Assumptions in Environmental Cost Studies

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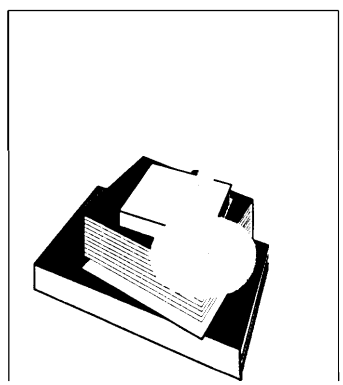
The assumptions underlying any environmental cost study strongly influence both the overall structure of the study and its quantitative results. Varying assumptions can include or exclude entire classes of environmental effects from consideration. For example, the assumption that studies should evaluate only relatively certain effects could exclude the potential effects of $C0_2$ emissions on global climate. For effects that are included in a given study, different assumptions can lead to dramatically different numerical estimates of the value of those effects. For example, monetized estimates of damage to wilderness areas can vary greatly depending on the valuation technique. If a study uses only the commercial value of the area's timber, then the damage estimate may be quite low; if the study includes non-use values, recreation impacts, and endangered species impacts, then the estimate may be much larger.

Assumptions are an integral part of any environmental cost study.[1] This does not mean the studies are intentionally biased. Rather, every environmental cost study is conducted within a general framework of assumptions and values. When these frameworks are the focus of social and political debate, environmental cost studies can become the focus of substantial controversy—as they have in some cases.

Underlying assumptions are a particular problem in environmental cost studies. Estimating environmental costs requires



[1] Some studies are more explicit than others about identifying their value frameworks. For example, the Department of Energy/Commission of the European Communities (DOE/EC) study explicitly discusses the basis of the economic framework that it uses. Although it does not discuss this framework within the context of competing frameworks, it makes its own framework reasonably clear.

using results from many other types of environmental studies, including studies of emissions generation, transport, deposition; environmental impact; risk assessment; and economic valuation. Because of this broad scope, environmental cost studies face a vast array of vexing problems that have emerged in the past two decades of research in biology, engineering, economics, and social science (see table 4-l).

Because environmental cost studies employ the results of these smaller studies, they necessarily take on their assumptions and uncertainties, and then add assumptions and uncertainties of their own. As a result, studies of environmental costs are likely to require a larger number of assumptions, to yield results with greater uncertainties, and to engender more controversy than studies of more limited scope.

There is no clear agreement about the most relevant set of assumptions, and this lack of agreement is reflected in how actual studies are conducted. Different environmental cost studies use different assumptions about how to define environmental costs, how to value environmental effects, and how to handle uncertainty. The lack of agreement is discussed in numerous critiques of published studies. Economists, ecologists, regulators, and others frequently argue over the propriety of assumptions made in specific studies.

Several existing reviews of environmental cost studies examine these assumptions at some level of technical detail.[2] These critiques are useful to analysts who are interested in improving the methodology of future studies and to policy makers who wish to evaluate the findings of an individual study. However, from the standpoint of using these studies in federal policymaking it is important to realize that *all* environmental cost studies make assumptions that affect their results, and these assumptions often involve fundamental questions that lie within the purview of policymakers rather than analysts. These questions include:

- *What is the goal of environmental policy?* Environmental cost studies are most frequently associated with the goal of economic efficiency. Other implicit and explicit goals assumed in environmental cost debates include equity, sustainability, and protection of health and safety. *What is the role of environmental cost studies in energy policy? These* studies can be used to quantify economic corrections to energy markets, facilitate compensation for environmental damages, or guide government regulation to protect health or encourage sustainability.
- *How is value determined?* Valuation can be based on consumers acting in markets, legislators and regulators acting in political systems, scientists studying ecological systems, or government oflicials acting in legal settings.

A few reviews of environmental cost studies discuss the studies' underlying assumptions and values.[3] Many of the concepts in those reviews are discussed in this chapter. In addition, several other reviews of related areas have concluded that differences in assumptions underlie many of the disputes over quantitative studies of environmental issues (see box 4-1). Reviews of the health effects of air pollution, the economics of salmon preservation efforts, and the risks of the herbicide alachlor all identify the importance of studies' underlying values and assumptions.

Despite the findings of these reviews, explicit discussion of the fundamental questions that underlie the assumptions of environmental cost studies, and even a recognition that these ques-

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[2]For example, see, Richard L. Ottinger et al., Pace University Center for Environmental Legal Studies, *Environmental Costs of Electricity* (New York, NY: Oceana Publications, 1990); Staff of the Federal Energy Regulatory Commission, *Report on Section 808: Renewable Energy and Energy Conservation Incentives of the Clean Air Act Amendments of 1990* (Washington, DC: December 1992).

[3]For example, Andrew Stirling, "Regulating the Electricity Supply Industry by Valuing Environmental Effects: How Much is the Emperor *Wearing, ''Futures,* December 1992, 1024- 1047; John P. Holdren, *Integrated Assessment for Energy-Related Environmental Standards: A* Summary *of Issues and* Findings, LBL-12779 (Berkeley, CA: Lawrence Berkeley Laboratory, October 1980).

TABLE 4-1: Fields and Selected Research Areas Used in Environmental Cost Studies

Fields	Selected rasearch araas
Economics	Determinants of value; methods of discounting.
Psychology	Perceived risk; accuracy of survey responses.
Biology and toxicology	Extrapolation of human health effects from animal studies.
Epidemiology	Health effects of pollutants.
Ecology	Systemic effects of pollutants; determinants and importance of biodiversity.
Sociology and anthropology	Cultural variations in value ascribed to environmental resources.
Atmospheric science	Transport and deposition of pollutants; long-term effects of carbon dioxide emissions.

SOURCE Off Ice of Technology Assessment, 1994

tions are important, is often absent from environmental cost analysis. Instead, the studies deal with the details of implementing the assumptions (e.g., the sources of data, the calculation techniques, and the intermediate results). Even if a study's authors discuss its assumptions at length, a technical analysis is unlikely to resolve the issues involved. In general, environmental cost studies *reflect,* rather than *address,* the political and social debates over these questions.

This chapter illustrates how many of the most controversial methods and assumptions of environmental cost studies are related to more fundamental questions. It discusses several major issues in environmental cost analysis and presents an overall framework to help organize and explain different sets of assumptions.

ISSUES AND UNDERLYING ASSUMPTIONS

Decisions about valuation and other methodologies do not take place in a vacuum. Such decisions are made in the context of assumptions about the goals of policy, the intent of the study, and what valuation is intended to achieve. Such assumptions become clearer in the context of debates over particular methodological issues. This section discusses selected issues, outlines the positions taken by different analysts, and identifies assumptions that lie at the core of each debate. Although other important issues may exist, the issues discussed here illustrate the importance of assumptions to the conduct and findings of environmental cost studies.

Quantification and Monetization

Environmental cost studies inevitably consider a collection of disparate effects. For example, evaluating the environmental costs associated with coal may involve combining occupational deaths and injuries from coal mining, chronic health effects of power plant emissions, ecological damage from global warming, property damage from acid rain, and resource depletion resulting from burning fossil fuels. Without a common set of units, these effects cannot easily be compared with each other or with the costs of controlling them-decisionmakers are left comparing "apples and oranges."[4]

The approach generally taken in environmental cost studies is to express all environmental effects in numeric form (quantification) and then to con-

[4]There is a growing body of work about decisions involving multiple objectives that cannot be easily compared (e.g., see Ralph L. Keeney, *Decisions With Multiple Objectives: Preferences and Value Tradeoffs* (Cambridge, England: Cambridge University Press, 1993). Several utilities are considering techniques that involve weighting and ranking impacts without explicit monetization (Robert L. San Martin, U.S. Department of Energy, personal communication, July 7, 1994). However, existing environmental cost studies do not employ these techniques.

BOX 4–1: Other Studies on the Importance of Values and Assumptions

Several independent studies have concluded that values and assumptions are fundamental to quantitative evaluations of environmental effects. Some of these studies are directly relevant to energy because they deal with a subset of the issues considered in environmental cost studies of energy (e.g., air pollution from fossil fuels and salmon losses from hydroelectric generation). To the extent that these smaller studies are strongly influenced by values and assumptions, then the results of energy studies will be **as well. Other studies deal more generally with environmental effects of non-energy activites (e.g., alachlor),**

The Health Benefits of Air Pollution Control

In 1989, the Congressional Research Service (CRS) undertook an extensive review of the health benefits of air pollution control within the context of the Clean Air Act (CAA). The study involved a review of literature, six CRS-contracted assessments of current knowledge and methods, and a colloquium at which the authors and commentators discussed the studies and their implications. The study concludes:

> . . . it is not currently feasible to produce an unambiguous evaluation of the health benefits of controlling air pollution . . . Estimates vary greatly, for two primary reasons: First, scientific uncertainties and data limitations necessarily result in estimates based on interpolations, projections, and assumptions. Second, the different professional orientations, personal values concerning environmental quality, and varying interpretations of the goals and procedures of the CAA lead assessors to differing views on what benefits mean, how they can be validly estimated, and what assumptions to make in the face of major uncertainties.

Endangered Species Act and the Pacific Northwest Salmon

Since 1984, researchers at Resources for the Future (RFF), a Washington-based independent research organization, have been studying the effects of hydropower on salmon populations in the Pacific Northwest. In summarizing some of RFF's recent experience with economic assessments of the costs and benefits of salmon preservation and restoration efforts, three researchers concluded:

> Traditional analyses do not easily capture or suitably address many of the different values associated with species preservation, ways-of-life, job-security, community stability, etc., particularly with the reductionist approach characteristic of most natural and social sciences . . . It is clear that all disciplines and much scientific analysis rest on a set of values which shape the focus and methodology of the analysis of many policy issues. The information of a single analysis is thus constrained by its value base. Particularly in the case of species preservation, the oftentimes narrowly-focused values of a reductionist approach are less-than-ideal information providers to a policy problem that **begs for insight into multiple values.**

The Risks of Alachlor

Researchers from the Institute for Risk Research at the University of Waterloo in Canada examined the Canadian debate over the risks of the chemical herbicide alachlor. In a 1991 study, they conclude:

> the debate over the risk of alachlor is *not* primarily a debate between those who accept the verdict of scientific risk estimation and those who do not. It is not a conflict between those who understand the "objective" risks of alachlor and those who are guided by an irrational "subjective" perception of its risks. Neither is it primarily a debate within science itself. Rather, it is primarily a political debat-a debate among different value frameworks, different ways of thinking about moral values, different conceptions of society, and different attitudes toward technology and toward risk-taking itself,

SOURCES: U.S. Congress, Congressional Research Service, *Health Benefits of Air Pollution Control: A Discussion, 89-161* ENR (Washington, DC: Feb. 27, 1989, pp. 1-2); Jeffrey B. Hyman et al., Resources for the Future, "Dollars and Sense Under the Endangered Species Act: Incorporating Diverse Viewpoints **in Recovery Planning for Pacific Northwest salmon," Discussion Paper QE93-11, 1993, p. 11; Conrad G. Brunk et al., *Value Assumptions in Risk Assessment: A Case Study of the Alachlor Controversy* (Waterloo, Canada: Wilfred Laurier Press, 1991) pp. 6-7,**

vert those numbers to a single unit of measure such as dollars (monetization).[5] The total monetary value of an energy source's environmental effects can then be compared easily with the total costs of other sources and with the costs of controlling those effects. If all effects of an energy source can be expressed in a monetary value, then two or more electricity generating technologies can be easily compared, and the option with the lowest total cost is clearly preferable. The costs of an energy source's environmental damages also can be compared with the costs of controlling those damages—helping to decide whether additional controls are warranted. If multiple units of measurement are used (e.g., dollars, lives, and acres of forest), then simple quantitative comparison becomes difficult or impossible.

All the studies discussed in this report quantify and monetize at least some of the effects they identify.[6] Several authors note that important classes of effects were either not quantified or not monetized in their studies. For example, Pace did not produce monetized estimates for impacts from greenhouse gases such as methane (CH_3) and nitrous oxide (N_20), air toxics, water use, land use, solid waste disposal, or the extraction and transportation of fossil and nuclear fuels. Similarly, Hohmeyer did not produce monetized estimates for impacts such as the psycho-social costs of deaths and illness, health care costs, the costs of losing biological species, certain costs of climatic changes, environmental costs of routine operation of nuclear plants, and aesthetic and land-use costs of renewable energy.

All of the studies reviewed in chapter 2 monetize the damages deemed reasonable by the study's authors. However, not all studies include the same damages. Damages may be excluded because a study's authors thought a damage was unquantifiable, or because they thought it was small enough to be ignored. Nearly every study explicitly notes broad classes of environmental costs that were not monetized.

Critiques of Quantification

Environmental cost studies focus on effects that can be expressed in quantitative terms. These terms are easier to discuss and handle analytically, and they can be presented in tables and graphs. The quantified results of environmental cost studies are almost always featured prominently when the results of studies are reported in technical literature and news accounts.

Accurate quantitative results can be among the most useful outcomes of an environmental cost study. If well presented, quantitative results can communicate a study's findings clearly, and they can give readers an idea of the relative magnitude of different sources of effects that have the same units of measure. Quantitative results also can be used easily by other analysts who are building on the work of the original study.

These advantages have led many analysts to pursue environmental cost studies—to quantify important environmental effects not currently quantified and thus not included in energy decisionmaking. Their success, however, has been incomplete. A variety of effects remains unquantifiable. Most environmental effects of energy sources have consequences that cannot be quantified.

Several analysts urge caution in the use of quantification and contend that nonquantitative results of environmental cost studies are at least as important as quantitative results.[7] Focusing only on quantitative results may construe the results of studies so narrowly that the studies' main points are missed. Underlying much of the environmental cost literature, however, is a strong drive to es-

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[5] This approach is, almost by definition, part of an environmental cost study.

[6] Other studies of the environmental effects of energy sources rigorously avoid producing monetized estimates of any kind. For example, see John P. Holdren et al., "Environmental Aspects of Renewable Energy Sources," *Annual Review of Energy, vol. 5, 1980,* pp. 241-291.

[7] See footnote 3.

timate and report quantitative results, often to the exclusion of nonquantitative ones.

Some studies (e.g., Shuman and Cavanagh) make an attempt to estimate even highly speculative effects, choosing to reflect the uncertainty in the ranges of the final results, rather than not include any estimates at all. Many other studies, however, only note that certain effects were not considered.

Critiques of Monetization

Monetization attaches estimates of value (most often expressed in dollars) to environmental effects. In general, these effects first have to be quantified in some way (e.g., days of lowered visibility or numbers of acres of forest affected). Then, a monetary value is attached to the quantified effect by using a valuation technique such as contingent valuation, hedonic valuation, or control costing (for details, see chapter 3).

Supporters argue that monetization is both a useful and inevitable part of energy decisionmaking. Considering no information about an environmental effect is equivalent to setting a value of zero.[8] Considering only qualitative information about an effect is equivalent to some quantitative value, although that value is never specified.[9]

However, the difficulties of monetizing environmental effects are so great that some analysts argue against it. The argue that the important characteristics of environmental effects include not only the expected harm,[10] but also a range of other measures:[11]

- *Probability and consequences:* Although the expected harm of two environmental effects may be equivalent, the characteristics of those harms' probability and consequences may differ substantially. For example, nuclear reactor accidents represent a large portion of the environmental costs of nuclear power in some studies. Such accidents are relatively unlikely, but could have extremely large consequences if they were to occur. Other risks (e.g., mining deaths and injuries) are relatively certain and have comparably small consequences. Comparing or combining these two risks can be problematic.
- *Distribution of damages across space, time, and classes of victims:* Where, when, and to whom impacts occur can affect how risks are perceived. For example, effects such as industrial accidents are immediate and affect only workers in a particular industry; global warming may remain a problem for centuries and may affect people who received little or no benefit from the electricity generation that led to the warming.
- *Degree of personal control: The* likelihood of some effects can be reduced by actions taken by affected individuals. For example, drivers can take extra care at railroad crossings to reduce their own likelihood of being killed or injured in rail accidents. Other effects, such as air pollution, are more difficult to avoid.
- *Degree of irreversibility:* Some environmental effects are reversible, others are not. For example, reduction of agricultural crop yields can be compensated for by production elsewhere; a unique ecosystem that is severely harmed by power plant emissions may be irreplaceable.

Because there is no generally accepted method for combining all of these characteristics into a

[8] Ottinger et al., op. cit., footnote 2, p. 14.

[9] Daniel Dodds and Jonathan Lesser, Monetization and *Quantification of Environmental Impacts,* State of Washington Interagency Task Force on Environmental Costs, Issue Paper ITF-3 (Olympia, WA: Washington State Energy Office, June 1992), pp. 84-85.

[10] *Expected harm* is usually defined as the probability of an event multiplied by its consequences. For example, if an accident has a 5 percent probability of Occurnng each year and would result in 200 deaths, then the expected harm would be 10 deaths/year.

[11] Holdren, op. cit., f∞mot₹3, p. *243;* John P. Holdren, "Energy Hazards: What To Measure, What To Compare," *Technology Review,* April 1982, p. 32-39,74-75.

single number,[12] some critics argue that monetizing and aggregating environmental effects are inappropriate tasks for analysts. Deciding how to weigh the different components of environmental effects is necessarily a matter of personal values as well as technical judgment. As a result, such decisions use as much political and social judgment as they do economic and ecological data.

Most critics of aggregation are not arguing that such valuations should never be made by anyone, only that such decisions should not be made by analysts.[13] Clearly, tradeoffs between environmental harms are necessary to make, but critics argue that such decisions should be made in public forums, not in analysts' offices.

Impacts

Merely because a factor cannot be quantified or monetized does not mean it is unimportant.] [4]For many conventional sources of energy, some of the environmental effects that are potentially the most damaging are the ones most resistant to convincing quantification and monetization. For example, nearly all the environmental cost studies reviewed in chapter 2 either explicitly exclude estimates of the costs of global warming or they produce estimates they regard as highly speculative. When studies do make estimates of costs associated with global warming, however, it often represents the largest single category of costs.

Unfortunately, nonquantitative results of environmental cost studies are often ignored in preference to results that can be expressed in monetary terms. Quantified results are easy to cite and summarize, whereas nonquantitative results are difficult to convey without long quotations or textual summaries. As a result, monetized results may receive more attention in news coverage and summaries aimed at policy makers.

In such cases, the inability to quantify and monetize all environmental effects may lead users of environmental cost studies to underestimate the total effects of some energy sources. If important effects of some energy source are inherently difficult to quantify and the monetized results dominate the presentation of conclusions, then the study may provide an inaccurate picture, despite solid analysis.

In addition, in studies that do not monetize all effects, far more attention must be paid to how results are presented. Such studies present results that are much more multifaceted and disparate, and thus require analysts to explore approaches to presenting complex data simply and clearly.

Underlying Assumptions

Decisions about quantifying and monetizing environmental effects reflect assumptions about the policy goals that environmental cost studies are meant to support and the process by which decisions about the environment should be made. Studies conducted within an economic framework often assume that economic instruments (e.g., pollution taxes) are the policy tool of choice. From this perspective, monetizing environmental impacts and combining them into a single value is entirely appropriate. Establishing such instruments requires that all environmental effects be summarized in a single number-the economic value of those effects. With such an estimate in hand, almost all that remains for decisionmakers is to use these values to establish appropriate economic incentives for energy producers. In studies conducted in noneconomic frameworks, there is far less agreement and less focus on specific policy instruments.

Furthermore, different analysts appear to have different assumptions about the preferred process

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[12] Stirling, op. cit., footnote 3, p. 1027-1029.

[13] Holdren, op. cit., footnote 11, p. 38.

14 Holdren calls this problem "confusing things that are countable with things that count." Ibid.

for making environmental decisions. Many supporters of monetizing environmental effects argue that individual preferences (expressed as monetary values) accurately summarize the overall value of any particular effect and that these estimates can be added (either across individual people or across individual effects) to reflect the overall environmental effects of an energy source. For example, an analyst might derive the cost associated with decreased visibility from coal emissions by determining an average individual willingness-to-pay from a survey of several thousand consumers and multiplying this by the total number of persons whose visibility would be affected. By conducting a similar process for each environmental effect, the analyst would add up all the costs and derive an overall estimate of damages for coal-fired generation.

However, some critics of monetization argue that choices about the environment are inherently a public function, not an activity that can be done outside of a public forum. [15] They claim that valuing the environment involves more than individuals acting as consumers and responding to surveys that estimate their willingness to pay for environmental improvements. Choices about the environment necessarily involve individuals acting as citizens involved in public debate, airing differing viewpoints, allowing individuals to become more fully informed, and finally choosing a course of action through a democratic process. To these critics, monetization usurps a public function.

Damage Costs vs. Control Costs

Environmental cost studies differ in the valuation methods used. Valuation methods are often divided into two categories-damage cost methods and control cost methods (see table 4-2). Damage cost methods trace the effects of energy generation from emissions to eventual environmental damages. The monetary value of those damages are then estimated using market, hedonic, and contingent valuation. In contrast, control cost methods circumvent this lengthy process by assuming that current environmental regulations implicitly value the environmental damages that regulations prevent. By examining the costs that legislative and regulatory bodies impose on utilities to prevent some environmental damages, analysts can estimate the value of the remaining damages.

TABLE 4–2: Categories of Valuation Methods

Category	Methods
Damage cost	Market valuation Hedonic valuation Contingent valuation
Control cost	Control cost valuation Mitigation cost valuation

SOURCE: Office of Technology Assessment, 1994.

Control cost methods have been pursued largely on pragmatic grounds. In most cases, control costs are substantially easier to estimate than damage costs. Most analysts who use control cost methods agree that damage costs would be preferable, but they contend that estimating damage costs is often hopelessly complex. Control costs are a "second-best" solution, they argue—a way of obtaining rough estimates without the immense analytical effort required to estimate damage costs.

Several studies use control cost methods to value environmental effects. The studies by Pace, Tellus, Chernick and Caverhill, Hohmeyer, and Shuman and Cavanagh all make at least some use of control cost methods, although the extent of use varies widely (see chapter 2 for details). Of the studies reviewed in detail by OTA, only the BPA, DOE/EC, and New York State studies make use of

[15] Mark Sagoff, The Economy *of the Earth: Philosophy, Law, and the Environment* (Cambridge, England: Cambridge University Press, 1988).

damage cost approaches exclusively.[lb] Control costs also are used by many state regulatory commissions that have incorporated environmental costs into utility requirements.

Critiques

Studies that have used control cost approaches have drawn heavy criticism.[17] For example, critics argue that public decisions do not represent a consistent and rigorous weighing of costs and benefits. Several studies have indicated that different regulations result in widely varying costs per life saved.[18] Such evidence is used to bolster the claim that current regulations are not economically efficient. Regulators either lack the appropriate information or, as in the Clean Air Act, are barred from considering the costs of control. Thus, critics argue, the implicit values assigned by environmental regulations are likely to be incorrect.

Supporters of control cost methods argue that, although control costing is imperfect, it represents the only currently feasible way to evaluate most costs.[19] Damage cost methods require an understanding of the emission of pollutants, the transport of those pollutants, the exposure of humans and ecosystems, and the dose/response relationship of those exposed. This multiplies the number of assumptions that a study must make and leaves room for substantial bias and error.

In addition, the same problems that afflict estimates based on control costs afflict estimates based on damage costs. For example, studies of individual judgments about risks are notorious for finding seemingly "irrational" choices.[20] These choices presumably would be reflected in purchasing decisions and survey responses and thus would afflict damage cost methods such as hedonic and contingent valuation. This has been borne out in contingent valuation surveys, where actual responses do not match the theoretical predictions of optimal consumer behavior (see chapter 3).

In fact, it is arguable that methods based on "revealed preferences," whether they be the revealed preferences of regulators (e.g., control cost valuation) or consumers (e.g., hedonic valuation), are more likely to reveal accurate answers than contingent valuation estimates. Revealed preference methods, at least, have the benefit of operating under some budget constraints and requiring real actions on the part of participants. In contrast, contingent valuation operates mainly within a hypothetical realm of what respondents *say* that they would do under the given circumstances, and past surveys have often lacked a budget constraint.

In addition to these methodological problems, however, some critics believe that control cost methods have an even greater flaw. They argue that control cost methods are not just inaccurate, but are nonsensical because they assume precisely what they should be trying to evaluate—whether current environmental regulations are economically efficient. Because the goal of evaluating environmental costs is to balance the costs and

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[16] Many studies make only limited use of control cost valuation. For example, the pace study uses control cost valuation solely to estimate damages for CO_2 emissions. Studies such as Pace nonetheless are labeled "control cost studies" by control cost critics. During reviews of draft versions of this report, several reviewers labeled the eight studies that OTA reviewed as "damage cost studies" or "control cost studies. " However, there was little agreement in the assignment of those labels.

[17] For example, see Paul L. Joskow, "Weighing Environmental Externalities: Let's Do It Right!" *The Electricity Journal*, May 1992, pp. 53-67; Staff of the Federal Energy Regulatory Commission, op. cit., footnote 2.

[18] For example, see John F. Morrall, "A Review of the Record," *Regulation,* November/December 1986, pp. 25-34.

[19] Stephen Bernow and Donald Marron, *Valuation of Environmental Externalities for Energy Planning and Operations 1990, May 1990 Update* (Boston, MA: Tellus Institute, May 18, 1990); Paul Chernick and Emily Caverhill, "Methods of Valuing Environmental Externalities," *The Electricity Journal*, March 1991, pp. 46-53.

[20] In studies of either individual or regulatory decisionmaking, the definition of "rational" or "consistent" decisionmaking is often based on expected harm (e.g., probability times consequences).

benefits of environmental controls appropriately, they argue, then using control costs as a measure of environmental benefits entails circular reasoning.[21,22] To allow balancing of costs and benefits, the estimates of these two quantities should be arrived at independently.

Impacts

There is disagreement over the impact of using control cost methods rather than damage cost methods. Supporters of control costing often argue that the methods probably *underestimate* the value of environmental effects of energy. Critics of control costing often argue that the methods vastly *overestimate* their value.

Control cost methods could underestimate environmental costs for several reasons. First, existing regulations may be an environmental "bargain" in the sense that they cost far less than the nation's citizens would be willing to pay. Just because citizens support one level of spending on environmental control or restoration does not mean they would be unwilling to support even higher costs for the same programs. In this way, control cost supporters argue, control costs represent only a lower bound on the value of environmental effects .23 In most cases, then, control costs represent an underestimate. Second, some argue that current environmental regulations systematically undercontrol environmental effects due to political reasons.[24] If this is true, then control cost methods would systematically underestimate the value of environmental effects.

Conversely, some critics claim that control cost methods may overestimate environmental costs. First, according to these critics, current regulations already overcontrol some pollutants. Using control costs for these regulations overestimates the value of the remaining emissions. Second, using the *highest* cost of control, as some studies do,[25] purposely selects for high values. These values may be too high due to ignorance or miscalculation, not because of careful evaluation about the costs citizens are willing to pay to avoid environmental damages. Using the highest cost of control, critics argue, is likely to inflate environmental cost estimates artificially.

Underlying *Assumptions*

Part of the dispute over the use of control cost approaches stems from underlying disagreements over policy goals and how environmental cost studies should be used to support those policy goals.

Critics of control costing often assume a policy goal of economically efficient regulation.[2b] In this framework, consideration of environmental costs represents a way of reforming environmental regulation—in particular, of reforming current command-and-control regulations with more market-based approaches, such as emissions taxes and tradable permits. This type of reform requires a balancing of economic costs and benefits. Within such a framework, the use of control cost methods appears to be nonsensical because it equates costs and benefits-using the costs of pollution controls to estimate the benefits associated with those controls.

Outside an economic framework, however, control costing appears far more acceptable. Sup-

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[21]Stirling, op. cit., footnote 3.

[22]Joskow (op. cit., footnote 17, p. 64) states his conclusion quite clearly: "The highest cost of control methodology is meaningless, arbitrary and capricious. It is not a second-best method for measuring environmental damages. It is absolutely worthless!"

[23]For this reason, some studies (e.g., Tellus) examine the control costs based on several regulations and then use the highest one as their estimate of the value of any particular environmental effect.

[24]Ottinger et al., op. cit., footnote 2, p. 42.

[25]E.g., Tellus.

[26]E.g., Staff of FERC, op. cit., footnote 2, p. iii, 15; Joskow, op. cit. footnote 17, pp. 54, 61.

porters of control costs genera lly are interested in policy goals other than economic efficiency. Policy goals such as protection of health and safety, sustainability, and equity do not focus on balancing costs and benefits. In addition, supporters of control costs generally are more interested in the overall ability to compare the effects of energy sources than in implementing specific market incentives.[27] From these perspectives, **control costs** appear to be a more valid method for arriving at estimates of environmental costs. The fact that they derive from existing regulations is important only in evaluating their accuracy, not their overall legitimacy.

Of course, the fact that *some* uses exist for control cost methods does not excuse their use for purposes to which they are not suited. If the goal of a particular environmental cost analysis is to balance costs and benefits, then control cost methods *would* embody circular reasoning. However, it is equally mistaken to say that control cost methods have no place whatsoever in environmental cost analyses that have goals other than economic efficiency.

Another portion of the dispute over the use of control costing stems from underlying disagreements over *who* should be empowered to make valuation decisions.[28] Proponents of control cost methods point out that the technique is merely extending the coverage of previous decisions made by elected and appointed government officials. Proponents of damage cost methods often point out that their estimates come from studies of consumers (i.e., contingent and hedonic valuation). These methods allow individual citizens to express their will more directly.

This issue demonstrates the tight links between seemingly technical issues of environmental cost studies and deeply held values about society and decisionmaking. Valuation brings out issues of how environmental problems are viewed and issues about what groups are invested with the power to make decisions that affect the health of individuals and ecosystems.

I Average Effects vs. Marginal Effects

One approach to determining the environmental effects of individual generating plants is to consider their *average* effect. For example, to determine the $S0_2$ emissions of an oil-fired plant, an analyst might find out the emissions of a random sample of generating plants and find the average number of pounds of $S0_2$ emitted per kilowatthour of electricity that reaches consumers. Similarly, an analyst attempting to determine the environmental impact of a pound of $S0_2$ might find the overall damages attributed to $S0_2$ emissions and then divide by the total number of pounds of the pollutant known to be emitted.

Another approach is to consider the *marginal* effect of an individual generating plant. For decisionmakers who are deciding whether to build an oil-fired plant, the relevant figure is how much $S0_2$ will be emitted by the new plant, not by the average plant that is now operating. The average figure will include old plants that are just a few years from retirement as well as new plants that were just constructed. Similarly, the environmental impacts associated with an *additional* pound of $S0_2$ maybe substantially different from the *average* damage.

These examples illustrate the difference between average and marginal effects. Economists are quick to point out that, for most decisions, it is the marginal effects that matter. For policy decisions such as building new power plants, taxing pollutants, and setting emissions limits, the marginal effects indicate what marginal benefits could be achieved by the measures.

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[27] Chernick and Caverhill, op. cit., footnote 19.

[28] Shuman and Cavanagh note: "The controversy over the 'true' value of human life may mask an intractable *moral* question about who should make the decision." Michael Shuman and Ralph Cavanagh, *A Model Conservation and Electric Power Plan for the Pacific Northwest*, Appendix 2 (Seattle, WA: Northwest Conservation Act Coalition, November 1982).

Marginal analysis does not always involve determining the emissions of new plants. Estimating the marginal cost might also be used for other purposes, such as determining which existing power plants to dispatch,[29] determining appropriate compensation for those who live near existing plants, or determining what plants to remove from service.

A special case of this problem is location specificity. Some studies attempt to produce national average estimates of the environmental costs associated with different types of generating plants. However, local conditions can vary greatly. Factors such as weather, surrounding ecosystems, and population density all are important inputs to environmental cost calculations.[30] Some studies have dealt with this problem by limiting the study to a relatively homogeneous region; for example, Shuman and Cavanagh focus on the Pacific Northwest. Other studies produce different estimates for different sites. For example, the BPA generic coal study provides six different estimates of environmental costs based on geographic location and the population of nearby cities.[31]

Critiques

Some environmental cost studies have been criticized for looking only at average effects. Critics argue this misrepresents the options available to decisionmakers. Decisionmakers (whether economic, regulatory, or legislative) can only affect energy generation *at the margin (e.g.,* by choosing what plants to construct, modify, or shut down).

The issue of marginal effects is particularly important to economists, but ecologists also argue for considering marginal effects. Ecological responses are often nonlinear.[32] Although little ecological damage may have resulted from current levels of pollution, additional amounts can have effects that are dramatically worse. Thus, ecologists argue, considering average effects of pollution may substantially underestimate the effects of some pollutants.

Most studies to date have examined average effects. In general, this has been because of the difficulty of examining marginal effects. There is great uncertainty in the estimation of average effects; marginal effects represent an even greater analytical challenge. However, a few studies have examined site-specific numbers. The DOE/EC study is focusing on specific sites in an effort to avoid this problem. Other studies have emphasized the environmental effects of *new* plants in an effort to avoid some of the pitfalls of considering average effects.

Impacts

The impact of considering average rather than marginal effects depends on the effect being examined. Considering average ecological effects probably lowers environmental cost estimates. Current levels of pollution maybe assimilated by the environment in ways that increased levels could not be. Similarly, if thresholds exist for ecological and human health effects from certain pollutants, then increasing pollutant levels might

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[29] Stephen Bemow et al., "Full-Cost Dispatch: Incorporating Environmental Externalities in Electric System Operation," *The Electricity Journal,* March 1991, pp. 20-33.

[30] Ottinger et al., Op. cit., footnote 2, pp. 68-69; Alan Krupnick, "The Social Costs of Fuel Cycles: Lessons Learned," Discussion Paper QE93-04 (Washington, DC: Resources for the Future, 1993), p. 15.

[31] ECO Northwest *et a]., Generic Coal Study: Quantification and Valuation of Environmental Impacts,* report commissioned by Bonneville Power Administration, Jan. 31, 1987.

[32] In this context, *nonlinearity* refers to how an ecological system responds to different levels of pollutants. For many ecological systems, adding a certain amount of a pollutant can have a small or a large effect, depending on the current level of pollutants already in the system.

cross those thresholds, resulting in ecological and human health effects that were not present previously.[33]

The impact of considering emissions from average electric generating plants is less certain. In general, newer plants are cleaner than plants based on older technology, but plant location matters as well. A specific plant may have higher or lower emissions depending on how its location compares with that of the generating plants used in the calculations of average environmental costs.

Underlying Assumptions

Arguments about the relative merits of considering average and marginal costs rest on assumptions about the role of environmental cost studies in policy. Analysts concerned with economic efficiency are likely to focus on the importance of marginal analysis when considering power plants and other technological infrastructure. In this view, considering average costs will raise environmental cost estimates artificially because, for example, new plants are cleaner than old ones.

Analysts concerned with sustainability are more likely to focus on the importance of considering marginal effects on ecosystems. In this view, considering average costs will lower environmental cost estimates artificially because, for example, it will not account for the probability of crossing some unknown threshold-beyond which an ecological system cannot assimilate additional pollutants.

Internalization

When examining environmental costs, economists are particularly concerned with *internalization.* Every environmental cost analysis attempts to quantify environmental damages in monetary terms, but economists generally go a step further to ask whether existing environmental regulations already *internalize,* or account for, these damages (see box 2-2 for the economic theory of externalities and internalization).

Many existing environmental cost studies largely ignore the question of internalization. Of the six completed studies reviewed by OTA, none systematically considers whether current regulations have internalized some or all environmental costs. The ongoing DOE/EC study will carefully delineate between damages and externalities for each damage pathway.[34] The ongoing New York State study has determined that a few classes of environmental damages were already internalized and excluded them from further consideration.

Critiques

When reviewing environmental cost studies, utility and industry representatives often respond by citing the large number of environmental regulations with which they already comply. A large number of existing regulations control human health and environmental impacts of mining, construction, transportation, and electricity generation activities.

Some critics of current environmental cost studies argue that, if a pollutant is currently regulated, and utilities are in compliance with that regulation, then no economic externality can exist. This argument generally is made from one of two perspectives. One perspective is that current regulations accurately weigh environmental costs and benefits. This is the same assumption that some economists criticize when it is used to justify control costing. However, to the extent that current regulations *do* balance costs and benefits, it can be argued that the regulations internalize the environmental costs associated with the pollutants they regulate. An alternative perspective is that some current regulations require that pollutants be reduced to levels where no significant health effects

[33] It is possible, though probably unlikely, that considering average costs rather than marginal costs would *increase* estimates of environmental costs. For example, there may be situations where "the damage is done" and the marginal damages might be less than the average damages.

[34] Pathways are the links between *emissions* and *impacts* (see figure 2-1).

occur. For example, the criteria for setting standards under the Clean Air Act is to "protect health with a margin of safety." By this reasoning, electricity utilities in compliance with standards should not produce *any* significant health effects, let alone effects that can be considered to be externalities.

Several responses are made to the argument that current regulations completely internalize environmental costs. First, existing regulations neither eliminate environmental effects entirely, nor do they effectively balance them against control costs. Health effects remain even after regulation and those effects are not always accurately balanced against the costs of control.[35] Some argue more broadly that relatively few environmental impacts are reflected in the market costs of energy, so largely ignoring internalization is appropriate.[36]

Second, some supporters of environmental cost studies reject a strict definition of externalities. They argue that it is important to understand the environmental effects of energy regardless of whether they are "internalized." Third, some economists argue that, in some cases, current regulations are largely irrelevant to determining externalities. Instead, studies can use the marginal environmental damages as a reasonable estimate of externalities.[37] Consistent with this conclusion, some studies, such as the Pace study, argue it is important to consider the costs of residual emissions—those emissions that remain after regulations have been imposed.

Impacts

Assuming that current regulations eliminate all externalities certainly would produce lower estimates of environmental cost. When studies assume that regulated pollutants still can produce externalities, they will include a larger number of effects than if they used a more restrictive definition. For example, risks of occupational deaths and injuries are assumed, by at least some analysts, to be compensated for by increased wages in hazardous industries. If environmental costs are defined as only those effects that are not already included in market prices, then occupational deaths can logically be excluded from total cost estimates. If environmental costs are defined more broadly as *all* environmental effects, however, then occupational risks should be included, and cost estimates will increase.

Underlying Assumptions

The issue of whether internalization is important depends upon assumptions of what policies environmental cost studies are intended to support. Estimating the monetary value of environmental damages associated with energy production, something all environmental cost studies do, addresses one question: What is the monetary value of the environmental effects of energy? Evaluating whether those damages are already internalized helps to address another question: What should we do about it? Both questions are important, but a study does not necessarily need to answer the second question in order to be useful.

To achieve a policy goal of economic efficiency, assessing the current degree of internalization is vital. Estimates of uninternalized environmental costs are necessary to achieving economic efficiency through economic instruments such as pollution taxes. Without analyzing the degree of

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[35] Krupnick, op. cit., footnote 30.

[36] Shuman and Cavanagh, op. cit., footnote 28, p. 1.

[37] In cases where existing regulations are based on "command and control" and not economic incentives, the correct monetary amount to add to private costs is equal to marginal damages. A. Myrick Freeman III, et al., "Accounting for Environmental Costs in Electric Utility Resource Supply Planning," Discussion Paper QE92-14 (Washington, DC: Resources for the Future, 1992).

internalization achieved by current regulations, it would not be clear where to set pollution taxes.[38]

If, however, the intent of an environmental cost study is to support different policy goals, then the degree of internalization may be less important. For example, to inform policies concerned with equity, it would be important to know *who* is affected by pollutants, even if the effects of those pollutants are fully internalized in an economic sense. Merely because utilities are taxed for the pollutants they generate, for example, says nothing about whether those affected by the pollutants are compensated.

Thus, for purposes other than economic efficiency, it can be useful for studies to estimate the costs of environmental effects, regardless of whether those effects are already internalized. Furthermore, estimating such costs is necessary before economic externalities can be estimated. In this sense, investigating and detailing all environmental effects is useful regardless of the policy goal.

Managing Uncertainty

Environmental effects differ in the certainty with which they can be established. Some effects are fairly well understood. For example, mining accidents are a known risk of coal-fired electricity generation. Accurate statistics have been kept for decades and the frequency and magnitude of the risk are well understood. Other risks are less certain. For example, the probability and consequences of large-scale nuclear reactor accidents are still the subject of substantial debate.

How to estimate and represent uncertainty is a persistent problem for many types of quantitative studies, but it can be a particular problem for environmental cost studies.[39] The data and relationships used in environmental cost studies are often uncertain, and this uncertainty propagates throughout the study and affects the final results. Furthermore, uncertainty tends to increase as the study moves from inputs to final results (e.g., from emissions to valuation).

Systematic treatment of quantitative uncertainty is not easy. The uncertainty of each piece of input data must be assessed, and then these uncertainties must be combined in a credible way. Analytical methods that combine uncertainties often make fairly large assumptions (e.g., that the uncertainty associated with one piece of input data is independent of the uncertainty associated with others). Even with these assumptions, however, the combination of many uncertain inputs is analytically challenging.,[40][41]

Critiques

Analysts differ on how to handle uncertainty. Some analysts argue for a restrictive stance on which effects to include. They exclude uncertain effects because they are too speculative and are likely to artificially inflate estimates of environmental costs. Other analysts are fairly liberal about which effects to include. They include un-

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[38] An added complication is that internalization represents a moving target. Environmental laws and regulations are frequently altered, SO an analysis can become outdated quickly.

[39] However, uncertainty is not unique to environmental cost studies. Other areas of utility planning and regulation encounter this problem as well. Paul Chernick, *From Here to Efficiency: Securing Demand-Management Resources, Volume 5, Quantifying the Benefits of Demand Management* (Boston, MA: Resource Insight, Inc., January 1993).

[40] For additional discussion of this problem, see M. Granger Morgan and Max Henrion, *Uncertainty: A Guide to Dealing With Uncertainty in Quantitative Risk and Policy Analysis* (Cambridge, England: Cambridge University Press, 1990).

[41] The DOE/EC study is making an extensive effort to rigorously deal with uncertainty. The approach used in the study is intended both to allow quantitative uncertainty estimates and to provide qualitative information to potential decisionmakers. See Oak Ridge National Laboratory and Resources for the Future, *U. S.-EC Fuel Cycle Study: Background Document to the Approach and Issues*, Report No. 1 on the External Costs and Benefits of Fuel Cycles: A Study by the U.S. Department of Energy and the Commission of the European Communities, ORNL/M-2500, November 1992, pp. 2-23-2-26.

certain effects because of concerns about grossly underestimating the true effects of energy production. Finally, some studies give a range of estimates, reflecting different thresholds of uncertainty.

For example, studies differ in whether they consider potential damages from global warming caused by greenhouse gas emissions. Some studies, such as the New York State study, have concluded that the uncertainties of estimating damages associated with $C0_2$ are so great that they will not attempt an estimate and will instead assign a default value of zero.[42] Other studies, such as Shuman and Cavanagh, assign a highly uncertain value to the damages, varying between zero and more than half of the total damages associated with coal generation.

Many current environmental cost studies do not systematically consider uncertainty throughout their calculations. In general, the studies make point estimates of potentially uncertain data and uncertainty is only discussed in the report's text, not indicated in the reports' quantitative results .43 Point estimates are rarely rounded to reflect their rough level of accuracy.

Impacts

A study's approach to uncertainty can have significant effects on results. Including uncertain environmental effects can only increase the estimates of environmental costs. Ignoring the issue of uncertainty may make the studies useless from a policy standpoint. If the cost differences between energy sources are significantly smaller than the range of uncertainty of the estimates, then the estimates will be of little value. Whether this is true of current estimates is difficult to say, given the way in which many current studies handle uncertainty. Readers are left with a clear idea of the studies' "best guesses," but little quantitative idea of the possible range of results.

Underlying Assumptions

Approaches to resolving uncertainty vary greatly and rest at least partially on value judgments of the analysts involved. For some, a lack of evidence indicates relative safety—if risks were present, then research would have indicated their presence. To others, a lack of evidence indicates how little is known about potential risks—if information is lacking, then research may be overlooking important risks.[44]

For example, a recent survey of 22 experts on the economic impact of global warming demonstrates the different reactions to uncertain evidence.[45] Quantitative studies are unable to predict the consequences of global warming with a high degree of certainty, so the survey sought to collect the subjective estimates of various experts. Their collective judgment might produce estimates of impacts to be used in quantitative models. However, the survey indicated afar more interesting result. The subjective estimates of different groups varied widely: mainstream economists expressed little concern about potential impacts and were confident that human societies would adapt handily to the changes. In contrast, natural scientists expressed great concern about potentially large and irreversible destruction of life-sustaining ecosystems.

Discounting

Discount rates are used to compare economic costs and benefits that occur at different times. A

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42 RCG/Hagler, Bailly, InC., "New York State Environmental Externalities Cost Study Report 1: Externalities Screening and Recommendations," ESEERCOPro@ctEP91 -50, December 1993, p. iii. The study's computer model will allow users to insert their own value for CO_2 damages.

43 When the DOE-EC studies are released, they may be an important exception.

44 Harold P. Green, "The Risk-Benefit Calculus In Safety Determinations," *George Washington University Law Review*, vol. *43, No. 3*, March 1975, pp. 791-808.

45 William D. Nordhaus, "Expert Opinion on Climatic Change," American *Scientist*, January-February]994, pp. 45-51.

positive discount rate indicates that a cost of $10 that will be incurred in five years is worth less than $10 today. How much more depends on the discount rate. For example, if the discount rate is 3 percent, a $10 expenditure five years in the future is only equivalent to $8.59 today.

The practice of discounting can reflect many concerns. First, discounting can reflect a fundamental human tendency. People would rather have a good now than later. Second, it can account for the productive nature of some resources. Between now and some future time, some resources can be productive, generating revenue for their owners. Resources such as farmland and livestock meet this criterion. Third, discounting can reflect risk and uncertainty about the future. The practice of charging interest on loans is a recognition of the business risks associated with investments. Fourth, discounting can be used to adjust for technological change. Environmental damages in the future may be less harmful than today because new technologies will be developed to mitigate them.

Environmental cost studies use discount rates to adjust some cost estimates. For example, Shuman and Cavanagh's study uses a 1 percent discount rate for property damage and a discount rate of zero for human lives. In general, environmental cost studies have applied discounting to only a few, long-term effects of electricity generation. These include the global warming effects of CO_2 emissions and the long-term risks of nuclear waste. Because these impacts are often a significant component of total environmental cost, discounting can be an important issue. However, discounting does not affect the majority of impact categories, either because the impact is relatively prompt (e.g., oil spills), because studies do not apply discounting to them (e.g., human deaths and injuries), or because a valuation technique is used that avoids discounting entirely (e.g., control cost valuation).

Critiques

There are several views on how discount rates should be used to value environmental resources. Some economists and utility experts argue for using rates similar to those used by utilities for valuing capital investments (e.g., 6 to 8 percent).[46] This provides a consistent basis for utility resource selection decisions, but it also has the effect of reducing the value of damages that occur far into the future (e.g., global warming or nuclear waste storage) to nearly zero.

Many environmentalists argue for using relatively low discount rates. Low discount rates have the advantage of treating future generations equally to our own, but they also may cause relatively certain, near-term effects to be ignored in favor of more uncertain, long-term effects. Future generations may have new technologies and knowledge that will cheaply and easily deal with long-term environmental threats such as global warming or nuclear waste storage.

Impacts

High discount rates will produce lower damage estimates because they reduce the costs associated with environmental impacts that occur in the future. For example, a high discount rate will decrease the importance of the impacts of global warming. The BPA generic coal study explicitly ignores the impacts of global warming for this reason.[47] Conversely, low discount rates will result in higher damage estimates.

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[46] Ottinger et al., op. cit., footnote 2.

[47] They calculate that, even if global *Wining damages are $5* trillion, because the damages will occur 100 years from now, the amount attributable to a single coal plant (after discounting at 3 percent) is less than $8,300 per year (this calculation assumes that coal is only responsible for 33 percent of all CO_2 emissions, and that a single plant consumes only 0.001 percent of all coal consumed in the world). The study ignores this amount because it would add less than 1 percent to the total environmental costs that the study attributes to a generic coal plant. ECO Northwest et al., op. cit., footnote31, pp. 4-7.

Underlying Assumptions

Some disputes over discount rates can be traced to assumptions about the relative importance of natural resources (e.g., forests, lakes, and animals) and technological resources (e.g., roads, dams, and machinery). Applying discount rates to environmental impacts implies an equivalence between natural and technological resources. The ability to trade off natural and technological capital has been strongly disputed by some ecologists. For example, some argue that natural and technological capital can be more clearly seen as *complements* than as substitutes—implying that we need both to make use of either.[48,49] Although funds used to construct technological systems can be banked and spent at a later time, the same cannot be said of human lives and the important characteristics of ecosystems. Similarly, once some ecological systems are consumed, they may be difficult or impossible to regain.

Discounting also raises questions of how much reliance can be placed on technological solutions to current and future environmental problems. Advocates of high discount rates sometimes argue that technological progress will find solutions to future environmental harms. Those who advocate low rates do not wish to depend on future progress to mitigate harms that could be prevented today.

I Conclusions

These issues do not exhaust the list of situations where disputes can be based on underlying assumptions and values, but they provide a starting point. Each of these issues can affect the outcome of a environmental cost study, and how each issue is resolved depends largely on an analyst underlying assumptions. The "right" assumptions for an environmental cost study are not clear, and current debates over environmental cost studies are doing little to resolve them. Instead, discussions of the technical details of individual studies often hide disagreements over basic assumptions.

FRAMEWORKS

The discussion above indicates the wide variety of issues that affect environmental cost studies and the diversity of assumptions that affect how analysts resolve those issues. The assumptions occur at many different levels of analysis. One way of understanding these assumptions is to divide them into three levels: first, the fundamental goals the study is intended to support; second, the general strategies used to frame the study; and third, the specific methods the study uses to make its estimates.

Table 4-3 provides examples of these frameworks. The positions outlined are extreme, and rarely adopted in unalloyed form, but they help illustrate different frameworks, the connections within individual frameworks, and the broad spectrum of possible assumptions that underlie environmental cost studies.

| Goals

Analysis of environmental cost issues does not take place in a vacuum. Nearly every analysis begins with a particular view of problems not fully addressed by current policies. For example, economic analysis of environmental questions often begins by examining why current markets fail to control environmental effects. Analysis of the same issues by environmental groups often begins by noting emerging global environmental threats that are linked to energy use.

These problems often are translated into an implicit or explicit policy goal. Economic efficiency is nearly always the presumed goal of economic analyses of environmental cost problems. Public protection is a traditional goal of much existing environmental regulation. Sustainability is quick-

[48] Here the term *complements* is used in an economic sense. complements are defined by economists as items whose consumption is closely related. Computer keyboards and monitors are complements—when purchases of one rises or falls, the purchases of the other moves similarly.

[49] Robert Costanza and Herman Daly, "Natural Capital and Sustainable Development," *Conservation Biology,* vol. *6, 1992,* pp. 37-46.

TABLE 4–3: Frameworks of Assumptions

Goals		Strategies		Methods	
Policy goal	**What is the source of environmental problems?**	**Role of environmental cost studies in energy policy**	**What are environmental costs?**	**Valuation approach**	**What is value?**
Economic efficiency	Markets do not capture all the important information for energy decisionmaking by producers and consumers. Existing regulations are inefficient.	Quantify the necessary corrections to energy markets so that all important decisionmaking information can be contained in prices. Compare the total costs and benefits of a specific policy.	Externalities—environmental effects that are not reflected in current energy prices and that are economically quantifiable.	Consumers acting in markets.	An amount that consumers are willing to pay for an environmental good or service.
Protection of public health and safety	Energy technologies have created risks to the public that are preventable.	Indicate where government action is necessary to minimize the health and safety impacts of energy production.	*Unintended* side effects of energy use.	Legislators and regulators acting in political systems.	One measure of the importance of an environmental effect.
Ecological sustainability	Existing energy use is not ecologically sustainable because individual consumers act according to their own narrow self-interest, instead of considering the impacts of their actions on the whole ecosystem.	Indicate where government action is necessary to make energy production sustainable.	Effects on global or local ecosystems that are not apparent or are not of interest to individual consumers.	Scientists acting in scientific settings.	An indicator that can be used to communicate ecological importance.
Equity	Disparities in political and economic power exist between different members of society. Powerful individuals attempt to push adverse effects onto others while retaining the positive effects for themselves.	Indicate situations where inequities occur and quantify the damages in order to facilitate compensation.	Adverse effects of energy use that are not borne by those who benefit.	Legislators, regulators, judges, and juries acting in political and legal systems.	An amount that provides just compensation and that punishes unjust actions.

SOURCE: Office of Technology Assessment, 1994.

ly becoming the predominant goal underlying many analyses that take an environmental perspective. Equity has recently emerged as a concern about environmental impacts

These policy goals are not mutually exclusive, and few analysts would explicitly advocate pursuing only one of them. However, single policy goals are often implicitly assumed without substantial attention to other goals. Such an approach is understandable because combining several policy goals is difficult and requires an overarching organization that needs to be explained and defended. Such an activity goes beyond the scope of most environmental cost studies.

Most existing environmental cost studies fall primarily within a framework of protecting public health and safety. The studies are aimed at identifying environmental effects of energy to indicate where government action is necessary. They broadly consider all environmental effects of energy, without substantial concern about whether such effects have already been, in a strict economic sense, internalized by existing regulations.

These studies and their use by state regulatory commissions have been strongly criticized for misunderstanding economic concepts. For example, questions have been raised about the use of control costing, not accounting for currently internalized effects, and using average instead of marginal effects. Partially in response to these criticisms, the ongoing DOE/EC study falls predominantly within a framework of economic efficiency. The study's authors take pains to explain the specifics of this policy goal, and they point out how current studies fail to inform such a policy goal adequately.

Few, if any, studies have approached environmental issues from a framework of equity. However, environmental equity has been the focus of intense attention recently, and casual readers of environmental cost studies often assume that the studies are primarily concerned with equity. In addition, equity is of great concern to federal policymakers, particularly Congress.

I Strategies and Methods

Policy goals often translate fairly directly into other important assumptions in environmental cost studies. Some of these assumptions concern a study's strategy (i.e., what role is envisioned for the study in energy policy). Other assumptions concern methodology (i.e., how the study assigns value to environmental effects).

Frameworks based on economic efficiency can appear to offer a complete basis for policy, providing an extremely clear, although limited, role for policymakers. Economics provides a theoretical description of environmental problems (market failures), a quantitative strategy for informing policy (estimating externalities), methods for carrying out that strategy (e.g., contingent valuation), and a set of policy tools (e.g., pollution taxes). Critics of exclusively economic approaches argue, however, that economics is far from a complete system. Other important goals such as sustainability and equity are not directly addressed by economics, and they can be difficult to integrate with economic goals.

Most proponents of economic approaches argue for a more moderate position—that economic information supports the creation of policies that are economically efficient, and that also achieve other ends such as equity or sustainability. Such a view, however, presupposes that environmental cost studies provide relatively technical and unbiased information to policymakers-casting policymakers as the arbiters and integrators of information. However, as indicated above, environmental cost studies themselves often embody, rather than inform, decisions about assumptions and values.

In addition, the tendency of some environmental cost studies has been to push the boundaries of technical analysis outward, attempting to subsume progressively larger set of issues within a quantitative framework. Such quantitative treatment can be appealing to policy makers faced with difficult decisions. Because economic efficiency

goals are more easily treated quantitatively, there is a danger they may effectively override other goals and become the de facto basis for policy.

Careful assessment of the policy role for environmental cost studies is needed, particularly given current and future attempts to use these studies on the federal level. How are environmental cost studies used in federal and state policymaking? What challenges await if they become more widely used on the federal level? How can they be conducted to best meet the needs of policymakers? These questions are considered in the next chapter.