs for refrigeration. Programs like PG&E's can help induce appliance manufacturers to look beyond the cheapest but least energy-efficient substitutes for ozone-depleting chlorofluorocarbons.

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[17]M. Browne, Saving Ozone May Prove to be Costly, New York Times, July 1, 1990, at 9, col. 1. The Times also reported that "refrigerators" will now have to be bulkier and less roomy inside to accommodate the much thicker substitute insulation that will be necessary," overlooking the availability of vacuum-based technologies that should allow for thinner and better insulated refrigerator doors.

V-E. The U.S. Department of Energy Should Substantially Expand R&D Support for Energy Efficiency and Environmentally Preferable Renewable Energy Resources

Research and development (R&D) activities during the 1990s will be critical in determining what the energy supply picture across the country will be in the next century. By the end of the decade, utilities will likely be looking at augmenting a portion of existing fossil capacity with new generation. The objective of R&D efforts over the coming decade should be to develop new energy-efficiency technologies, as well as supply alternatives that will be cost-effective, environmentally cleaner, and, where possible, renewable.

Energy Efficiency

DOE's collaboration would be welcome on a series of initiatives recently begun by PG&E for demonstration of advanced energy-efficiency technologies. These initiatives are collectively designed to demonstrate the practical applications of new technologies, and to assure both their acceptance in PG&E's program, and their solid contribution to the company's resource plan. One of the tests is the Advanced Customer Technology Test (ACT^2 or ACT-squared) for Energy Efficiency, which will involve installation and evaluation of state-of-the-art packages of commercial and residential sector technologies that offer large savings potentials. ACT^2 is a joint project of PG&E, NRDC, the Lawrence Berkeley

Laboratory and Rocky Mountain Institute. The list of attractive candidate technologies will quickly exhaust the $10 million now available over the next two years. We believe that DOE shares this project's objectives, and we would welcome the agency's involvement in the continuation of this project.

Several other demonstrations will reinforce our program of customer incentives and assure accelerated acceptance of new energy-efficient technologies. PG&E is constructing a Customer Energy Technology Center to show architects, builders, engineers, and end users the advantages of advanced energy-efficiency technologies. The company is also building 28 highly-efficient showcase homes with advanced efficiency and control technologies. These well-focused, localized demonstrations provide a useful model for efforts that DOE might promote in other parts of the country.

Renewable Energy

Opportunities exist during the 1990s to accelerate the commercial readiness of renewable technologies so that they will be poised for widespread utility application at the beginning of the next century. Capitalizing on these opportunities depends heavily on the extent and nature of government/utility industry collaboration. PG&E, and others in the utility industry, are committed to support this process, particularly with respect to the next generation of solar and wind technologies.

Nationwide application of California's experience with wind is possible, including site identification, technical improvements, and plant design and integration. Multiple sizes and configurations and further advancements, such as the third generation, variable-speed wind turbine currently being developed, are needed over the next ten years. Such progress would improve operational flexibility and energy capture, reduce levelized energy costs to less than 5.5 cents/kwh in good wind areas, and exploit the variety of wind regimes in the United States.

To help facilitate the development and commercialization of renewable energy technologies, DOE must play a substantial role, as it has in past and current DOE and industry programs. One such program that PG&E has been pleased to be involved with is the highly successful photovoltaics systems test initiative, Photovoltaics for Utility-Scale Application (PVUSA). This program may be a model of what DOE, in collaboration with utilities, can achieve.

A great deal can be accomplished within the limits of a technology readiness initiative embracing several technologies. Key ingredients of the initiative would be to follow up aggressively in areas of past cooperation between DOE and utilities and to strive for significant capital cost reductions in demonstrating the technologies for utility scale demonstration. PG&E has expressed its willingness to collaborate with DOE in such an initiative.

Wind, solar thermal and photovoltaics are some of the emerging renewable technologies in which PG&E is actively interested. The output of

such renewable technologies generally tracks with California's daily load, providing substantial peaking benefits. To enhance their development as the backbone of the utility system, we envision uniting wind and solar generation with storage plants, such as compressed air energy storage (CAES). Fuel cells, though non-renewable, are a high-efficiency, low-polluting generation option which would satisfy dispatchability needs and supplement systems based on energy efficiency, renewables and storage. Each of these technologies is poised to have an early, significant impact if aggressive steps are taken to address market entry barriers.

There are other emerging supply, conversion and storage technologies where active R&D cooperation between utilities and DOE should be developed or continued. Examples, which would advance the important objectives of environmental compatibility, efficiency, safety, and utilization of indigenous resources, include advanced solid fuel technologies such as biomass combustion, municipal waste utilization, and battery energy storage.

V-F. Auction Systems for Acquiring Electrical Energy Resources Should be Integrated With Utilities' Least-Cost Resource Plans and Should Accommodate Environmental Costs and Benefits

NRDC and PG&E have extensively analyzed alternative proposals for using competitive mechanisms like auctions in utility acquisitions of new electricity supplies. According to a recent survey, as of the end of 1989,

"27 states have adopted or are developing competitive procurement systems that, together with the access already granted by (federal law), are restructuring the nation's electric power markets."[18]

We agree that utilities should use all-source bidding to meet any residual system needs for electricity that remain after accounting for the contributions of government efficiency standards, utility-financed efficiency programs, and utility niche resources that lack any plausible independent supplier. Any untapped conservation should have the opportunity to compete with new generation in these auctions, and credits should be assigned to resource characteristics of demonstrable value to the utility system. In addition to characteristics such as resource operating flexibility, project location and fuel diversity, these credits should, though difficult to quantify, reflect environmental impact.

V-G. The IRS Should be Prevented From Imposing Taxes on Energy-Efficiency Improvements

We strongly recommend that the National Energy Strategy include a legislative initiative to assure that customers are not penalized through the tax system for efficiency investments encouraged by utility programs. Taxing utility incentive payments to customers will add a substantial additional hurdle to expanding acceptance of energy-efficient equipment.

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[18]National Independent Energy Producers, Bidding for Power: The Emergence of Competitive Bidding in Electric Generation, (March 1990), at 1.

The Internal Revenue Service (IRS) currently treats rebates paid by utilities for energy-efficiency equipment as income to the customers, rather than considering them to be price reductions (as is done with, for example, car rebates). This interpretation not only adds yet another hurdle to national efforts to promote energy efficiency, it penalizes consumer actions that benefit society as a whole, and effectively raises the cost of conserved energy to utilities. We endorse the legislation (HR 4249 and SB 2312) currently before the Congress which would overturn this IRS interpretation.

V-H. National Energy Strategy Can Promote Customer Energy Efficiency and Non-Fossil Resources as a Hedge Against the Potential Environmental Impact of Greenhouse Gases

The National Energy Strategy should recognize that the cost of continued emissions of greenhouse gases, including carbon dioxide, cannot be zero in all future scenarios. Although there is still a great deal of scientific uncertainty about the impact of greenhouse gases on global climate, it is no longer prudent to plan for future energy resources without considering the policy and economic consequences of this potential relationship. There is sufficient concern among segments of the scientific community to warrant serious consideration of the energy policy consequences of a global warming future in which greenhouse gases must be regulated. The costs of committing to a fossil fuel strategy would escalate significantly under this scenario.

It is, therefore, important to factor into national energy policy the environmental and economic uncertainty associated with continued dependence on fossil fuels. It is too early to be sure of the economic value of the avoidance of greenhouse gas emissions, but it is certainly not too early to develop and pursue a hedging strategy against this uncertainty. Non-fossil resources such as customer energy-efficiency programs and renewable and alternative electric supply technologies are all key to reducing risk in our national energy portfolio. These technologies add value as they diversify the resource base and reduce our exposure to potential cost increases associated with increased fuel demand, emission fees, emission controls, or mitigation of impacts. One or all of these might be expected under a global warming scenario.

This hedging strategy against future economic and environmental disruption can be viewed as a bridging strategy to get us into the next century when better information on global warming and further development of clean technologies will offer us insight and options not currently available. Relying on efficiency gains in both the end-use and supply sectors, as well as encouraging the further development of renewable technologies, will minimize additional investment in fossil resources between now and the year 2000, and build the resource options we will need in the future. During this period, a renewed emphasis on R&D, particularly in bringing down the cost and demonstrating the commercial viability of the most promising non-fossil options, will position us to meet both the environmental and energy needs of the next century with a minimum of corrective costs. Besides making sound economic choices by valuing the diversification of our energy portfolio, this strategy

could place the U.S. in a competitive position to meet the market demand for clean technology, should a global warming scenario unfold.

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