VALUATION OF SELECTED ENVIRONMENTAL IMPACTS
ASSOCIATED WITH BONNEVILLE POWER ADMINISTRATION
RESOURCE PROGRAM ALTERNATIVES

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SUMMARY

This report describes work undertaken by Pacific Northwest Laboratory (PNL) and its contractors to assist the Bonneville Power Administration in evaluating the potential environmental consequences of new power resources. The report describes and evaluates the available techniques for assigning economic values to environmental impacts. It also documents their use to value selected environmental impacts associated with each of the new power-generation alternatives discussed in Bonneville's Resource Program Environmental Impact Statement.

ENVIRONMENTAL COST EVALUATION

Techniques for valuing environmental impacts, or externalities, associated with power generation have become increasingly sophisticated in recent years.^(a) Externalities can be incorporated into resource evaluation decisions in two ways: qualitatively or quantitatively. Qualitative assessments do not enter directly into cost calculations but can be used to differentiate resources with similar costs. Although qualitative assessments can cover all impacts that can be identified, it is difficult to assess the relative importance of each impact when each is measured differently.

On the other hand, quantitative assessments, at least in principle, place each of the impacts of the resource choice decision on a common footing, namely dollars. Economic costs then can be compared easily with the other costs of the generation resource, and, ultimately, different resources can be compared to each other. However, it can be difficult and expensive to develop dollar damage estimates for each environmental impact. As a result, efforts to quantify damages from externalities are usually limited to a handful of major damages.

The so-called damages-based approach used in this analysis to estimate environmental costs requires two types of quantified information: the extent

(a) The term "externalities" refers to residual environmental impacts that are not included in the internal resource costs. Externalities often represent uncompensated environmental damages although they may also represent benefits.

or amount of environmental change (impact), for example the decrease in crop production or visibility, and the price or economic value of the good or quality impacted.^(a) The total cost or change in social welfare can then be calculated by multiplying this value times the amount of physical damage.

For the purposes of the RPEIS, the environmental impacts are being modeled at four sites in the Bonneville service area: Eastern Montana, Eastern Washington, Western Washington, and Eastern Oregon. The air quality, health, and ecological effects analyses are reported in separate appendices in the RPEIS.

Economic values are taken from market prices or estimated using various economic models for valuing nonmarket goods and qualities. For this analysis, the economic models were not actually estimated, instead the results of existing studies were used. The validity and applicability of these numbers depends on the type of model used and the way in which the study was conducted. Thus, this document describes and evaluates these models in detail (see Chapter 2).

Economic Valuation Techniques

Bonneville's current practice reflects economists' conventional breakdown of resources into market and nonmarket goods. Market goods are those goods which are bought and sold in an organized, observed market; nonmarket goods are those which are not. Crops and timber are examples of market goods that are affected by air pollution; an example of a nonmarket good affected by air pollution is human health. Although each of these goods must be treated differently, methodologies to evaluate both categories of

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- (a) The difficulty in developing estimates of the damage from externalities has lead to an alternative form of quantification known as the cost-based approach, which uses the cost of mitigation of the externality as a proxy for the dollar value of the damages. This is the approach used by most states that attempt to quantify environmental damages. Increasingly states and public utility commissions are attempting to implement damages-based evaluations of externalities. See the Appendix for a description of these efforts.

goods are available. As is discussed in detail in Chapter 2, each approach has its own strengths and weaknesses.

Market goods are the most straightforward to evaluate because they have observed prices and quantities. Quantifying the physical damage in relation to the overall market provides the information needed to determine the value of the damages. This allows economists to estimate the relative size of damages from pollution, for example, and to value those damages. For example the economic value to society of reduced crop production associated with increased air pollution is simply the change in crop output times the appropriate value.

The tools for quantifying effects on nonmarket goods are well-understood and have been refined over the last 10 years. There are both direct and indirect approaches to valuing environmental externalities. The direct approach is represented by a survey technique known as the contingent valuation method (CVM), which bases value on how respondents react to hypothetical markets. This provides what economists call a "stated preference." Indirect methods infer value from behavior observed in real markets. These yield what economists call a "revealed preference." Indirect techniques used in this analysis include hedonic techniques and travel cost methods.

Hedonic models are based on the notion that the price of a market good (e.g., a house) is the sum of the value of the characteristics of the good (the number of bedrooms, square footage, neighborhood, etc.). These techniques have been applied with considerable success to value human health risks, air pollution, and other externalities tied to jobs or property. Travel cost methods use cost of travel to a site as a proxy for price. They are useful for valuing impacts at a location that people visit, but which is not subject to market transactions. These methods have been used extensively to value impacts on recreational sites and activities.

Although the CVM is gaining increased acceptance by the economics profession, especially for valuing environmental resources, economists have traditionally placed more reliance on indirect methods that base the value of the nonmarketed goods on observed behavior in real markets. In situations

where it may be possible to apply either a stated preference or a revealed preference technique, but not both, most economists would be likely to opt for the revealed preference approaches.

Model Application

Variations in the nature of the data, the character of the economic impacts, and the usefulness of the results determine the specific methodologies selected to assess impacts in this analysis. While there are a variety of environmental impacts associated with power resources, studies have concentrated primarily on four areas: visibility, human health, recreational fishing, and agricultural crops. The applicability of these studies to Bonneville's service area is limited because a) most values tend to be specific to a given geographic area, and b) studies have been conducted, for the most part, by academic researchers who have focused on a specific valuation problem. The studies are not, therefore, a comprehensive analysis of power resource environmental impacts.

Nevertheless, with effort, existing studies can be utilized to provide information that can be useful to Bonneville generally and to the RPEIS specifically. Although presently available data cannot be applied directly to Bonneville's service area, and cannot provide estimates of environmental costs with pinpoint accuracy, these studies can provide "ballpark" estimates of the economic value of a given environmental effect. Furthermore, careful and prudent calculation of these values can provide important insight into the relative environmental costs of power resources under consideration by Bonneville and others.

Results

This analysis estimates costs for the 12 alternative power-generation scenarios. Whenever possible, impacts are evaluated quantitatively, i.e., in dollar terms. Sufficient data were available to permit quantified assessments of human health, visibility, and crop impacts. These values are determined directly for market goods, and indirectly for nonmarket goods. The estimated economic values of human health effects due to ozone and criteria pollutants are shown in Figures S.1, S.2, and S.3. The estimated economic values of

visibility reduction due to total suspended particulates and crop losses due to ozone are shown in Figures S.4 and S.5.

FIGURE S.1. Economic Value of Human Mortality due to Ozone

FIGURE S.2. Economic Value of Human Mortality due to Criteria Pollutants

FIGURE S.3. Economic Value of Human Morbidity due to Criteria Pollutants

FIGURE S.4. Economic Value of Visibility Reduction due to Total Suspended Particulates

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1.0 INTRODUCTION

This report documents work undertaken by the Pacific Northwest Laboratory (PNL) and its contractors to assist the Bonneville Power Administration (Bonneville) in assessing the potential environmental consequences of new power resources. A major purpose of this effort is to describe and evaluate the techniques available for economic valuation of environmental costs. Another is to provide estimates of the environmental costs associated with specific power resources called for under Bonneville's Resource Programs. Bonneville's efforts to extend valuation techniques to as many impacts as can be reliably assessed represents a substantial advance in the application of state-of-the-art economic techniques to environmental assessments.

This economic analysis evaluates effects on human health, wildlife, crops, and visibility impacts associated with air pollution. This report also discusses river recreation (primarily fishing) which may be affected by fluctuations in water levels. Costs are estimated for the 12 alternative resource acquisition scenarios posed by the Resource Program Environmental Impact Statement (RPEIS) presently under development by Bonneville. Documentation of the analysis includes reporting of the data, calculations, and assumptions that were used in these estimations.

1.1 BONNEVILLE POWER ADMINISTRATION RESOURCE PROGRAMS

Historically, Bonneville develops a Resource Program every two years, the documented result of an extensive planning process. Essentially, a Resource Program is Bonneville's proposed means of meeting its forecasted load obligations. Resource planning is conducted within the context of the Northwest Power Planning Council's (Council's) most recent long-range regional Power Plan for the Pacific Northwest. The Power Plan provides guidance for the development of the Resource Program; the program, in turn, translates the Power Plan into specific near-term actions with associated budgets.

The load forecast is jointly prepared by the Council and Bonneville. The load forecast is developed based on five possible levels of load growth (low, medium-low, medium, medium-high, and high) to reflect the uncertainties

in growth that planners must accommodate. Next, a similar range of load/resource balances is developed to compare existing resources in the Federal system to the range of Federal system loads predicted over a 20-year planning horizon. Based on these load/resource balances, the Council and Bonneville develop new resource supply forecasts to facilitate timely acquisition of cost-effective resources to meet new demand and to assist in long-term program design.

The most recent medium forecast indicates that the Federal system is now in load/resource balance and that Bonneville's power resources should be sufficient for the rest of the decade. However, the exact level and pattern of future loads is not known. Demand could grow faster or resources may not perform as expected; it is not unrealistic to anticipate that Bonneville may face a power deficit. Under present high-load-growth forecast conditions, for example, Bonneville may require up to 5,000 average megawatts (aMW) to meet its load obligations during the period covered by the 20-year planning horizon.

Bonneville's methodology for determining the cost-effectiveness of resource alternatives calls for the inclusion of all system costs of a prospective resource. System costs embrace all direct costs as well as the estimated cost of distribution and transmission, waste disposal, end-of-cycle requirements, fuel, and quantifiable environmental costs and benefits. It should be noted that while most system costs relate directly to, and are borne by, rate payers, environmental costs and benefits affect a broader population.

1.1.1 The Resource Program Environmental Impact Statement

Bonneville considers the RPEIS to be an integral part of its planning process, ensuring that Bonneville meets its future load obligations in a cost-effective and environmentally sound manner. Recent load growth has underscored the need for flexible planning to meet projected but uncertain (and possibly irregular) growth without making unnecessary expenditures. It is Bonneville's intention that the RPEIS evaluate environmental trade-offs among various resources potentially available in its resource stack (resources, listed roughly by cost, that Bonneville anticipates will be available to meet electric power needs).

The RPEIS outlines 12 alternative resource acquisition scenarios to meet forecasted load growth (see Figure 1.1). To ensure that the maximum potential environmental impacts of the 1990 Resource Program are evaluated, Bonneville is examining resources called for under the high load forecast as the basis for the RPEIS.

The economic valuation of environmental impacts for the RPEIS is not mandated by law. However, Bonneville has recently determined that environmental costs should be determined to the extent and degree of accuracy possible so that these costs can be included in the calculation of cost-effectiveness the agency currently uses to evaluate new power resources.^(a) To provide a consistent basis for evaluating potential power resources, their environmental costs will, wherever possible, be reduced to and expressed in dollars. However, both quantifiable and nonquantifiable costs will be analyzed.

The RPEIS analysis is intended to be broad enough to support future Resource Programs. Bonneville plans to begin using the RPEIS, along with other analyses, to guide its Resource Program planning in 1992 and beyond. When or if specific resource acquisitions are proposed, Bonneville anticipates that "site-specific" environmental documents will be prepared to evaluate their impacts. Thus, a major purpose of this report is to review techniques that are candidates for use in economic valuation of the wide range of environmental impacts associated with power resources.

Of particular importance to Bonneville is the development of a set of standards that can be applied to economic estimates of the value of environmental change. The establishment of such standards will permit proposals to be assessed fairly, enhance the credibility of the analyses, and improve the efficiency of decision-making.

(a) State governments and Public Utility Commissions increasingly are requiring environmental costs to be included in resource decisions. These efforts are briefly described in the Appendix.

1.1.2 Limitations of the Analysis

There are three major types of limitations to the economic analysis documented in this report. There are a host of problems associated with the transfer of economic results from one area of the country to another, and from one time period to another. There is uncertainty about the interactions between the economic effects evaluated. Finally, there is uncertainty about which environmental effects are important to model. These limitations are discussed in more detail in Chapter 3.

1.2 STRUCTURE OF REPORT

Following the background information provided in this introduction, Chapter 2 details the economic techniques used to quantitatively value economic impacts. Chapter 2 also reviews the literature pertinent to the specific resources of interest to Bonneville. Assumptions and adjustments made in these approaches to derive the specific cost estimates provided in Chapter 3 are described in the course of developing and documenting these costs. The limitations of both the existing tools and present calculations are also discussed in Chapter 3. References are in Chapter 4.

1. **Status Quo**
Bonneville continues doing business as usual. Bonneville chooses new resources based upon minimizing system total cost, without accounting for environmental externalities.
2. **Base Case**
Bonneville includes environmental externalities in calculating total system cost. This is the benchmark case against which other cases will be compared.
3. **Emphasize Conservation**
This alternative moves lost opportunity and discretionary conservation resources to the top of the resource stack.
4. **Emphasize High Conservation**
A higher amount of conservation is emphasized than in the previous alternative, reflecting conservation measures expected to become cost effective within the planning horizon.
5. **Emphasize Coal** - This alternative has two subalternatives:

 Conventional Coal
 This alternative places coal as the first resource added to meet new loads.

 Clean Coal
 Clean coal technology, including fluidized bed and coal-gassification, are moved to the top of the resource stack.
6. **Nuclear**
This scenario meets load requirements by completing nuclear plants WNP-1 and WNP-3.
7. **Combustion Turbines**
Combustion turbines will be the first resource used to meet load growth.
8. **Renewables**
Renewable resources (hydro, solar, wind, and geothermal) will be moved to the top of the resource stack.
9. **Cogeneration**
This alternative makes cogeneration resources the first to be completed to meet new loads.
10. **Fuel switching**
This alternative will model fuel switching as a program.
11. **Imports**
This alternative uses energy from long-term firm contracts to supply new energy to the region.

FIGURE 1.1. Resource Program Scenarios Proposed by the RPEIS

2.0 ECONOMIC TECHNIQUES

This chapter describes available techniques for use in the economic valuation of environmental impacts associated with new power resources. This chapter surveys the literature pertinent to evaluation of the specific environmental impacts--human health, ecological, visibility, and river recreation--covered in Bonneville's RPEIS.

The applicability of these methodologies to the cost estimates developed in Chapter 3 is also discussed. Each of the methods will be used to value one or more impacts for the RPEIS. Variations in the nature of the data, the character of the impacts, and the usefulness of the results, determines the specific methodologies selected for the assessment of a particular impact.

2.1 OVERVIEW OF TECHNIQUES

This section provides background information on economic valuation. It discusses the term economic welfare and the distinction between market and nonmarket goods. Section 2.2 discusses the straightforward valuation of market goods. Sections 2.3 through 2.10 describe specific techniques available for estimating the economic value of goods that are not priced, bought, or sold in observed markets.

2.1.1 The Valuation Process

Figure 2.1 illustrates the process of assessing the environmental impacts of a coal-fired power plant. This process involves five steps: 1) identifying what is emitted and which emissions present environmental risks; 2) determining the dispersal of the pollutants and the transformations they undergo; 3) determining the size and type of population exposed to the environmental risk associated with the pollutants; 4) estimating the response of the exposed populations based on dose-response functions; and 5) assigning a dollar or market value to the physical effects calculated in Step 4.

This process requires complex linkages between measured and modeled data produced by a variety of analytical techniques. For example, plume dispersion models are used to determine air pollution levels and exposures areas; dose-

response relationships and risk factors are used to determine biological effects. The economic valuation process properly describes only the last step, Step 5, which assigns an economic (dollar) value to the physical effects calculated in Step 4.

Economic values or costs represent the value of foregone opportunities or reductions in well-being caused by power plant emissions. Economic value, which represents the net benefit or net cost of an economic good or service, is the amount an individual would be willing to pay for it (or what the individual would accept to sell it). This willingness to pay (WTP) may only exist under hypothetical circumstances.

In the context of this report, there are two kinds of value associated with an environmental resource: its consumption value (use value) and its intrinsic value (nonuse value). Use values are associated with activities such as fishing, hunting, picnicking, or boating. Nonuse values represent people's willingness to pay who will never use the resource, but are willing to pay something to know that others can use it. Nonuse values include such things as existence values, sacred values, and bequest values. Both measures are legitimate economic measures, although the majority of existing economic valuation studies are based exclusively on use values.

The evolution of environmental economics techniques has created a hierarchy of perceived reliability, as shown in Figure 2.2. This hierarchy is hotly disputed within the economics profession. Nevertheless, an important criteria in selecting a valuation technique is where it falls in the reliability/ease of implementation hierarchy.

2.1.2 Market and Nonmarket Goods

Bonneville's current practice reflects a conventional breakdown of resources among economists: the categorization of resources as either market or nonmarket goods. Market goods are those goods which are bought and sold in an organized, observed market. An example of market goods that are affected by air pollution is crops. Nonmarket goods are those which are not sold in organized markets. An example of a nonmarket good is human health. Although each of these goods must be treated differently, methodologies to evaluate

both categories of goods are available. BPA has determined that its present use of valuation techniques should be extended to include as many nonmarket goods in the RPEIS as can be reliably included.

Market goods are the most straightforward for economists to evaluate, because they have observed prices and quantities. This allows economists to estimate the relative size of damages from pollution, for example, and to value those damages. For small changes the value is the price, for larger changes the value can be assessed from the demand schedule.

Two types of approaches are available for the valuation of nonmarket goods. Each approach type has different strengths and weakness, as is discussed in the following sections. The first approach is a survey technique, known as the contingent valuation method (CVM), which bases value on how respondents react to hypothetical markets. This approach provides what economists call a "stated preference." The second type of approach embraces a number of indirect methods that yield what economists call a "revealed preference" and these approaches are based upon behavior observed in real markets. Indirect methods discussed in this chapter include hedonic and travel cost models.

Demand equations typically isolate the factors that influence how much of a particular good or service is purchased by a consumer. However, there are some goods that consumers purchase as a single unit, rather than in quantity. For such goods, the choice is not how much of the good to purchase, but rather which particular type, style, brand, or model best fits the consumer's needs, or, in the choice of a recreation site, which bundle of attributes to select.

2.1.3 The Contingent Valuation Method

The contingent valuation method is the most direct, and most commonly applied, method of eliciting the value of a given resource. In this process, respondents are posed questions on their willingness to pay for a good or service not usually traded in a market. The economist's ability to deduce value from these responses depends on the researcher's ability to define and

establish the hypothetical market in such a way that the respondent can make meaningful choices and thus provide a credible response.

A wide range of environmental resources have been valued using the contingent valuation method, including recreational fishing, hunting, water, air, quality improvements to lake preservation, and trees in urban parks. Although the contingent valuation method is gaining increased acceptance by the economics profession, especially for valuing environmental resources, economists have traditionally placed more reliance on indirect methods that base the value of the nonmarket goods on observed behavior in real markets. In situations where it may be possible to apply either a stated preference or a revealed preference technique, but not both, most economists would be likely to opt for the revealed preference approaches.

2.1.4 Hedonic Methods

Although economists have long acknowledged that there are more dimensions to a good than simply its quantity, efforts to incorporate such characteristics into theoretical and empirical models have been relatively recent. The hedonic method is based on the notion that the price of a market good (e.g., a house) is the sum of the value of the characteristics of the good (the number of bedrooms, square footage, neighborhood etc). This idea has been applied with considerable success to both property values and wages.

In the case of property values the effect of environmental externalities (such as a bad smell from a smelter) reduces the value of the house in an amount equal to the value of the externality. In the case of wages, the additional risk to health from a dangerous job should be equal to the additional wages needed to get an individual to take the job. These methods have been applied to value human health risks, air pollution, and other externalities tied to jobs or property. An additional technique, the hedonic travel cost method, determines the value of individual recreational sites. The major hedonic techniques are illustrated in Figure 2.3.

2.1.5 Travel Cost Methods

Travel cost methods use cost of travel to a site as a proxy for price. These techniques are useful for valuing impacts at a location that people

visit, when that location is not subject to market transactions. Figure 2.4 illustrates the major travel cost variations. The simple travel cost method is used to determine the value to users of a single site. Recently, methodologies have been developed that extend the simple approach and provide different interpretations of how to use travel costs and site information. These techniques estimate individual values of a related group of sites. These techniques have been used extensively to value impacts on recreational sites and activities.

The multiple-site travel cost model can be used to define types of sites and to value the loss of one or more sites. The most important contribution of this method is its ability to treat substitute sites. Share models allocate the share or proportion of a season's trips to a particular site as a function of the site's characteristics. Allocation of the proportion of visits to a site is analogous to the quantity purchased in a neoclassical model of consumer behavior. The hedonic travel cost model can be used to value individual characteristics of a site and the changes associated with both large or small changes in site quality.

All of these travel cost models assume that the choice to participate has already been made. The random utility model differs from these models in that it recognizes that site selection is a discrete choice process and models the decision accordingly. Random utility models are discussed in more detail in Section 2.10.

2.2 MARKET-BASED VALUATION TECHNIQUES

For a market good, the economic value of the impacts to society from increased pollution is simply the change in output times the appropriate value of the good. Evaluating the size of the damages to market goods is done by comparing the total damages to the total quantity sold in the market. For example, the ECO Northwest Generic Coal Study (ECO Northwest 1987) found that the wheat crop could be expected to drop 3,048 bushels due to ozone damage from a coal plant located on the east side of the Cascade Mountains; this equates to a dollar value loss of \$10,744. Similar calculations can be made for any given marketed good.

2.2.1 Application of the Technique

The process through which valuation is undertaken is relatively straightforward. The first step is to determine whether the environmental damage is marginal. A marginal damage is one that does not affect prices. For example, losing a ton of wheat will not affect the world price of wheat. Losing a million metric tons of wheat may affect prices. If the loss is marginal, the quantity lost is simply multiplied by the observed market price. This results in an estimate of social loss that is easy to obtain (prices are easy to find) and is not overly controversial.

If one finds that the loss is not marginal (i.e. it will result in a change in prices), then a demand curve must be estimated. A demand curve is simply the relationship between the reduction in the quantity of the good and the change in the price. Estimating demand curves for market goods is well-understood and is well-accepted. In general, the data used is relatively available and is of good quality. Given the demand curve, the economic loss from the environmental impact is straightforward to estimate even given large losses.

2.2.2 Advantages/Disadvantages

The distinguishing feature of the market-based valuation is that consumers and producers are observed making direct decisions about the good. As a result there is very little interpretation involved until the statistical analysis begins. Even then, the statistical analysis is based upon several decades of experience.

Quantifying the physical damage in relation to the overall market provides the information needed to determine the value of the damages. Confidence in demand curves estimated for marketed goods is relatively high among economists. When an environmental factor effects large changes in the quantity of a market good that is produced, the demand curve will provide the value for each unit.

2.3 CONTINGENT VALUATION METHOD

The contingent valuation method is the most direct, and most commonly applied, method of eliciting the value of a given resource. In this process, respondents' willingness to pay (WTP) for a good or service (not usually traded in a market) or their willingness to accept compensation for giving up the commodity (WTA) is established. The economist's ability to deduce value from this response depends on their ability to define and establish the hypothetical market in such a way that the respondent can make meaningful choices and thus provide a credible response.

2.3.1 Application of the Technique

The essential features of all CVM surveys include 1) a clear description of the valued commodity and the circumstances the respondents are asked to consider; 2) questions that elicit the respondents' WTP or WTA; and, 3) questions that provide such information as the respondents' characteristics, their preference for the valued good, and their experience with the good. When designing the valuation question(s), the researcher must make several choices, i.e., whether to determine WTP or WTA, resolving whether ex ante or ex post measure is most relevant, and determining whether to elicit total value, use value, or existence value for the good.

Researchers usually have considerable leeway in designing the hypothetical contingency. For example, investigators may emulate a private market situation or a public referendum. In most cases, the choices made depend upon creating situations that are the most credible to respondents and/or most relevant to the policy choices that must be made. Methods, as well, must be determined by the researcher(s). There are several well-established options: an open-ended framework, payment card, sealed bid auction, bidding game, oral auction, and dichotomous choice framework. Finally, the researcher(s) must specify a payment vehicle for the hypothetical situation that is appropriate for the good in question.

Generally, contingent valuation method surveys can be administered using one of three methods: in-person interview, telephone survey, or mail questionnaire. The choice often depends on the survey's complexity, the

projected usable response rate, the ability to account for missing data, and practical factors such as timeliness and cost. If funding permits, the personal interview is most often the preferred technique because more complex ideas can be treated, respondents may be more conscientious in replying, and data obtained in this manner can more easily be corrected for missing data. On the other hand, when a valuation is straightforward, alternative instruments can reach a wider population at lower cost. Sample size can sometimes be a critical factor since the reliability of sample statistics depends upon sample size as well as the treatment of outliers (Mitchell and Carson 1989).

Estimation of WTP and WTA depends upon the design features of the survey. If questioning is open-ended (where respondents are asked for their maximum WTP), the responses may simply be averaged across the entire sample. The average (or median) WTP can then be aggregated to the total population affected. In some cases, researchers may choose to regress WTP based on individual characteristics, e.g., age, income, biases toward the particular good, experience with the good, etc. This enables evaluation of the reliability of the responses and their possible sensitivity to individual differences (Cameron and James 1987; Kealy, Dovidio, and Rockel 1988).

Because surveys using the dichotomous choice framework ask individuals to indicate only whether they are willing to accept a specified sum for the good, calculation of mean WTA using these responses requires the application of an empirical model to estimate the parameters of the utility function (Hanemann 1984) or WTA function (Cameron and James 1987). The characteristics of the model depend on the procedure chosen by the researcher(s) and the specified sum is randomly distributed across the survey sample.

For example, in one such model, the probability of acceptance would be estimated and then either the maximum WTP (from the expected value of the individual's utility function) or the point at which the individual becomes indifferent to accepting or rejecting the offer would be derived. The point where the respondent becomes indifferent is interpreted as the median of the distribution of WTP. Generally, these measures are different except when

assumptions are very restrictive in regard to the utility function; in these cases, the investigator can choose which measurement to use.

An alternative procedure has been developed that makes use of the variation of specified sums to derive point estimates and uses these estimates to establish the parameters of the individual's true WTP (Cameron and James 1987; Cameron 1988).

2.3.2 Relevant Studies

A wide range of environmental resources/commodities have been valued using the contingent valuation method. Among the activities assessed have been recreational fishing (Cameron 1988; Cameron and James 1987; Mitchell and Carson 1989) and hunting (Bishop and Heberlein 1979). More general resources have also been valued, such as water (Desvousges, Smith, and Fisher 1987; Kealy, Dovidio, and Rockel 1987), air (Loehman and De 1987), quality improvements to lake preservation (Loomis 1989), and trees in urban parks (Brookshire and Coursey 1987).

Certain recreational fishing studies have compared the results of contingent valuation method studies (stated preference) to those obtained from travel-cost demand models (revealed preference). In Montana, results based on a sample of 2,171 recreational fishermen completing a mail survey of their WTP for catching larger or more trout yielded a mean estimate of \$127 across all user types and rivers. In 1985, an earlier study, using a demand model (anglers were asked whether they would have made their current trip to a visited site if their share of expenses had been higher by a specified sum) revealed an extremely similar mean WTP estimate of \$122 across all sites and angler types.

Another comparison of the contingent valuation method and the travel cost model is provided in a study related to a reduction of anadromous fish in the San Francisco Bay and ocean areas. The contingent valuation method approach revealed much larger welfare estimates (by a factor of 1.5 for WTP and 3.5 for WTA) than those estimated using the travel cost model approach. In this case, the investigator concluded that the estimates were not the same and did not reflect the same underlying utility function. However, the WTA

and WTP, which were based on the same utility function, also reflected a significant difference in value. This variation in values may be due to more complex factors than simply the choice of valuation technique (Huppert 1988).

2.3.3 Advantages/Disadvantages

An advantage of using the contingent valuation method to measure welfare is that the technique permits the design of questions to elicit exactly the valuation data needed. Conceptually, the contingent valuation method is simple and straightforward but, as has been indicated, implementation of contingent valuation method studies appears to require great care. Researchers must resolve issues of theory and must carefully address broadly held concerns about how clearly the good to be valued is defined and described. In addition, researchers must determine the market context, the method of obtaining information, the payment mechanism, the survey method, and the sample design. Lastly, researchers must realize there are several possible sources of bias in individual WTP and WTA responses that should be circumvented to the extent possible.

Potential sources of bias in contingent valuation methodology are a concern of many economists and the literature on this subject is extensive. Detailed assessments of the technique have been made and may be useful for those who seek more information than this overview is designed to provide (Cummings, Brookshire, and Schulze 1986; Mitchell and Carson 1989).

2.4 HEDONIC PROPERTY VALUE MODELS

The hedonic property value technique is based on observations of housing sales. In this technique, the price of a house is regressed on the characteristics of the house. The estimated parameters from this approach provide an estimate of the price of an additional unit of that characteristic. In the case of environmental externalities, the parameter on the externality variable is the price of additional unit of the externality. If the externality is bad, then the price will be negative. Essentially, people have to be bribed to accept an additional unit. This approach has been widely applied to value air pollution. If the city has prevailing winds, then the quantity of nitrogen oxide, for example, will be negatively related to housing

prices. The parameter on the nitrogen oxide variable will be the price of additional nitrogen oxide.

2.4.1 Model Specification

Most analyses of relationships between environmental factors and property values have made use of a specialized version of the Rosen model that concentrates on the consumer. Environmental factors that may be present in different locations are assumed to be exogenously determined. To illustrate, an abridged version of the model used in a study conducted by Polinsky and Shavell (1976) is included:

An individual living in a small open city with a central business district (CBD) to which all individuals travel for work faces the following problem:

$$\begin{array}{ll} \text{Maximize} & U(X, Q, A(K)) \\ X, Q, K & \end{array} \quad (2.1)$$

Subject to

$$M = P_x X + P(K)Q + T(K)$$

where

X	=	a private good
Q	=	housing
$A(K)$	=	amenities available K miles from the CBD
M	=	income
P_x	=	the price of the private good
$P(K)$	=	the price of housing K miles from the CBD
$P(T)$	=	transportation costs K miles from the CBD.

$A(K)$ and $T(K)$ are exogenously determined while $P(K)$ is exogenous to the individual but determined by the equilibrium of the local housing market. In this model, the indirect utility function can be represented by $V(M - T(K), P_x, P(K), A(K))$. In a small open city it can be assumed each individual is able to enjoy a common, exogenously determined level of utility, or $V^* = V(M - T(K), P_x, P(K), A(K))$. This equation can be used to determine the equilibrium rent function, $P^*(K)$, which depends on the function $A(K)$ as well as other factors.

2.4.2 Relevant Studies

Price indexing problems created by quality changes were the underlying factor driving the earliest research that attempted to analyze the characteristics of goods. In these early studies, two sources of price variations were established: changes in the amount of the good's characteristics and changes in the prices of the characteristics themselves. Since the prices for most characteristics are not explicit, their levels must be discerned from an analysis of the variations in the price of the goods in question. The price indexes derived from this type of analysis are called hedonic price indexes or hedonic functions.

Early empirical work focusing on the valuation of characteristics was also conducted in the analysis of property values in an attempt to determine the relationship between property values and air pollution (Ridker 1967; Ridker and Henning 1967). The studies concluded that air pollution (measured in terms of sulfation levels) was negatively related to median property values but this conclusion was subsequently challenged (Freeman 1971). Later, it was shown that the relationship between a product's price and one of its characteristics does not clearly establish the value of the characteristic itself but simply the locus of market opportunity--the price at which the characteristics can be traded (Freeman 1974).

Up to that point, the theoretical foundation to permit deriving individual values from the market opportunity did not exist. However, in 1974, this foundation was supplied by Rosen, who created a model, building on work by other researchers (Becker 1965; Lancaster 1966; Muth 1966). Rosen's model has been used in one form or another in nearly all of the hedonic work done since 1974 and is the theoretical basis for the specific hedonic models discussed in this report.

The pioneering studies assessing the cost impacts of air pollution, while controversial and perhaps flawed, established the principle that environmental factors, at least air pollution, have a significant effect on property values. Despite disagreements over how to interpret results, early findings encouraged further work on assessing environmental costs.

For example, later examination of property value in three cities included two air pollutants (sulphur oxides and suspended particulate matter). Although the degree of collinearity between the two pollutants measured was high, the study found that the effect of pollution on median property values was both significant and mostly negative (Anderson and Crocker 1971).

Up to that point in time (1971), study results could not be translated into an estimate of the benefits of reducing air pollution. This effort was advanced by Freeman (1974) who suggested a procedure similar to Rosen's. A model developed by Polinsky and Shavell (1976, 1978) was used to estimate the total market's WTP for improvements in amenities and could also be used for individual WTP if sufficient restrictions were placed on the structure of preferences.

Later, Nelson (1978) used the model suggested by Rosen to study the effect of particulate and oxidant concentrations on residential property values in Washington, D.C., revealing a significant negative relation between property values and measures of pollution. A study of housing values in Boston, separately measuring nitrogen oxide levels and particulate concentrations, estimated the hedonic price function. This was later regressed to analyze estimated marginal prices for the pollution measures on income and pollution levels, finding that the relationship was positive over a number of functional specifications (Harrison and Rubinfeld 1978).

Several other studies examined property values with the hedonic method but differed from the "standard" model in one way or another. These analyses determined that environmental factors had significant economic impacts. For example, David (1968) studied the effect of water quality on property value. Miranowski and Hammes (1984) examined the relation between farmland prices and measures of topsoil quality (depth, a measure of potential erosion, and soil Ph). Farmland prices were also analyzed by Palmquist and Danielson (1989) in a study that included measures of erosion, drainage, and soil quality.

2.4.3 Advantages/Disadvantages

Development of hedonic property models has not taken place in an unquestioning, uncontroversial environment. Certain assumptions in most

property value studies (chiefly those involving individual behavior, the continuous nature of the market, and the structure of the hedonic rent or price function) have been questioned by Maler (1977). Maler concluded that the hedonic estimates of WTP for environmental amenities will tend to include biases that are generally difficult, if not impossible, to predict. According to Freeman (1979), much of the criticism does not imply a systematic bias in such estimates although he pointed out that the bias can be predicted in several cases. For example, if it is expected that air pollution will be reduced over time and these expectations are capitalized into the present value of property, the true WTP will be underestimated in the relationship between present property values and present air pollution.

Despite such criticism, however, the hedonic property value methodology and approach can be useful in examining the value of the types of characteristics associated with housing. The method relies on market data to estimate the value of nonmarket benefits. The characteristics under study are part of a "market bundle" but are not themselves sold in a marketplace. The data requirements can be high, increasing with the number of factors studied, but the quality of the data derived from the approach is also high and the approach is preferred by many economists.

2.5 HEDONIC WAGE MODELS

The underlying premise of hedonic wage studies is that a job, like property, may have special characteristics that affect its "price." The most common approach uses a model similar to that developed by Polinsky and Shavell (1976) from which a labor supply function is derived. This function can be found to depend upon a city's level of amenities. To complete the labor market, a demand for labor can be derived, producing an equilibrium wage that is a function of amenities such as environmental quality.

2.5.1 Relevant Studies

Fewer studies have assessed the effect of environmental amenities on wages than on property values. A model in which environmental factors affect production and vary across cities was developed by Getz and Huang (1978). They found that air pollution measures are positively related to the wages of

only one of the three professions included in their study. This was not the case with a study conducted by Cropper and Arriaga-Salinas (1980) who found that air pollution was positively and significantly related to the earnings of eight out of nine professions they examined.

Roback (1982) estimated the effect of several city characteristics on both wage and property values. In the model for this study, city-specific amenities entered both the utility and production functions. In cases where land is consumed by both workers (for residences) and firms (for production), these amenities should be related to both wages and property values. Results showed a mostly positive relationship between particulate levels and wages but no significant relationship between particulate levels and property values.

2.5.2 Advantages/Disadvantages

Not as much attention has been given to hedonic wage models as to hedonic property value models. It is thus more difficult to evaluate their advantages and disadvantages. Wage studies clearly complement property value studies by capturing additional effects of environmental factors on economic values, i.e. wages. These studies also have an advantage in being able to access established microdata sets such as the Public Use Microdata Sample (containing hourly wages, years of education, job experience, etc.) However, these data sets do not contain information on nonmarketed amenities and this information must be somehow gathered and combined with the wage data.

To date, most applications of the hedonic wage model are somewhat incomplete because a model of firm decision-making has not yet been developed for use in a non-market context. This deficiency is important; without such a model it is presently unclear how firms can afford to pay the higher wages associated with lower amenity levels. Although this shortcoming can be overcome, the lack of such a tool creates the need for complex evaluation models and increases the data requirements.

2.6 SIMPLE TRAVEL COST MODEL

The simple travel cost model is designed to locate the market demand for a single recreational site and represents the most intuitive use of travel

costs as a proxy for price. Typically, no price is charged for access to a recreation site or, if a price is charged, it does not reflect the full cost of visiting a site. Travel costs to and from the site are often used as a proxy for the unpriced aspects of access to the site, based on the assumption that the utility of travel does not equal the full cost of the trip; that is, people do not travel for travel's sake alone. These techniques assume that if all else is equal, recreationists will select the site resulting in the lowest travel cost.

2.6.1 Model Specification

The demand for a free site is determined by a simple procedure. First, the area around the site is divided in circular zones within which travel costs are assumed to be equal. Second, the visitation rate from each zone is calculated from either site-specific or zonal sampling. (The "visitation rate" is the fraction of people from a given zone of origin who travel to a specific site.) The visitation rates are then regressed on the travel costs and socio-demographic variables. One point on the demand curve is the total visitation without any site fees and additional points are located by assuming that visitors respond to changes in site fees in the same way as to changes in travel costs. Each point is located by calculating the change in visitation due to an increase in fee costs. This process can be continued until the cost becomes so high that no one visits the site.

Finally, the visitation rate from each zone is regressed on the travel costs from that zone:

$$q = f(p_i, w_i) \quad (2.2)$$

where q = visitation rate from zone i
 p = travel costs to site
 w = demand shift variables.

The resulting Equation (2.2) can be interpreted as the demand curve for the site, if all other substitute sites and on-site characteristics remain unchanged. Any change in either the substitutes or the on-site

characteristics will produce unknown shifts in the demand curve which are not captured in Equation (2.2). This approach gives the demand for the site as a whole but does not allow one to separate the incremental value associated with the various specific attributes of the site.

2.6.2 Relevant Studies

The use of travel costs as a proxy for the price of a visit to a recreation site was first suggested by Harold Hotelling in 1947.^(a) Clawson and Knetsch (1966) developed this insight into the travel cost technique for valuation of a single site. The classic application of the relationship between travel costs and the economist's conventional concept of price is known as the Hotelling-Clawson-Knetsch Travel Cost technique.

2.6.3 Advantages/Disadvantages

There are a variety of circumstances for which the valuation of a single site may be insufficient for policy makers. In particular, issues related to enhancement of an existing site's attributes or the creation of a new site cannot be addressed in the context of the single-site travel cost. These limitations restrict the applicability of simple travel cost estimates. The simple travel cost model works best when the site already exists and no changes are expected in the available substitutes. For example, if policy makers asked how the number of users would change if an entry fee were charged at the site, a simple travel cost would reveal the answer. However, the questions of interest when assessing an impact (for example, of an acid deposition policy on fishing opportunities) would center on the attributes of a site.

Although this technique would provide an intuitive base from which to begin, it would be inadequate for more complex issues such as some of the types of issues that must be addressed in the RPEIS. More advanced techniques are available to provide responses to more complicated questions.

(a) See Clawson and Knetsch (1966).

2.7 MULTIPLE-SITE TRAVEL COST MODEL

The multiple-site travel cost model can be used to define types of sites and to value the loss of one or more sites. The most important contribution of this method is its ability to treat substitute sites.

2.7.1 Model Specification

The steps in model specification are listed as follows. First, sites with similar characteristics are grouped together by their characteristics. Second, travel costs from each origin to the closest site of each type are constructed. The number of visits to sites in a particular group is then regressed on the travel costs for the closest site in the group and the travel costs to other site groups. This procedure is repeated for all sites. The set of equations is shown in Equation (2.3).

$$q_i = f(p_i, p_j, w_k) \quad (2.3)$$

where q_i = visitation rate to site i
 p_i = travel costs to site i
 p_j = travel costs to site j
 w_k = k demand shift variables.

A second important contribution of the Burt-Brewer (1971) framework was to impose symmetry in the cross-price effects. This restriction, if valid, assures that the estimated demand system will provide unique welfare measures.

2.7.2 Relevant Literature

The multiple site travel cost technique was suggested by Burt and Brewer (1971). The most important contribution of this technique was its approach to treating substitute sites in a travel cost setting. LaFrance (1985, 1986) and LaFrance and Hanemann (1989) provided a derivation of the restrictions needed to assure that an incomplete demand system for several specifications can be derived from a well-behaved utility function. In the case of a linear demand system, for example, the symmetry constraint is consistent with the model in which there are no income effects from these goods. Most of the time this constraint has been justified on the grounds that recreation forms a very

small part of consumers' budgets, and so the restriction is approximately satisfied. However, Burt and Brewer (1971) found that the data rejected the restriction in their example.

2.8 SHARE TRAVEL COST MODELS

Share models allocate the proportion of trips among a discrete set of alternatives. The allocation is based on the characteristics of the site, the costs of access, and the characteristics of individuals. Distinctions between share models and demand models such as the Multiple Site Travel Cost model arise in the econometric specification.

In general, specifying that the share equation is normally distributed, for example, implies that the stochastic specification of the demand system is intractably distributed. The same holds true for the share equation if the demand equations are believed to be normally distributed. The choice between conventional demand and share equations depends on where the analyst believes the error terms belong.

Share models proceed from neoclassical economic models of consumer behavior. Allocation of the proportion of visits to a site is analogous to the quantity purchased in a neoclassical model of consumer behavior as shown in Equation (2.4). Suppose that visits to the recreational sites under consideration are denoted as x_i and all other goods are subsumed into z . Given a standard utility function and a budget constraint, it is possible to derive demand functions like Equation (2.4).

$$x_i = f(p_{xi}, p_{xj}, p_z, y) \quad (2.4)$$

where

p_{xi}	=	the price of the good x
p_{xj}	=	the price of the other recreational sites
p_z	=	the price of the composite good
y	=	income.

A quantity share equation expresses demand in terms of the fraction of visits to a given site, rather than the total number of visits to a site. That is, x_i in Equation (2.4) is replaced by the term $[x_i/(x_i + \sum(x_j))]$. Expenditure share equations can also be developed in an equally simple manner.

The share equations can be derived from a well-understood utility function. Morey (1984) has used the constant elasticity of substitution preferences and the quadratic expenditure system to derive share equations. As a result, this approach will lead to well-defined measures of economic welfare. The tightness of the theoretical structure of share models allows them to be well-understood.

2.9 HEDONIC TRAVEL COST MOOEL

The hedonic travel cost method focuses on valuing the characteristics of recreation sites. Each site is viewed as a bundle of attributes (e.g., fish species, fish size, campgrounds, access) with the travel cost being the purchase price of this bundle. If quantities of attributes and travel costs vary across the sites, the travel cost may be apportioned among the attributes of the sites.

2.9.1 Model Specification

The first stage of the hedonic travel cost method seeks to explain why people from a particular origin select certain recreation sites to visit. The travel cost that an individual is willing to incur to visit a specific site is postulated to be a function of the attributes of the site:

$$TC = f(q_i) \quad (2.5)$$

where TC is travel costs and q_i is the vector of attributes at the site. Clearly residents of any particular origin need not visit all sites. Some sites will not be worth the travel cost incurred in visiting them and therefore will not be visited. Equation (2.5) should be estimated for each origin using only the sites visited and their characteristics as observations. In equilibrium for all sites visited, the travel costs will equal the value of

all the attributes. The marginal travel cost associated with the acquisition of an additional unit of an attribute is the derivative of Equation (2.5) with respect to that attribute.

Equation (2.6) shows a linear version of Equation (2.5). The estimated coefficients (p_i) of the vector of attribute quantities (q_i) represent the marginal willingness-to-travel for the corresponding attributes. Equivalently, those coefficients are the implicit prices of the attributes:

$$TC = a + p_i * q_i \quad (2.6)$$

Since each origin faces a different travel cost structure, a second stage of regressing the quantities of characteristics on the estimated implicit willingness-to-travel reveals the demand function for a given attribute:

$$q_i = f(p_i, p_j, w_k) \quad (2.7)$$

where q_i = quantity of attribute i
 p_i = estimated implicit price i
 p_j = estimated implicit price of substitutes
 w_k = demand shift variables.

The demand system implied by Equation (2.7) can be estimated using different functional forms. If the functional form chosen is compatible with a well-behaved quasi-concave utility function, then Hicksian welfare assessments can be made using the estimated parameters.

2.9.2 Relevant Literature

There have been two applications of the hedonic travel cost method in the Pacific Northwest. Brown and Mendelsohn (1984) apply the hedonic travel cost method to value steelhead fishing attributes in the Pacific Northwest. Englin and Mendelsohn (1991) apply the method to examine the value hikers place on forest eco-systems in the Cascade Mountains. Englin and Mendelsohn (1991) apply the appropriate restrictions to allow the estimated demand system

to be used to evaluate multiple simultaneous price or quantity changes in attributes.

2.9.3 Advantages and Disadvantages

The hedonic travel cost method has several advantages and disadvantages. One of its important advantages is that it provides direct estimates of both the marginal and non-marginal values of attributes. If the physical effect being valued is known to create only marginal impacts then the first stage of the method is sufficient for valuation. If not, then the second-stage demand functions can also be estimated.

A characteristic of the method is that it requires many recreation sites where visitation comes from a broad area. This is a disadvantage in that it requires a lot of data. The data needed, however, is often routinely collected as visitor permits or from site questionnaires. Two further difficulties are associated with the method. One is the need for good information about the characteristics of sites. The second is the extensive computational requirements of the method (typical applications require 30 to 60 price regressions and up to a dozen demand regressions).

2.10 RANDOM UTILITY MODELS

A common characteristic of all the travel cost models presented above is that the choice to participate has already been made; the travel cost model predicts which site will be chosen. The random utility model differs from these models in that it explicitly recognizes that site selection is a discrete choice process and models the decision accordingly. The underlying assumption of the random utility model is that the consumer, when faced with the choice between a number of different alternatives, will select the one that brings him or her the greatest enjoyment, or utility.

2.10.1 Model Specification

Suppose, then, that an individual faces m choices. According to the random utility model, there is an unobservable utility index associated with each choice which can be expressed as $U_i = V_i(X_i) + u_i$, where X_i represents the observable attributes of the i th choice and u_i is a disturbance term that

captures the unobserved random influences on the consumer's utility level. The probability that an individual chooses alternative i is given by:

$$\begin{aligned} \text{Prob}(U_i > U_k \text{ for all } k \neq j) = \\ \text{Prob}(u_i > u_k - (V_i - V_k) \text{ for all } k \neq j) \end{aligned} \quad (2.8)$$

Once the functional form of $V(\bullet)$ has been specified, and with it the joint probability distribution for the disturbance term, then a likelihood function can be determined and the parameters of $V(\bullet)$ can be estimated by any of the various maximum likelihood methods.

If the decision process being modeled involves sequential choices, the model can be empirically estimated by "nesting" the choices in the framework of a decision tree. In that case, there are several different solutions to the problem, but the one used most commonly in the recreation valuation literature is the nested logit model, attributed to McFadden (1974). This approach, which McFadden showed was consistent with the random utility model, involves the sequential application of the conditional logit model.^(a)

Given the multitude of recreational activities and sites, a single-stage estimation procedure, such as one advocated by Hausman and Wise (1978), is intractable. Nested logit formulations of the recreation decision tree allow the model to be applied to complex recreation valuation exercises.

Decision trees are usually organized along the following lines. The first choice a consumer makes is what sort of recreation to participate in. The choice set here may be fishing, boating, or swimming. If fishing is chosen, then the recreationist chooses the kind of waters to fish. The consumer may choose a large lake, small lake, a river or a stream. The consumer then would choose the species of fish to be sought, e.g., catfish,

(a) A second important feature of the nested logit model is that it can be specified in a manner to eliminate the IIA problem. Whereas the residuals in the conditional logit model have independent extreme value distributions, those in the nested logit model conform to the generalized extreme value distribution, which does not require the residuals to be independently distributed among choices.

bluegill, trout, or steelhead. So, even in this simple model, there are three nested choices. The first is what kind of recreation, the second is what kind of water, and the third is what species of fish.

2.10.2 Advantages/Disadvantages

The random utility model represents one of the most well-developed models of recreation behavior. As a result of this clarity, well-defined welfare estimates can be produced for multiple price or quantity changes. How characteristics enter the random utility model can also be understood, and therefore, the model allows evaluation of changes in characteristics at recreational sites.

1. AIR EMISSIONS FROM COAL PLANT
 - Sulfur dioxide
 - Carbon monoxide
 - Carbon dioxide
 - Particulates
 - Nitrogen oxides
2. DISPERSION
 - Pollutant concentrations
 - Downwind
 - Atmospheric chemical changes
3. EXPOSURE
 - Population exposures to pollutants
 - Human
 - Crop
 - Materials
 - Wildlands
 - Forests
 - Aquatic systems
4. DOSE RESPONSE
 - Premature mortality
 - Increased morbidity
 - Minor ailments
 - Lost visibility
 - Reduced crop productivity
 - Reduced forest yields
 - Reduced fish populations
 - Visibly altered wildlands
5. VALUATION
 - Dollar value of increased mortality risk
 - Dollar value of increased morbidity risk
 - Dollar value of minor ailments
 - Dollar value of visibility loss
 - Market value of materials lost
 - Market value of crops lost
 - Market value of timber lost
 - Dollar value of lost fish
 - Dollar value of altered wildlands

Sum of above damages = Total Damages

Total Damages/kWh = \$/kWh

FIGURE 2.1. Example of Valuation for Coal-Fired Power Plant

FIGURE 2.2. Types of Values and Hierarchy of Uncertainty

HEDONIC TECHNIQUE

Hedonic: (pleasure seeking) determines value of component parts

A. Hedonic Wage

- 1) Used to value risk of injury
- 2) Jobs with greater risk have higher pay
- 3) Regress wage rate on job characteristics
- 4) Reveals that risk 1/10,000 worth between \$100 and \$500.

B. Hedonic Property Studies

- 1) Used to value air pollution, hazardous waste, visibility
- 2) Regress house value on home features including environment
- 3) Reveals residential value for particulates and visibility

C. Hedonic Travel Cost

- 1) Used to value the quality of a site, fish catch of a river, harvest rate of big game
- 2) Regress miles traveled on recreation site features. People travel further for better sites: reveals values.
- 3) Has shown that acid rain effects in New England are only in the millions of dollars. Has shown that people travel further to see old-growth forest implying a value of about \$2 per trip per mile of old growth.

FIGURE 2.3. Major Hedonic Technique Variations

TRAVEL COST VARIATIONS

A. Simple Travel Cost

- 1) Used to determine value users place on a site.
- 2) Estimate demand for trips to the site. Regress trips taken on travel cost and other variables.
- 3) Estimate consumer surplus underneath demand function for each user.
- 4) Sum value across all users.

B. Multiple Site Travel Cost

- 1) Define types of sites.
- 2) Estimate demand functions across types.
- 3) Value loss of one or more sites.

C. Generalized Travel Cost

- 1) Estimate across many sites.
- 2) Explain variation by quality of own site.
- 3) Estimate value of any single site.
- 4) Estimate value of quality by change in consumer surplus.

D. Hedonic Travel Cost

- 1) Estimate value of site characteristics.
Regress travel cost on site features.
- 2) Estimate demand for site features.
Regress quantity of feature chosen on price.
- 3) Value either small or large changes in site quality.

E. Random Utility Model

- 1) Estimate logit choice model across sites.
- 2) Value any specific site.
- 3) Value site features.

FIGURE 2.4. Major Travel Cost Technique Variations

3.0 APPLICATION OF ECONOMIC VALUATION TECHNIQUES

This chapter documents the economic valuation of environmental impacts associated with the alternative resource scenarios in Bonneville's RPEIS. Regional economic values are calculated for human health effects, crop losses, and visibility reductions associated with increased air pollution from power-generation sources. The impacts are converted to dollar terms using economic estimates of value from studies that have applied the quantitative valuation techniques discussed in Chapter 2. Variations in the nature of the data, the character of the economic impacts, and the usefulness of the results determine the specific methodologies selected to assess the impacts.

3.1 BACKGROUND INFORMATION

The economic analysis takes the physical effects data and combines it with price data (for market goods such as crops) or values produced by economic valuation studies (for nonmarket goods) to calculate the total costs associated with the environmental effects of each of the alternatives. The physical effects data is described in the following section. Sources of price data and economic values will be discussed as they are employed in the cost calculations.

3.1.1 Physical Effects Data

Separate studies of air quality and visibility effects, human health effects, and ecological effects were conducted to produce the original physical effects data needed to evaluate the impacts of the power-generation scenarios (Glantz et al. 1992). Each study evaluated impacts at the beginning of the study period (1991) and in the years 2000 and 2010 for the 12 alternative power-generation scenarios. Effects were estimated for four generic plant locations: Western Washington, Eastern Washington, Eastern Oregon, and Eastern Montana. The effects at each site were then summed to determine the total impact of each resource program alternative.

The air quality analysis is described in Chapter 5 of Bonneville's RPEIS (BPA 1991) and provides information on emissions and dispersion for criteria pollutants (nitrogen oxides, sulfur oxides, and particulate matter), ozone,

and heavy metals. The air quality analysis also estimates the amount of acidic deposition associated with each of the power-generation alternatives. For the visibility analysis, the air quality data is used to evaluate the reduction in visual range associated with air pollution.

The human health effects analysis (Glantz et al. 1992) takes the air quality data and estimates the human health risks for the population exposed to power-plant emissions. Mortality effects are evaluated for the criteria pollutants and ozone; morbidity effects of the criteria pollutants are also evaluated.

The ecological-effects analysis estimates the impacts of air quality changes on crops, vegetation, and wildlife. The ecological effects analysis also estimates the impacts of changing water levels on wildlife, recreation, and irrigation. The analysis of hydro effects is primarily qualitative, consisting of narrative descriptions of the effects on wildlife habitats and human activities.

3.1.2 Sources of Economic Value

The economic value of health and environmental risks is measured in terms of society's willingness to pay to avoid the risks. Willingness to pay can be calculated using the various valuation techniques discussed in Chapter 2. Table 3.1 shows the specific impacts evaluated for the RPEIS and the economic techniques commonly used to value them. The economic values for specific impacts are taken from existing studies. These values are multiplied by the magnitude of the physical effects to derive the total regional costs associated with the environmental impacts. All dollar values are adjusted to reflect 1991 dollars using the factors in Table 3.2.

The costs associated with human mortality risks are estimated in this analysis using the results of hedonic wage studies; contingent valuation study results are used to value morbidity risks. Contingent valuation studies also provide the value for reductions in visibility associated with power-plant emissions. The value of reductions in crop yields are estimated using a straightforward application of market prices. Travel cost methods are used primarily to value recreation. The application of travel cost methods to valuing the effects such as wildlife mortality, forest effects, and

recreational fishing is discussed in this report. However, the costs associated with these impacts are not actually calculated due to insufficient data.

3.2 HUMAN HEALTH IMPACTS

The specific health impacts evaluated in this analysis are the risks of cancer and other deaths and nonfatal respiratory illness among the entire population exposed to power-plant emissions. This section briefly describes the derivation of the physical data, in this case health risk estimates, and the selection of economic values for mortality and morbidity (nonfatal) risks, and reports the resulting health effects costs.

3.2.1 Physical Effects Data

The health effects analysis calculates cumulative mortality and morbidity risks associated with the 12 power-generation alternatives. Results from the air quality analysis were coupled with population data for each site to estimate collective exposure to critical pollutants. The exposure data were combined with published risk estimates for acute morbidity and mortality. Mortality effects include cancer fatalities and deaths from acute illness. Estimates of lifetime cancer risk were developed for metals and radionuclides associated with airborne particulates. Lifetime cancer risks are based on an assumed average lifetime of 70 years. Morbidity effects include bronchitis, lower respiratory disease, coughs, and colds.

Table 3.3 summarizes the results of the health effects analysis for pollutants other than ozone for the 12 resource program alternatives. Compared to the Base Case, impacts in the year 2000 increased by 29% to 59% for lifetime cancer risk, and from 13% to 27% for acute mortality and morbidity. Corresponding increases for the year 2010 ranged from 56% to 94% for lifetime cancer risk and 26% to 34% for acute morbidity and mortality.

Metals accounted for the majority of lifetime cancer risk, and sulfur oxides dominated the risks for acute morbidity and mortality. Compared to the 1991 Base Case, the largest increases in health risk resulted from the Conventional Coal alternative, followed by the Imports alternative.

Cogeneration and High Conservation produced the smallest increases in health risks.

Table 3.4 gives the health risk estimates for ozone mortality (no data were available for morbidity). The impact of ozone from power-plant emissions was smaller than that of the background ozone concentrations, primarily because of the smaller population affected. Emission levels from power production facilities had a negligible effect on the ozone mortality estimates. The risk of acute mortality from background ozone levels was several times greater than for any other types of air pollutants.

3.2.2 Valuing Mortality Risks

The majority of efforts to value human mortality risks have been wage compensation studies, which apply hedonic wage models to calculate willingness to pay to accept increased risk associated with dangerous work. A survey of the literature by Ottinger et al. (1990) found estimates of health risk value ranging from about \$1 million to \$12 million for a statistical life.^(a) Table 3.5 reports these value estimates in 1991 dollars. Based on these studies, Ottinger et al. recommend using a mid-range value of \$4 million for mortality risks in evaluating the costs associated with increased health risks.^(b)

Accordingly, \$4 million was inflated to 1991 dollars and used in this analysis to value the risk of fatal cancers and other deaths (acute morbidity) associated with air pollution from power generation. The adjusted value of \$4.388 million was multiplied by the health risks in Tables 3.3 and 3.4 for each alternative in order to derive costs.^(c) Tables 3.6 and 3.7 report the expected mortality costs for criteria pollutants and ozone for all alternatives in each study year.

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- (a) It is important to note that the value of a statistical life is derived by aggregating the value of small risks faced by the entire population. Although health risk values are often expressed as values per human life they really indicate a statistical life.
 - (b) Thus, society is willing to pay \$4 million per avoided death.
 - (c) The lifetime fatality estimates from the health effects analysis were divided by an expected lifetime of 70 years to derive annual mortality risks.

Conventional Coal results in the highest mortality impacts from criteria pollutants, primarily from noncancer deaths, in 2000 and 2010. Cogeneration and High Conservation produce early savings--they have the smallest total costs in 2000--but by 2010 they have similar values to most of the other alternatives. The value of Imports is higher than all the other alternatives except Conventional Coal in 2010.

For ozone, the mortality rates were the same across all alternatives. Thus, there is a single dollar amount for all alternatives in each study year (\$27.90 million in 1991, \$42.65 million in 2000, and \$40.72 million in 2010). The estimated ambient ozone levels are very similar in 2000 and 2010, as are the economic values of ozone mortality.

3.2.3 Valuing Morbidity Risks

The economic value of morbidity (nonfatal) risks was taken from a contingent valuation method (CVM) study conducted by Berger et al. (1987). This study questioned individuals on their willingness to pay for reductions in various light symptoms of illness, such as coughing and nausea. The results of this study are given in Table 3.8 in 1991 dollars. Since the morbidity health effects do not specify symptoms, it was not possible to value symptoms. Instead, the value specified by Berger et al. for a general sick day ("All Symptoms Experienced") was used. This value (\$95.62/day) was multiplied by the morbidity risks from Table 3.3 to determine the costs associated with respiratory illness (morbidity). Table 3.9 gives the results of these calculations for all alternatives in each study year.

3.3 VISIBILITY IMPACTS

The air quality analysis calculates the value of visibility attenuation from criteria pollutant emissions for each alternative. The physical effects data and the estimation of the costs associated with these impacts are discussed below.

3.3.1 Physical Effects Data

The air quality analysis estimates the visibility attenuation associated with criteria pollutant emissions for each power-generation alternative. The study used a plume dispersion model to calculate the reductions in visual

range that would occur against a clear sky background at each of the four release sites for each study year. The reductions in visible range were found to be greatest where pollutant emission rates were highest. The greatest reductions in visible range occurred under the Conventional Coal alternative. Most other alternatives have slightly lower reductions in visual range.

The air quality analysis calculated the average changes in visibility for three representative sets of meteorology. Each set of meteorological conditions is assumed to represent one-third of the days in an average year at each site. These calculations are repeated for two different observer locations. This analysis takes these data points and calculates an annual average reduction in visual range for an observer at an arbitrary location for each site as follows.

The change in visibility at each site is found by averaging the lost visibility throughout the 360-degree field of each of the two observer locations. Of course, visibility losses in the direction of the plume are positive, while there is no loss in visibility when looking directly away from the plume. Because there is no information about which direction people look most of the time it is assumed that each direction is equally likely.

These estimates are used to calculate an average annual loss in visibility for the entire area downwind of the coal plant. The area-wide annual loss is the average of the annual loss of the two observers. Therefore, the average annual loss values given in Table 3.10 represent the loss in visual range averaged across the year, two observer locations, and the entire field of view.

3.3.2 Valuing Visibility Effects

Estimates of damages related to visibility have focused on regional haze, or the loss of visibility over a distance. Several studies have estimated the willingness to pay for visual range using either the contingent valuation method or hedonic property value techniques (see Chapter 2). Table 3.11 summarizes the major results relating to visibility. For the purposes of this analysis, visibility reduction was valued at \$41 per mile per person on the west side of the Cascade Mountains and \$7 per mile per person on the east

side. These different values were chosen because of the wide difference in baseline visibility for the two regions.

In order to calculate the economic value of visibility reduction associated with power-plant emissions, the average annual loss in visibility for each coal plant is multiplied by the appropriate value of dollars per mile of visual range (i.e., \$7 per mile for Centralia, \$41 per mile for the other three plants). The costs for each coal plant are aggregated to regional costs for each alternative by weighting up the per-mile losses for each plant by the total population downwind of each plant. The total population-weighted losses for each plant are then aggregated by alternative to find the regional losses from diminished visibility. Table 3.12 gives the resulting values calculated for each alternative in all study years.

3.4 CROP EFFECTS

The ecological effects analysis evaluated the impacts of criteria pollutants and ozone on a variety of crops, including hay and wheat. The physical effects data for regional hay and wheat production and the economic valuation of this impact--which is a straightforward case of using market prices to value damages--are discussed below.

3.4.1 Physical Effects Data

The ecological effects analysis calculated crop losses due to power-plant emissions for a variety of crops at each of the generic generation sites. Effects were calculated for the criteria pollutants and ozone. The results show no significant impact on crops from criteria pollutants under any of the alternatives. The crop results do show ozone effects in each of the study years. However, impacts from exposure to ozone are equal for all the alternatives, with no more than 1% crop losses at some locations. The expected crop effects are shown in Table 3.13.

3.4.2 Valuing Crop Effects

The 1989 market prices for hay and wheat are shown in Table 3.14 for Idaho, Montana, Oregon, and Washington. The prices were averaged and inflated to 1991 dollars, resulting in values of \$89.26 per ton of hay and \$4.45 per bushel of wheat. These values multiplied by the estimated crop losses give

the results shown in Table 3.15. These costs apply to all alternatives in all study years.

3.5 WILDLIFE IMPACTS

The ecological effects analysis evaluated the impacts of power-plant emissions on wildlife, including avian species, rodents, deer, and elk. The physical effects data for wildlife and the economic valuation of these impacts are discussed below. However, actual costs are not estimated for these impacts due to insufficient data.

3.5.1 Physical Effects Data

Wildlife impacts from criteria pollutants, trace metals, and acid deposition were estimated for each of the alternative generation scenarios. Wildlife biologists estimated the wildlife population density for each of the four study sites. Mortality estimates for avian species were based on the total adult breeding birds of all species per square mile of habitat type. Waterfowl production estimates were obtained from state wildlife biologists and the U.S. Fish and Wildlife Services.

Acute mortality risk estimates were developed using those for human populations. Criteria pollutant impacts were calculated for species within 32 kilometers (20 miles) of each study site. Mortality risks are not estimated for nitrogen oxides because no information is available on the effects of chronic low exposures on mortality rates. The number of deaths resulting from exposure to sulfur dioxide and particulates is highest for birds and rodents. For example, in Western Washington, mortality estimates include 300 birds and 12,000 rodents, or about 0.02% of the local populations of these species.

The impacts of increased acidic deposition on waterfowl include increased mortality rates for some species and increased foraging which ultimately reduces the population of other species. The results showed that acidification in Western Washington may result in 2,000 additional duckling deaths per year. Although species may continue to live in the area, increased difficulty in foraging will reduce the population of species in the area.

3.5.2 Valuing Wildlife Effects

Although mortality data for different wildlife species are available, for most of the species in question (e.g., rodents) there has been no research on the consumption value (e.g., for hunting or observation) of an individual animal, therefore assessment of the costs of wildlife mortality is not possible. Table 3.16 gives consumption values that have been estimated for game species.

Even when the consumption values are known, the economic values associated with population reductions cannot be calculated without specific information about species, visits (for observers), or success rates (for hunters). For example, an increased mortality risk of 1/100,000 per deer due to air emissions would be worth about $\$1.80 \times 10^{-6}$ per hunter using the above consumptive value. Assuming that the value is the same for all consumptive and nonconsumptive users, with an average of 100,000 visits per year to hunt or view wildlife in the affected area, the reduction in value due to air pollution would be \$1.80 per year. Other estimates have put values for deer as high as \$6,285 each. However, these studies have been found to be over-inflated.

In any case, the ecological effects analysis shows small mortality impacts on game species. For the entire region, less than one statistical elk or deer is lost. Thus, economic values were not calculated for wildlife impacts.

3.6 HYDRO EFFECTS ON FISHERIES

A wide range of economic techniques have been applied to value recreational and commercial fisheries. Table 3.17 summarizes the results of the major valuation studies. These values could be used to estimate the economic value associated with the impacts of air emissions on fisheries, e.g., acidification, as well as the effects on fishing of changing water levels caused by hydroelectric projects.

3.7 FORESTRY EFFECTS

Like the other elements examined in this study, forests have both market and nonmarket values. The primary market value of a forest is its timber

value. Nonmarket uses of a forest include its beauty, its value in stabilizing soil, and its value as a wildlife habitat, among other things. Market impacts are easily valued using timber prices. Nonmarket uses can be valued using one of the techniques described in Chapter 2.

Few nonmarket values of forests have been quantified. One use that has been examined in the Pacific Northwest is backcountry hiking. Table 3.18 summarizes the results of a study that estimates hikers' willingness to pay for forests along hiking trails (Englin and Mendelsohn 1991). As discussed in Chapter 2, travel cost techniques produce marginal willingness to pay, which can be used to value small changes in quality, and total willingness to pay, which is used to value large changes in quality.

The negative values in Table 3.18 for hemlock and alpine fir indicate that hikers are not willing to pay for more miles of these tree species along hiking trails because there currently are so many of them. However, they are willing to pay rather than have all of these trees removed. In the case of hemlock, hikers would be willing to pay \$2.08 to have small amounts of hemlock removed from the trail, but would pay \$19.43 rather than have all the hemlock trees removed from the trail.

The values in Table 3.18 represent the recreational value of forests and could be used to estimate economic costs associated with ozone impacts on forests. These costs are not calculated in this analysis because of insufficient data on dose-response relationships between forests and ozone emissions.

3.7^b LIMITATIONS TO THE ANALYSIS

The analyses described above provide information about environmental costs that can be used to compare alternative scenarios. Since each alternative is evaluated using a common set of assumptions the comparative results are meaningful. There are, however, considerable uncertainties and limitations to each analysis. This section provides a discussion of several of the key limitations and omissions of the results reported in this analysis.

One set of limitations has to do with transferring economic study results from another area of the country or time period to the contemporary Pacific

Northwest. A key difficulty is the plausibility of the transfer of the economic results from one area of the country to another, and from one time period to another. In general, there is no reason to believe that the valuation of environmental impacts is identical in different areas of the country. There may even, in fact, be a systematic impact if people move to an area of the country in part because of its environmental qualities.

Even holding the area of the country constant, the total amount of an environmental attribute may change from year to year. In that case the remaining amount can become even more valuable. A compelling example of this effect is old-growth forests. Of course, improved conditions are likely to cause older estimates of value to be over-estimates of value. Finally, the changing composition of the population (for example, the aging of the "baby boom" generation) is also affecting the value of environmental attributes over time. Each of these affects the quality of the economic values used in this analysis.

A second set of difficulties has to do with the interactions among environmental attributes. To some degree, the demand for and, therefore, the willingness to pay for, any environmental good depends on the quantity of all other environmental goods available. For projects that affect only one environmental attribute these impacts may be quite small. The issue is less clear for projects, such as the alternatives in the RPEIS, that affect much of the environment over broad areas. Unfortunately, there is no way to correct for this problem within the confines of an EIS. It is, however, important to be aware of the possible inappropriateness of simply adding up the dollar value of the environmental impacts valued in this report.

Finally, considerable uncertainty remains about which impacts should be evaluated. The impacts evaluated in this study were chosen because they met three criteria: 1) The impacts have been thought important in other studies; 2) the impacts had economic values that could be transferred to the Pacific Northwest; and, 3) the impacts were physical impacts that could be differentiated between alternatives.

This set of criteria generates a list of conventional environmental impacts that have been well studied. There may remain additional impacts that

have not been studied that could differentiate the environmental effects of the alternatives. For example, acid rain has not been carefully examined in this study. It may or may not be an important impact associated with some alternatives.

TABLE 3.1. Type of Environmental Impact and Method of Assessment

Impact	Assessment Technique
Human Health Effects Mortality Morbidity	Hedonic Wage and Contingent Valuation Studies
Visibility	Hedonic Property Value and Contingent Valuation Studies
Crop Reductions Wheat Hay	Market Prices
Wildlife^(a)	Travel Cost and Contingent Valuation Studies
Forest Recreation^(a)	Travel Cost and Contingent Valuation Studies
Hydro Effects^(a) Recreational fishing	Travel Cost and Contingent Valuation Studies

(a) Costs not actually calculated in this analysis for this impact.

TABLE 3.2. PGNP: Gross National Product Implicit Price Deflator (PGNP Index 1982 = 1.000)

YEAR	PGNP	% Change
1971	0.444	NA
1972	0.485	4.8
1973	0.495	6.5
1974	0.540	8.9
1975	0.593	9.9
1976	0.631	6.3
1977	0.673	6.7
1978	0.722	7.3
1979	0.786	8.8
1980	0.857	9.1
1981	0.940	9.6
1982	1.000	6.4
1983	1.039	3.9
1984	1.077	3.7
1985	1.109	3.0
1986	1.138	2.6
1987	1.174	3.1
1988	1.213	3.3
1989	1.263	4.2
1990	1.309	3.7
1991	1.360	3.9
1992	1.419	4.3
1993	1.480	4.3
1994	1.549	4.6
1995	1.624	4.8
1996	1.703	4.9
1997	1.787	4.9
1998	1.877	5.0
1999	1.971	5.0

TABLE 3.3. Criteria Pollutant Mortality and Morbidity Effects

Cumulative Health Risk						
Scenario:	Mortality		Morbidity (Effects per year)			
	Cancer (lifetime)	Acute (deaths/yr)	Bronchitis	Lower Respiratory	Cough	Colds
				Disease		
Year: 1991 - Impact of Existing Facilities at Beginning of Study Period						
1 - ALL PROGRAMS	0.34	18.44	190.27	91.93	183.86	165.47
Year: 2000 - Impact of New and Existing Facilities						
1 - STATUS QUO	0.46	22.04	228.29	109.84	219.68	197.71
2 - BASE CASE 4	0.46	21.96	227.47	109.43	218.86	196.97
3 - CONSERVATION	0.46	21.96	227.43	109.42	218.84	196.96
4 - CONVENTIONAL COAL	0.54	23.24	241.62	115.78	231.56	208.40
5 - CLEAN COAL	0.48	22.30	231.24	111.14	222.29	200.06
6 - NUCLEAR	0.45	21.79	225.60	108.59	217.18	195.46
7 - COMBUSTION TURBINE	0.47	21.98	227.79	109.54	219.07	197.16
8 - RENEWABLES	0.47	22.01	228.09	109.69	219.38	197.44
9 - COGENERATION	0.45	20.79	215.54	103.58	207.15	186.44
10 - FUEL SWITCHING	0.48	22.15	229.69	110.37	220.73	198.66
11 - HIGH CONSERVATION	0.44	21.38	221.34	106.56	213.11	191.80
12 - IMPORTS	0.54	22.70	236.31	113.09	226.19	203.57
Year: 2010 - Impact of New and Existing Facilities						
1 - STATUS QUO	0.55	23.35	242.99	116.31	232.62	209.36
2 - BASE CASE 4	0.55	23.28	242.33	115.99	231.98	208.78
3 - CONSERVATION	0.55	23.28	242.33	115.99	231.98	208.78
4 - CONVENTIONAL COAL	0.62	24.46	255.12	121.80	243.59	219.23
5 - CLEAN COAL	0.53	23.50	244.07	117.08	234.16	210.75
6 - NUCLEAR	0.56	23.30	242.56	116.08	232.17	208.95
7 - COMBUSTION TURBINE	0.55	23.27	242.13	115.93	231.87	208.68
8 - RENEWABLES	0.55	23.29	242.39	116.04	232.09	208.88
9 - COGENERATION	0.54	23.24	241.65	115.77	231.55	208.39
10 - FUEL SWITCHING	0.54	23.30	242.31	116.08	232.15	208.94
11 - HIGH CONSERVATION	0.55	23.28	242.11	115.95	231.90	208.71
12 - IMPORTS	0.66	23.76	248.91	118.28	236.56	212.90

SOURCE: NOX, SOX, and TSP Health Effects Analysis, RPEIS, Appendix F, Section 2 (BPA 1991)

TABLE 3.4. Summary of Mortality Risks due to Ozone

Year	Western Washington (deaths/year)	Eastern Washington (deaths/year)	Eastern Oregon (deaths/year)	Eastern Montana (deaths/year)	Regional Average (deaths/year)
1991	4.88	0.00	1.45	0.05	1.59
2000	4.66	3.65	1.36	0.05	2.43
2010	4.51	3.52	1.22	0.04	2.32

SOURCE: Ozone Health Effects Analysis, RPEIS, Appendix F, Section 1 (BPA 1991)

TABLE 3.5. Summary of Published Health Risk Values (dollar value per statistical life)

Study	Value Per Life (1991 dollars)
Brown (1980)	\$1.4 to 2.0 million
Olson (1981)	\$9.9 million
Smith (1976)	\$10.3 million
Thaler and Rosen (1976)	\$0.7 million
Viscusi (1979)	\$3.9 to 5.3 million
Viscusi (1983)	\$9.3 to 14.0 million
Moore and Viscusi (1988a)	\$5.0 million
Moore and Viscusi (1988b)	\$5.8 to 7.0 million
Shuman and Cavanagh (1981)	\$0.4 to 4.8 million
ECO Northwest (1987)	\$3.6 million

SOURCE: Ottinger et al. 1990

TABLE 3.6. Economic Value of Criteria Pollutant Mortality

	Cancer Costs (1991 dollars)	Acute Morbidity Costs (1991 dollars)	Total Costs (1991 dollars)
1991	\$21,313	\$80,914,720	\$ 80,936,033
2000			
Status Quo	\$28,835	\$96,711,520	\$ 96,740,355
Base Case 4	\$28,835	\$96,360,480	\$ 96,389,315
Conservation	\$28,835	\$96,360,480	\$ 96,389,315
Conventional Coal	\$33,850	\$101,977,120	\$ 102,010,970
Clean Coal	\$30,089	\$97,852,400	\$ 97,882,489
Nuclear	\$28,209	\$95,614,520	\$ 95,642,729
Combustion Turbine	\$29,462	\$96,448,240	\$ 96,477,702
Renewables	\$29,462	\$96,579,880	\$ 96,609,342
Cogeneration	\$28,209	\$91,226,520	\$ 91,254,729
Fuel Switching	\$30,089	\$97,194,200	\$ 97,224,289
High Conservation	\$27,582	\$93,815,440	\$ 93,843,022
Imports	\$33,850	\$99,607,600	\$ 99,641,450
2010			
Status Quo	\$34,477	\$102,459,800	\$ 102,494,277
Base Case 4	\$34,477	\$102,152,640	\$ 102,187,117
Conservation	\$34,477	\$102,152,640	\$ 102,187,117
Conventional Coal	\$38,865	\$107,330,480	\$ 107,369,345
Clean Coal	\$33,223	\$103,118,000	\$ 103,151,223
Nuclear	\$35,104	\$102,240,400	\$ 102,275,504
Combustion Turbine	\$34,477	\$102,108,760	\$ 102,143,237
Renewables	\$34,477	\$102,196,520	\$ 102,230,997
Cogeneration	\$33,850	\$101,977,120	\$ 102,010,970
Fuel Switching	\$33,850	\$102,240,400	\$ 102,274,250
High Conservation	\$34,477	\$102,152,640	\$ 102,187,117
Imports	\$41,373	\$104,258,880	\$ 104,300,253

TABLE 3.7. Economic Value of Ozone Mortality

Year	Regional Mortality Risk^(a) (deaths/year)	Annual Cost (1991 dollars)
1991	6.36	\$27.9 million
2000	9.72	\$42.65 million
2010	9.28	\$40.72 million

(a) Regional Average from Table 3.4 multiplied by four.

TABLE 3.8. Willingness to Pay to Avoid Illness

Symptom	WTP per Day (1991 dollars)
Coughing Spells	\$90.11
Stuffed-Up Sinuses	\$32.40
Throat Congestion	\$52.10
Itching Eyes	\$57.49
Heavy Drowsiness	\$168.41
Headaches	\$128.93
Nausea	\$56.78
All Symptoms Experienced	\$95.62

SOURCE: Berger et al. 1987

TABLE 3.9. Economic Value of Criteria Pollutant Morbidity (1991 dollars)

Alternative	Bronchitis	Lower Respiratory Disease	Coughs	Colds	Total Costs
1991	\$18,195	\$8,791	\$17,582	\$15,823	\$60,391
2000					
Status Quo	\$21,831	\$10,504	\$21,007	\$18,906	\$72,248
Base Case 4	\$21,752	\$10,464	\$20,929	\$18,836	\$71,981
Conservation	\$21,748	\$10,464	\$20,927	\$18,835	\$71,974
Conventional Coal	\$23,105	\$11,072	\$22,143	\$19,929	\$76,249
Clean Coal	\$22,113	\$10,628	\$21,257	\$19,131	\$73,129
Nuclear	\$21,573	\$10,384	\$20,768	\$18,691	\$71,416
Combustion Turbine	\$21,783	\$10,475	\$20,949	\$18,854	\$72,061
Renewables	\$21,812	\$10,489	\$20,979	\$18,881	\$72,161
Cogeneration	\$20,611	\$9,905	\$19,809	\$17,829	\$68,154
Fuel Switching	\$21,965	\$10,554	\$21,108	\$18,997	\$72,624
High Conservation	\$21,166	\$10,190	\$20,379	\$18,341	\$70,076
Imports	\$22,598	\$10,814	\$21,630	\$19,467	\$74,509
2010					
Status Quo	\$23,236	\$11,122	\$22,245	\$20,021	\$76,624
Base Case 4	\$23,173	\$11,092	\$22,184	\$19,965	\$76,414
Conservation	\$23,173	\$11,092	\$22,184	\$19,965	\$76,414

TABLE 3.9. Economic Value of Criteria Pollutant Morbidity (1991 dollars) (contd)

Alternative	Bronchitis	Lower Respiratory Disease	Coughs	Colds	Total Costs
Conventional Coal	\$24,396	\$11,647	\$23,294	\$20,964	\$80,301
Clean Coal	\$23,340	\$11,196	\$22,392	\$20,153	\$77,081
Nuclear	\$23,195	\$11,100	\$22,202	\$19,981	\$76,478
Combustion Turbine	\$23,154	\$11,086	\$22,173	\$19,955	\$76,368
Renewables	\$23,179	\$11,097	\$22,194	\$19,975	\$76,445
Cogeneration	\$23,108	\$11,071	\$22,142	\$19,928	\$76,249
Fuel Switching	\$23,171	\$11,100	\$22,200	\$19,980	\$76,451
High Conservation	\$23,152	\$11,088	\$22,176	\$19,958	\$76,374
Imports	\$23,803	\$11,311	\$22,622	\$20,359	\$78,095

TABLE 3.10. Annual Average Visibility Reduction from Criteria

Resource Alternative	Loss East of Cascades (km)	Loss West of Cascades (km)
1991	0.216129	0.3435484
2000		
Status Quo	0.3870968	0.4354839
Base Case	0.3870968	0.4451613
Conservation	0.3870968	0.4354839
Conventional Coal	0.4629032	0.4790323
Clean Coal	0.4032258	0.4451613
Nuclear	0.3822581	0.4209677
Combustion Turbine	0.3903226	0.4548387
Renewables	0.3903226	0.45
Cogeneration	0.3822581	0.4209677
Fuel Switching	0.3903226	0.4548387
High Conservation	0.3903226	0.4548387
Imports	0.3951613	0.4741935
2010		
Status Quo	0.5919355	0.4693548
Base Case	0.5209677	0.4887097
Conservation	0.5209677	0.4887097
Conventional Coal	0.6274194	0.5177419
Clean Coal	0.5419355	0.4596774
Nuclear	0.5209677	0.4887097
Combustion Turbine	0.5241935	0.4790323
Renewables	0.5209677	0.483871
Cogeneration	0.5306452	0.483871
Fuel Switching	0.5209677	0.4741935
High Conservation	0.5209677	0.4645161
Imports	0.5483871	0.5225806

TABLE 3.11. Summary of Visibility Valuation Results

Study	Estimation Procedure	Annual Average WTP for a 1-mile Change in Visual Range	WTP/Mile (1991 dollars)
California Studies			
Brookshire et al. (1979) Los Angeles (1978\$)	Property value study using NO ₂ and TSP	\$14 - \$15	\$19.49-19.81
	Contingent valuation bidding for a change in typical conditions	Obtain Improvement: \$5 - \$6	\$6.60-7.92
Loehman, Boldt, and Chaikin (1981) San Francisco (1980\$)	Contingent valuation bidding for a change in the distribution of conditions	Obtain Improvement: \$30 - \$31	\$39.63-40.95
		Prevent Deterioration: \$42 - \$65	\$55.48-85.86
Trijonis et al. (1984) Los Angeles (1978-79\$) San Francisco	Property value study using light extinction	\$34 - \$64 \$29 - \$32	\$44.90-84.54
	Property value study using light extinction		\$38.30-42.27
Eastern Studies			
Randall et al. (1981) Chicago (1981\$)	Contingent valuation bidding for a change in typical conditions	Obtain Improvement: \$13 - \$24	\$17.17-31.70
Tolley et al. (1984) Six Cities (1982\$)	Contingent valuation bidding for a change in typical conditions payment card format	Obtain Improvement: \$9 - \$15	\$11.88-19.81
		Prevent Deterioration: \$29	
Rae, Hausman, and Wickham (1983) Cincinnati (1982\$)	Contingent valuation bidding for a change in typical conditions	Obtain Improvement: \$30	\$39.63
	Contingent ranking for a change in typical conditions	Obtain Improvement: \$71 - \$108	\$93.79-\$142.66
	Contingent ranking for a change in distribution of conditions	Obtain Improvement: \$39 - \$225	\$51.51-\$297.22

SOURCE: Bhardwaja 1987, p. 166

TABLE 3.12. Economic Value of Regional Visibility Reductions

Resource Alternative	Total Regional Cost
1991	\$8,664,069
2000	
Status Quo	\$11,336,803
Base Case	\$11,561,801
Conservation	\$11,336,803
Conventional Coal	\$12,586,623
Clean Coal	\$11,612,296
Nuclear	\$10,984,157
Combustion Turbine	\$11,796,898
Renewables	\$11,684,399
Cogeneration	\$10,984,157
Fuel Switching	\$11,796,898
High Conservation	\$11,796,898
Imports	\$12,262,042
2010	
Status Quo	\$12,765,590
Base Case	\$12,993,405
Conservation	\$12,993,405
Conventional Coal	\$14,001,670
Clean Coal	\$12,384,056
Nuclear	\$12,993,405
Combustion Turbine	\$12,778,506
Renewables	\$12,880,906
Cogeneration	\$12,911,204
Fuel Switching	\$12,655,908
High Conservation	\$12,430,910
Imports	\$13,866,741

TABLE 3.13. Crop Losses due to Ozone

Crop	Loss
Wheat	13,743 bushels
Hay	163.48 tons

TABLE 3.14. Regional Market Prices for Hay and Wheat in 1991 Dollars

State	Wheat (per bushel)	Hay (per ton)
Idaho	\$4.29	\$88.79
Montana	\$4.18	\$78.31
Oregon	\$4.68	\$93.20
Washington	\$4.74	\$98.72
Regional Average	\$4.46	\$89.76

SOURCE: U.S. Department of Agriculture 1990

TABLE 3.15. Economic Value of Crop Losses due to Ozone

Crop	Annual Loss (1991 dollars)
Wheat	\$61,394
Hay	\$14,673

TABLE 3.16. Economic Value of Game Species

Study	Species	Economic Value^(a)
Brown and Hammack (1973)	Waterfowl	\$2.40 to \$4.65 per bird
Nickerson (1990)	Deer	\$1.80 per animal per square mile

(a) Not adjusted to 1991 dollars.

TABLE 3.17. Summary of Economic Valuation Study Results for Recreational Fishing

Source	Type of Fish	State	Valuation Method Used	Value Estimated ^(a)
Brown, Singh, and Castle (1964)	All salmon/steelhead	Oregon	TC	\$22/day (1987\$)
Mathews and Brown (1970)	Ocean salmon	Washington	CV	\$211/day (1987\$)
	Freshwater salmon		CV	\$109/day
	Ocean salmon		TC	\$6/trip
Crutchfield and Schelle (1970)	Ocean salmon		CV	\$34/day (1987\$)
Brown, Sorhus, and Gibbs (1980)	Ocean salmon	Oregon	TC	\$97/trip (1987\$)
	Freshwater salmon			\$32/trip
	Steelhead			\$46/trip
	Ocean salmon	Washington		\$94/trip
	Freshwater salmon			\$79/trip

TABLE 3.17. Summary of Economic Valuation Study Results for Recreational Fishing (contd)

Source	Type of Fish	State	Valuation Method Used	Value Estimated ^(a)
Charbonneau and Hay (1978)	Ocean fishing	United States	CV	\$154/day (1987\$)
	Freshwater salmon			\$107/day
	Trout			\$29/day
Brown and Shalloof (1986)	Freshwater salmon/ steelhead	Oregon	TC	\$41/trip (1987\$)
	Ocean salmon			\$108/trip
Brown and Hay (1987)	Trout	United States	CV	\$15/day (1987\$)
Sorg et al. (1985)	Trout	Idaho	CV	\$26/trip (1987\$) \$16/day
			TC	\$50/trip \$29/day
Donnelly et al. (1985)	Steelhead	Idaho	CV	\$36/trip (1987\$) \$23/day
			TC	\$27/trip \$16/day

TABLE 3.17. Summary of Economic Valuation Study Results for Recreational Fishing (contd)

Source	Type of Fish	State	Valuation Method Used	Value Estimated ^(a)
Vaughn and Russell (1982)	Trout	United States	TC	\$25/day (1987\$)
Johnson and Adams (1989)	Steelhead	OR	CV	\$6.65/day (1989\$)
Samples and Bishop (1985)	Salmon/trout	MI	TC	\$10.25/fish (1987\$)
Loomis (1988)	Steelhead Salmon	OR	TC	\$23 to \$103/fish (1987\$) \$7.48 to \$64.61/fish (1987\$)
Cameron and James (1987)	Salmon	Canada	CV	\$14.47/fish (1984 Canadian\$)
Olsen (1990) Existence Value	Salmon	Pacific Northwest	CV	\$17.70/fish (1990\$)

(a) TC = Travel Cost Method
CV = Contingent Valuation Method

(b) Not adjusted to 1991 dollars.

TABLE 3.18. Hikers' Valuation of Forest Existence Values^(a)

Forest Type	Average Marginal WTP ((\$/mile)/trip)	Average Total WTP (\$/trip)^(b)
Douglas fir	\$0.49	-- ^(b)
Hemlock	-\$2.08	\$19.43
Spruce	\$2.50	\$12.96
Old-growth	\$1.31	\$35.77
Silver fir	\$0.32	\$7.05
Alpine fir	-\$0.70	-- ^(b)

(a) Travel time and distance valued at \$0.50 per mile.

(b) Average total WTP could not be calculated because of flat demand.

SOURCE: Englin and Mendelsohn 1991

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APPENDIX

STATE AND PUBLIC UTILITY COMMISSION APPROACHES TO INCORPORATING EXTERNALITIES

APPENDIX

STATE AND PUBLIC UTILITY COMMISSION APPROACHES TO INCORPORATING EXTERNALITIES

This appendix discusses the various approaches that states and public utility commissions are taking toward incorporating environmental externalities into planning and resource decisions. These approaches range from actively developing techniques for valuing externalities to taking no action at all. Section A.1 briefly discusses the pros and cons of a quantitative versus qualitative assessment of externalities. The remaining sections describe the activities of specific states. These can be divided into three broad categories: active, well-defined approaches to incorporating externalities; efforts toward developing an approach; and no activity aimed at including environmental costs.

A.1 QUALITATIVE VERSUS QUANTITATIVE VALUATION

Environmental externalities can be incorporated into state public utility commission decisions in two ways: either qualitatively or quantitatively. Qualitative assessments do not enter directly into calculations of the levelized cost of resources. Rather, they can be used to differentiate resources that have levelized costs that are close to one another. Qualitative assessments are also attractive because they can cover all externalities that can be identified. However, it is difficult to assess the relative importance of each externality when they are each measured differently.

Quantitative assessments extend the qualitative assessment to address the relative importance of each environmental externality. In principle, this places each of the impacts of the resource choice decision on a common footing, namely dollars. The advantage of putting environmental impacts into dollar terms is that they can then be easily compared with the other costs of the generation resource, and, ultimately, different resources can be compared to each other. The disadvantage is that it can be difficult and costly to

develop dollar damage estimates for each environmental impact. As a result, quantitative estimates of the damages from environmental externalities are rarely used in isolation.

Efforts to quantify damages from externalities are usually limited to a handful of major damages. The difficulty in developing estimates of the damage from externalities has lead to an alternative form of quantification known as the cost-based approach. This approach uses the cost of mitigation of the externality as a proxy for the dollar value of the damages. This is the approach used by most states that attempt to quantify environmental damages. However, increasingly states and public utility commissions are attempting to develop damages-based approaches to valuing environmental externalities.

A.2 OVERVIEW OF STATE ACTIVITIES

State activities can be divided into three broad categories: those with active, well-defined approaches to incorporating externalities, those in the process of developing an approach, and those that are not including environmental costs. Table A.1 summarizes each state's current status (based on Cohen et al. 1990). Section A.2.1 will outline the activities of states that are undertaking some action with regard to environmental externalities. Section A.2.2 describes what other states are doing.

A.2.1 Active States

Six states have active programs to include environmental externalities in their evaluation process. Active states include those with actual experience including externalities in their resource acquisition process. These six states are California, Massachusetts, New York, Oregon, Vermont, and Wisconsin. Each of these states takes a different approach to the inclusion of environmental externalities.

California includes environmental externalities through the California Energy Commission (CEC). The CEC has proposed an adder of 10% to 25% to the generation costs to account for environmental externalities. This adder is based on the use of control costs as a proxy for the social damages caused by generation. The adder is imposed in the assessment of utility resource plans.

Massachusetts has also instituted an adder approach to incorporating environmental externalities. Its approach adds up to 15% of the resource cost depending on the precise mix of resources in the utilities plan. The basis for the adder is the quantifiable externalities impacts. Non-quantified externalities are ignored.

Oregon has adopted a qualitative approach to incorporating environmental externalities. The Oregon Public Utility Commission requires a qualitative discussion of the impact of environmental externalities in the utilities' least-cost plan, and some consideration when selecting the least-cost resources. Oregon has also developed some guidelines. The Oregon Public Utility Commission requires that utilities quantify environmental externalities to the greatest extent feasible. Unlike the approach taken by New York, Oregon has not provided dollar estimates of the damage from the different environmental impacts. Rather, it has placed the burden on the utilities. In its least-cost plan, each utility is directed to call out the environmental costs of the proposed method of meeting its demand. If the direct economic costs of the damages associated with a resource are not known or cannot be calculated then these impacts are to be addressed qualitatively. The Oregon Public Utility Commission's approach is closely aligned with the economic ideal of using economic damages to value environmental externalities.

New York has, perhaps, the most well-defined approach to including externalities. The New York Public Service Commission has developed precise directives that guide utilities' treatments of environmental externalities. The New York system is based on a point system. This system assigns a score of 1 to 5 according to the quantity of environmental externalities associated with the resource. These scores are then weighted according to the importance of the externality and aggregated into an overall environmental score.

The New York Public Service Commission has determined that the avoided cost for its system is 6 cents per kWh. The most environmentally costly resource is assigned a cost penalty of up to 1.405 cents per kWh when being compared to the avoided cost estimate. Table A.2 shows how the system weights different external impacts by major effect area and breaks down the air impacts (see Foley and Lee 1990). In total the system separately identifies 13 different environmental attributes. The key environmental impacts in New

York are the effects of nitrogen oxides (NO_x) and sulphur oxides (SO_x). Global warming implications are included through the use of a penalty on carbon dioxide. Particulates receive a small weight. All in all, the New York system provides strong guidance about the penalty associated with different kinds of environmental damage.

The Vermont Public Service Board includes environmental externalities when calculating the benefit-cost ratio of a new resource. Vermont notes that excluding the environmental costs is equivalent to setting them to zero, something that is clearly inappropriate. However, given the difficulties associated with estimating environmental damages, the Vermont Public Service Board chooses to apply percentage adjustments to new supply and demand-side control options. The new supply options have an adder of 10% applied to their total cost while the demand-side options have an adder of 5% applied to their cost.

Wisconsin is another state that has an active, on-going program. The Wisconsin Public Service Commission addresses environmental costs as part of its least-cost planning process. Wisconsin's approach is to apply a credit to non-combustion sources of electricity in the least-cost planning process. This credit has been set at 15% of total cost. As a comparison, the air pollution portion of the New York scoring system adds up to 15% of avoided cost (.9 cents per kWh/6 cents per kWh) to account for environmental damage. Wisconsin, while less comprehensive than New York, has chosen a cost penalty which is roughly equivalent for the emission from combustion sources of electricity.

A.2.2 Other States

The remaining states are in the process of developing a strategy, have just begun to consider the issue, or have not considered externalities at all. Several states, including Nevada, Colorado, New Jersey, Minnesota, and Arizona, have taken the first step toward formally including externalities into the resource selection process.

Nevada has provided their public utility commission with the discretion to select new resources with a qualitative eye towards environmental consequences. The language of the regulations imply that Nevada Public

Utility Commissioners should incorporate a full damage assessment of new resources where feasible.

Colorado has developed a point system similar in spirit to New York's. The Colorado system provides 17 bonus points to renewable energy sources while coal (5), natural gas (2), and oil (1) receive considerably fewer points. A total of 100 points is possible under the Colorado system. This system has not yet been implemented, however.

New Jersey is currently negotiating the treatment of environmental externalities in new resource proposals. Recent negotiations with utilities have put non-economic considerations, including environmental ones, at a minimum of 20% of the total points when examining new resources. The role of the environment in these negotiations is still being developed.

The treatment of externalities by public utility commissions is just being acknowledged in Minnesota and Arizona. In both states the primary consideration is environmental impacts that affect special state resources. In Minnesota, a particular concern is the reduction of acid rain in the state's watersheds. Arizona is specifically interested in SO₂ and CO₂ emissions.

A number of other states have just begun to consider the role of environmental externalities in their resource process. In general these considerations take the form of either proposed legislation to include environmental considerations in the resource acquisition process or discussions among PUC staff and utilities about how to include them.

Finally, some states are not considering environmental externalities at all. In general, the southeastern and southern parts of the United States do not consider environmental externalities when examining new resources. Nor is there any indication that discussion about how to include environmental externalities is forthcoming.

A.3 CONCLUSIONS

Six states have active programs to include environmental externalities into their new resource acquisition processes. These states have undertaken a wide range of approaches, from point systems such as New York's to

straightforward inclusions of environmental costs in Oregon. Five others have begun implementing legal and regulatory structures that will allow them to include environmental externalities in the future, and are likely to refine their regulatory structure in the near future as the implications of their decisions, and those of other states, are discovered. Finally, the majority of states are either at the discussion stage, or are not considering the environmental impacts of new resources at all.

A.4 REFERENCES

Cohen, S. D., J. H. Eto, C. A. Goldman, J. Beldock, and G. Crandall. 1990. "Environmental Externalities: What State Regulators are Doing." The Electricity Journal, 3:24-35.

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TABLE A.1. Status of Public Utility Commission Activities

State	Status	How Requirements Are Imposed	Quantification Basis	Value
Alabama	None			
Alaska	None			
Arizona	Operational			
Arkansas	None			
California	Operational	Assessment of utility resource plans	Control costs (probably)	Add 10-25% to generation costs (proposed)
Colorado	Operational			
Connecticut	Operational			
Delaware	Awareness			
District of Columbia	Developing			
Florida	None			
Georgia	None			
Hawaii	Awareness			
Idaho	Operational			
Illinois	Awareness			
Indiana	None			
Iowa	Developing			
Kansas	Operational			
Kentucky	None			
Louisiana	None			
Maine	Developing	Cost-effectiveness evaluation of large DSM programs	Uncertain	No values specified
Maryland	Developing			
Massachusetts	Operational	Resource solicitation process	Quantifiable external impacts	NEES adds up to 15% to resource cost based on matrix, similar to New York approach
Michigan	Developing			
Minnesota	Operational			
Mississippi	None			
Missouri	Awareness			
Montana	No Response			
Nebraska	Does not regulate			
Nevada	Operational			
New Hampshire	Awareness			
New Jersey	Operational			

TABLE A.1. Status of Public Utility Commission Activities

State	Status	How Requirements Are Imposed	Quantification Basis	Value
New Mexico	None			
New York	Operational	Resource bid process	Mitigation cost of different externalities	Up to 1.4 cents/kWh, 24% of avoided cost with quantity determined by score matrix
North Carolina	None			
North Dakota	None			
Ohio	Operational			
Oklahoma	None			
Oregon	Operational	Least-cost planning	Control costs (Pacific)	Depends on utility evaluation
Pennsylvania	Operational			
Rhode Island	Developing			
South Carolina	Awareness			
South Dakota	None			
Tennessee	Does not regulate			
Texas	Operational			
Utah	Awareness			
Vermont	Operational	Integrated resource assessments	Assumed benefits of DSM options	Deduct 5% from DSM costs for environmental benefits and 10% for risk reduction
Virginia	Developing			
Washington	Awareness			
West Virginia	None			
Wisconsin	Operational	Least-cost planning	Assumed benefits of noncombustion resources over combustion resources based on NWPPC recommendation	Automatic 15% credit for noncombustion resources
Wyoming	Awareness			

TABLE A.2. New York Scoring System

Externality	Mitigation Cost (cents/kWh)	Weight
Air Emissions		
Sulphur Dioxides	0.250	10
Nitrogen Dioxides	0.550	23
Carbon Dioxide	0.100	4
Particulates	0.005	1
Water Impacts	0.100	4
Land Use	0.400	18
Total	1.405	60