Item 17

ORIGINAL
N.H.P.U.C. Case No. DE 11-250
Exhibit No. 132
Witness Panel 5
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March 2009

Environmental Costs and Economic Benefits of Electric Utility Resource Selection

Nevada Power Company

NERA
Economic Consulting

Project Team

David Harrison, Jr., Ph.D., Project Director
James Johndrow
Mark LeBel
David Nagler

NERA Economic Consulting
200 Clarendon St, 11th Floor
Boston, Massachusetts 02116
Tel: +1 617 927 4500
Fax: +1 617 927 4501
www.nera.com

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Chapter 1: Introduction and Background

This report was prepared for Nevada Power Company d/b/a NV Energy ("Nevada Power") to provide information relevant to the four plans identified in the Eleventh Amendment to the 2006 Integrated Resource Plan ("Eleventh Amendment") for Nevada Power. This report provides cost estimates related to environmental effects of the plans as well as economic benefits ("impacts") related to the expenditures under the plans.

The environmental cost estimates focus on air emissions and include two methodologies depending upon whether the pollutant is regulated by a cap-and-trade program. For air emissions that are regulated or expected to be regulated by a cap-and-trade program, we develop estimates of the financial costs related to these emissions that could be included in the present worth of revenue requirements ("PWRR"). For emissions that are not covered by a cap-and-trade program, we develop estimates of the present worth of social costs of the emissions associated with each plan. In the first situation, costs are based on estimates of the allowance prices that could prevail under the cap-and-trade program as well as on likely allowances that would be obtained for free. In the second situation, the estimates are based on the damage value per ton for various air emissions.

The economic benefit estimates are measures of the effects of the plans on the Nevada economy. These effects are typically referred to as "economic impacts."

Both assessments are based upon the combined operations of the two major utility subsidiaries of NV Energy, Inc. ("NV Energy"), Nevada Power and Sierra Pacific Power Company d/b/a NV Energy ("Sierra") (together, the "Companies").

A. Background on Utility Resource Planning in Nevada

Nevada Power and other Nevada electric utilities are required by Nevada regulations to file plans describing their options for supplying electricity to their service territories in the future. Nevada regulations require that the utilities consider environmental costs and "economic benefits," when evaluating potential plans. The Public Utilities Commission of Nevada ("PUCN" or "the Commission") has laid out these regulations in the Nevada Administrative Code ("NAC").

1. Present Worth of Societal Costs and Environmental Costs

The NAC requires Nevada electric utilities to rank their power supply options on the basis of the Present Worth of Revenue Requirements ("PWRR") and Present Worth of Societal Costs ("PWSC"). The PWSC of a resource plan ("plan") is defined as the sum of the PWRR plus environmental costs (NAC 704.937). Environmental costs are defined by the PUCN as "costs, wherever they may occur, that result from harm or risks of harm to the environment after the application of all mitigation measures required by existing environmental regulation or otherwise included in the resource plan" (NAC 704.9359). In addition, "environmental costs to the State associated with operating and maintaining a supply plan or demand-side plan must be quantified for air emissions, water and land use" (NAC 704.9359). Among these potential costs, environmental costs associated with air quality impacts typically (and appropriately, given their relative importance) receive the most attention in the evaluation of plans. As noted above, emissions subject to a cap-and-trade program lead to financial effects that could be included in the PWRR.

2. Nevada Portion of Present Worth of Revenue Requirements and Economic Benefits

The NAC requires utilities to assess the "economic benefits" of plans in certain cases. Economic benefits include the portion of PWRR that is expended within Nevada, as well as economic effects resulting from such expenditures. As noted above, such "economic benefits" are often referred to as economic impacts, so that they are distinguished from other types of benefits. Benefits of public or private investments include the ability to produce various outputs (e.g., steel, electric power, transportation services). Economic benefits or impacts account for the gains to a local or state economy from locating investments and expenditures within the jurisdiction.

The NAC specifies that economic benefits are to be calculated when a competing plan is within 10 percent of the lowest-cost plan considered, in terms of social costs. The calculations are to include estimates of the portion of expenditures made within the State of Nevada for the following five categories (NAC 704.9357):

1. Capital expenditures for land and facilities located within the State or equipment manufactured in the State;
2. The portion of the cost of materials, supplies and fuel purchased in the State;
3. Wages paid for work done within the State;
4. Taxes and fees paid to the State or subdivisions thereof; and
5. Fees paid for services performed within the State.

The NAC does not provide specific guidelines on how this information is to be used. The NAC notes that *the Commission*—not the utility—may adjust the social cost comparisons to consider "all, or only a portion, of the calculated economic benefit" (NAC 704.9357).

B. Plans Included in the Eleventh Amendment and Implications for Environmental Costs and Economic Benefits

1. Overview of Alternative Plans

The Eleventh Amendment considers four plans. These plans aim to satisfy expected future energy requirements through the operation of existing generating units as well as through construction and operation of new generating units and the purchase of imported power. The four plans vary in terms of the existence of and transfer capacity for a segment of the previously approved "ENti" (now the One Nevada Transmission Line or "ON Line"), a transmission line that would connect the Nevada Power system to the Sierra system:

- Plan 1 has no ON Line;
- Plan 2 has a 400 MW ON Line;
- Plan 3 has a 600 MW ON Line; and
- Plan 4 has an 800 MW ON Line.

Plan 3 is the preferred plan for the Eleventh Amendment.

2. Implications for Calculations of Environmental Costs and Economic Benefits

For each plan, Nevada Power has projected how its units and those of Sierra (existing as well as new units, plus purchased power) would be dispatched to meet demand at minimum cost given the alternative configurations and projected fuel and other input prices. Because differences among the plans extend to the operation of existing units and to power purchases, the calculations of environmental and economic effects should not relate only to the new generating units considered in the plans. Thus, the environmental cost and economic benefit estimates developed in this report account for the overall effects—including operation of all existing and new units, construction of new units and purchased power—of each plan, calculated over the 30-year period from 2010 to 2039.

Our calculations of environmental costs consider internal and external costs associated with emissions attributable to electricity use on the system as a whole, including costs from plants outside Nevada Power and Sierra's system that generate power purchased by the two Companies. The economic impacts of the plans also are estimated for the system as a whole, taking account of differences in construction and operation costs.

C. Outline of this Report

The remainder of this report is organized as follows.

- Chapter 2 provides an overview of the national and state air quality standards that are relevant to Nevada, as well as a summary of our methods for characterizing relevant air emissions and their associated internal/external costs.
- Chapter 3 provides an overview of our methodologies for assessing environmental costs from air emissions, including carbon dioxide ("CO_2").

- Chapter 4 discusses the calculation of environmental costs for air emissions and summarizes the differences between the plans.
- Chapter 5 discusses other environmental costs.
- Chapter 6 describes our approach to calculating economic benefits from the plans, and also provides the estimates of the economic benefits.

Chapter 2: Background on Nevada Air Quality and Characterization of Air Emissions

This chapter provides an overview of air quality in Nevada, which relates to conventional air emissions. We then discuss the mechanisms through which various emissions are regulated and how we estimate costs under the two regulatory cases noted above.

A. Background on Air Quality in Nevada

We consider air quality for counties within Nevada in the context of the National Ambient Air Quality Standards ("NAAQS") for various criteria pollutants. Although compliance or non-compliance with the NAAQS does not affect the calculation of environmental costs (which depend on per-ton values for emissions), this information provides a context for our environmental cost estimates.

1. National Ambient Air Quality Standards

The Clean Air Act of 1970 directs the Administrator of the U.S. Environmental Protection Agency ("U.S. EPA") to set maximum permissible ambient (outdoor) concentrations for air pollutants considered harmful to public health and the environment. There are two types of NAAQS (EPA 2009a):

- ***Primary standards*** set limits to protect public health, including, in particular, the health of "sensitive" populations such as asthmatics, children, and the elderly; and
- ***Secondary standards*** set limits to protect public welfare, including protection against decreased visibility, and damage to animals, crops, vegetation, and buildings.

Currently, NAAQS exist for six "criteria" pollutants: carbon monoxide ("CO"); lead; nitrogen dioxide ("NO_2"); ozone, which forms from nitrogen oxide ("NOx") emissions and volatile organic compound ("VOC") emissions; particulate matter ("PM"); and sulfur dioxide ("SO_2"). Table 1 shows the NAAQS and the relevant averaging times for each of these pollutants. There are two particulate matter standards, one for PM_{10} ("coarse particles," which range in size from 2.5 to 10 micrometers ("µm") in diameter) and another for $PM_{2.5}$ ("fine particles," which are smaller than 2.5 µm in diameter). For the environmental cost assessments in this study, PM generally means $PM_{2.5}$ because $PM_{2.5}$ is the source of the health effects used to value ambient PM concentrations.

Table 1. National Ambient Air Quality Standards

Pollutant	Primary Standard	Averaging Times	Secondary Standard
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour [1]	None
	35 ppm (40 mg/m^3)	1-hour [1]	None
Lead	1.5 $\mu g/m^3$	Quarterly Average	Same as Primary
	0.15 $\mu g/m^3$	Rolling 3-Month Average	Same as Primary
Nitrogen Dioxide	0.053 ppm (100 $\mu g/m^3$)	Annual (Arithmetic Mean)	Same as Primary
Particulate Matter (PM_{10}) [2]	150 $\mu g/m^3$	24-hour [3]	Same as Primary
Particulate Matter ($PM_{2.5}$)	15.0 $\mu g/m^3$	Annual (Arithmetic Mean) [4]	Same as Primary
	35 $\mu g/m^3$	24-hour [5]	Same as Primary
Ozone[6]	0.08 ppm (1997 Standard)	8-hour [7]	Same as Primary
	0.075 ppm (2008 Standard)	8-hour [7]	Same as Primary
Sulfur Dioxide	0.03 ppm	Annual (Arithmetic Mean)	--
	0.14 ppm	24-hour [1]	--
	--	3-hour [1]	0.5 ppm (1300 $\mu g/m^3$)

Notes: Units of measure: ppm (parts per million) by volume; mg/m^3 (milligrams per cubic meter of air); $\mu g/m^3$ (micrograms per cubic meter of air).
(1) Not to be exceeded more than once per year.
(2) Due to a lack of evidence linking health effects to long-term exposure to coarse particle pollution, the U.S. EPA revoked the *annual* PM_{10} standard effective December 17, 2006. The 24-hour standard remains in effect.
(3) Not to be exceeded more than once per year on average over three years.
(4) To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0$\mu g/m^3$.
(5) To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35$\mu g/m^3$.
(6) The U.S. EPA revoked the *one-hour* ozone standard, except for a limited set of counties, effective June 15, 2005. The 1997 8-hour Standard will remain in place while EPA undertakes rulemaking to address the transition to the 2008 8-hour Standard.
(7) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.
Source: EPA 2009a.

Areas where air pollution levels persistently exceed the NAAQS may be designated as "nonattainment" areas by the U.S. EPA. In every state containing nonattainment areas, air pollution control authorities are charged with developing a State Implementation Plan ("SIP") aimed at bringing all counties into compliance with the NAAQS.

In Nevada, the Department of Conservation and Natural Resources, Division of Environmental Protection, Bureau of Air Quality Planning ("BAQP") is responsible for air quality surveillance in all areas of state other than Clark and Washoe Counties. These two counties operate and maintain separate monitoring networks and publish their findings independently.

2. Compliance with NAAQS in Nevada

Table 2 summarizes the NAAQS attainment status for counties in Nevada. Only Clark and Washoe counties are in nonattainment for any of the criteria pollutants.

Table 2. Current Nonattainment Areas in Nevada

Pollutant	Averaging Times	Nonattainment Areas in Nevada
Carbon Monoxide	8 hours	Clark County (Las Vegas)
	1 hour	None
Lead	Quarterly Average	None
Nitrogen Dioxide	Annual (Arithmetic Mean)	None
Particulate Matter (PM_{10})	24 hours	Clark County (Las Vegas), Washoe County (Reno)
Particulate Matter ($PM_{2.5}$)	Annual (Arithmetic Mean)	None
	24 hours	None
Ozone	8 hours	Clark County (Las Vegas)
Sulfur Dioxide	Annual (Arithmetic Mean)	None
	24 hours	None
	3 hours	None

Note: Washoe County was classified as in non-attainment for carbon monoxide from 1992 until 2008 but was reclassified as in attainment in April 2008 (EPA 2008).
Source: EPA 2009.

3. Nevada Air Quality Standards

Although the state air quality standards in Nevada are generally based upon the national standards, there are a few exceptions. The eight-hour state standard for CO is reduced to 6.0 ppm (from 9.0 ppm in the NAAQS) at altitudes above 5,000 feet in Nevada because of the decrease in available oxygen at higher altitudes. Currently, the Lake Tahoe monitoring sites are subject to this stricter standard. Also, the one-hour ozone standard in Nevada is 0.12 ppm (similar to the previous national one-hour standard that was revoked in 2005) with the exception of the Lake Tahoe Basin, where the standard is 0.10 ppm.

4. Trends in Nevada Air Quality[1]

The most recent Trends Report published by the BAQP (the 2003 Trends Report), covering the 12-year period from 1992 to 2003, generally found no deterioration in air quality over the report period, and found improvement in CO levels. In particular, there were no violations of the one-hour or eight-hour ozone standards within the BAQP jurisdiction (which excludes Clark and Washoe Counties). In 2004, the U.S. EPA designated all these areas as attainment/unclassifiable for the national eight-hour ozone standard.[2] NO_2 concentrations throughout Nevada were generally less than one-fifth of the standard and were in all cases below the standard. Although

[1] The information in this section relies on the 2003 Trends Report published by the Nevada Bureau of Air Quality Planning (BAQP 2004).

[2] Clark County, which is not in the BAQP jurisdiction for air quality monitoring, does have areas designated as nonattainment for the national eight-hour ozone standard.

SO_2 levels were not monitored throughout much of the report period, the existing data suggested that the SO_2 standard also was not violated.[3]

In general, there were few exceedances of the 24-hour or annual standards for PM_{10} for the 2003 Trends Report period. Although several exceedances were reported, they were excluded from nonattainment determinations under U.S. EPA policies to account for "exceptional events and natural events." The one area in nonattainment of the PM_{10} standard is a portion of Pahrump Valley in Nye County. The U.S. EPA, Nevada, the Pahrump Town Board, and Nye County are currently working to bring the area back into attainment in 2009.[4]

$PM_{2.5}$ monitoring began in Nevada in 1998. Early monitoring indicated low levels in all three monitored locations, at Carson City, Gardnerville, and Fernley. An exceedance of the $PM_{2.5}$ standard was recorded in 2001 as a consequence of a California forest fire. However, the U.S. EPA has designated all jurisdictions in Nevada as attainment/unclassifiable for the $PM_{2.5}$ standard.

5. Air Quality in Clark County

The ambient air quality standards in Clark Country are the same as the NAAQS given in Table 1. Las Vegas Valley in Clark County has been designated by the U.S. EPA as a nonattainment area for CO (eight-hour standard), PM_{10}, and ozone.

Specifically, in 1997, the U.S. EPA designated Las Vegas Valley a "serious" nonattainment area for CO (Clark County Department of Air Quality and Environmental Management 2008). By December 31, 2000, however, the county had achieved the CO standard, and an April 2006 report by the U.S. EPA (EPA 2006b) noted that there had been no exceedances since 1999. However, the valley remains classified as a nonattainment area.

Las Vegas Valley has also been designated as a "serious" nonattainment area for PM_{10} for violations of the 24-hour standard. In June 2004, the U.S. EPA extended the deadline for Las Vegas Valley to comply with the PM_{10} standards from 2001 to 2006. At the same time, the U.S. EPA approved the Clark County PM_{10} plan, which calls for strict control of fugitive dust (EPA 2004a). The valley remains classified as a PM_{10} nonattainment area.

Las Vegas Valley was designated as a "basic" nonattainment area for the eight-hour ozone standard in April 2004 (Clark County Department of Air Quality and Environmental Management 2008a). Clark County is required by U.S. EPA to attain the eight-hour ozone standard by June 2009 (EPA 2008).

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[3] The central Steptoe Valley in Ely (White Pine County) was listed until 2002 as not meeting primary SO_2 standards as a result of copper smelting activity at McGill that ceased operation in 1983. This area was reclassified as attainment on April 12, 2002.

[4] The U.S. EPA does not list Nye County as nonattainment (EPA 2009).

6. Air Quality in Washoe County[5]

Washoe County is subject to the NAAQS listed in Table 1. The county has been designated as in attainment for $PM_{2.5}$, NO_2, lead, SO_2, and ozone (excluding the one-hour standard, which was revoked in 2005). However, parts of Washoe County have been categorized in recent years as nonattainment areas for the eight-hour CO standard and the 24-hour PM_{10} standard.

For CO, the Reno-Sparks urban area was considered a "moderate" nonattainment area for the eight-hour standard. However, the last recorded exceedance of the standard occurred on December 13, 1991. EPA recently reclassified the area as in attainment (U.S. EPA 2008a).

For PM_{10}, Washoe County is categorized as a "serious" nonattainment area for the 24-hour standard. An exceedance of the standard was recorded on January 14, 2005. This exceedance was the first since 1999, and no additional exceedances have been recorded since.[6]

B. Categorization of Air Emissions

The calculation of environmental costs associated with a particular set of air emissions depends substantially on the regulatory treatment of the air emissions. In particular, air emissions that are covered by a cap-and-trade program warrant a different treatment from that applied to air emissions not covered by such a program. Because of the likelihood of the enactment of a greenhouse gas ("GHG") cap-and-trade program in the near future, CO_2 has been categorized as an air emission covered by a cap-and-trade program. There are, however, special challenges in estimating costs related to CO_2 emissions because there are great uncertainties about the specific elements of the likely cap-and-trade program. Thus, for CO_2, we develop a range of possible costs rather than a single set of estimates.

1. Air Emissions Included in this Study

We consider five emissions that are related to the criteria air pollutants covered by the NAAQS. The five emissions are PM, NOx, SO_2, CO, and VOC. These emissions contribute to ambient concentrations of criteria air pollutants in several ways:

- PM, NOx, and SO_2 emissions contribute to ambient PM concentrations. (The relevant PM concentrations for the environmental cost estimates in this study are $PM_{2.5}$ concentrations because the concentration response functions used to estimate the incidence of health effects use $PM_{2.5}$ concentrations).
- VOC and NOx emissions contribute to ambient concentrations of ground-level ozone.
- NO_2, SO_2, and CO emissions are themselves criteria air pollutants.

[5] This section relies on information from the Washoe County District Health Department (Washoe County District Health Department 2008).

[6] Personal communication with Washoe County District Health Department Air Quality Management Division.

We also consider emissions of mercury, which is not subject to an ambient air quality standard but which is regulated under Section 112 of the Clean Air Act. We categorize all these air emissions as covered or not covered by a cap-and-trade program.

In addition, as noted, we treat CO_2 as an air emission covered by a cap-and-trade program because of the likelihood of the enactment of a greenhouse gas cap-and-trade program in the future.

2. Air Emissions Covered by a Cap-and-Trade Program

In a cap-and-trade program, total emissions from covered facilities are capped, and covered facilities can buy or sell allowances (i.e., rights to emit). As discussed below, the requirement that NV Energy cover its emissions of SO_2 with allowances implies that the net cost of those emissions (i.e., costs of emissions minus allowance allocation) is appropriately considered a private cost and included in the PWRR rather than in environmental costs. The likelihood of a federal cap-and-trade program in the near term makes it appropriate to treat CO_2 in the same way.

a. SO_2 Regulation

SO_2 emissions from generating units in Nevada are currently covered by the Acid Rain Trading Program, a nationwide cap-and-trade program (Ellerman et al. 2003). Under the U.S. EPA Clean Air Interstate Rule ("CAIR"), many eastern states[7] implicitly will face a tighter cap on SO_2 emissions starting in 2010 (70 Fed. Reg. 25162) and this cap is scheduled to grow even tighter in 2015. Although Nevada is outside the covered area, there will continue to be a national market in allowances, and this change may affect the price of emissions in all states, not just the covered eastern states.[8]

CAIR has been the subject of several legal decisions over the last year. In July 2008, the U.S. Court of Appeals for the D.C. Circuit ruled that CAIR was fatally flawed and ordered the EPA to end the program. However, in December 2008, the same court reinstated CAIR until it can be replaced with another program consistent with the court's July 2008 ruling (U.S. EPA 2008b). As a result, there is considerable uncertainty about medium-to-long term SO_2 regulation and the price trajectory for SO_2 allowances.

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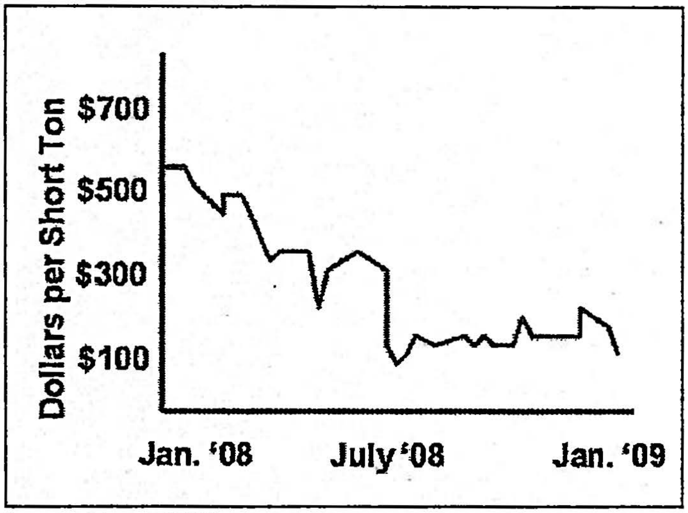
[7] The 28 eastern states covered by CAIR are largely those either east of the Mississippi River or bordering it on the west. The exceptions are Texas (which is covered) and Vermont, New Hampshire, Maine and Rhode Island (which are not).

[8] Under CAIR, the allocations of allowances will continue to be the same as under the Acid Rain Trading Program. However, for states covered by CAIR, each allowance will cover less then one ton. Initially an allowance used in the covered states will cover 0.5 tons, with the exchange rate falling to 0.35 tons in later years. Although each allowance will continue to cover one ton in Nevada and other uncovered states, the program, as originally constructed, may increase demand for allowances from eastern units, thus driving up the price and also the value of the allowances allocated to units owned by Nevada Power.

The changes in spot prices for SO_2 allowances since January 2008 have reflected the changes in the regulatory status of CAIR. Spot prices from the beginning of January in 2008 to the end of January in 2009 are shown in Figure 1. Before the initial court decision in July of 2008, the price of allowances typically was more than \$300 per ton and reached as high as \$500 per ton.

Figure 1. Historical Sulfur Dioxide Spot Allowance Prices



Source: Argus 2009.

In the days after the ruling, the spot price declined from more than \$300 to about \$100 per ton and spot prices were typically in the \$100 to \$200 range between July and December. In the immediate aftermath of the December ruling, prices increased from \$150 to about \$250 dollars but have since declined back towards \$100 per ton (Argus 2009).

b. CO_2 Regulation

Most commentators expect the federal government to develop a cap-and-trade program for greenhouse gas ("GHG") emissions in the 111th Congress, although there are of course uncertainties regarding any prediction of potential future legislation. Moreover, even if there is widespread agreement that a federal program will be established, there is much less agreement (and thus much greater uncertainty) about its specific elements. These design elements include the stringency of the program and the timing of required emissions reductions, scope of program coverage, allowance allocations, and rules regarding offset credits. Indications of what elements might be included come from the elements in the climate change bills that were put forward in the 110th Congress. There are several features in common in the most recent Senate bills, including "upstream" coverage of natural gas and oil-based fuels combined with "downstream" coverage of coal, bonus allowances for carbon capture and sequestration ("CCS") and limits on offset use in the range of 20 to 30 percent of the yearly cap.

One area of importance to the calculation of the financial effects of legislation in which there have been substantial differences between proposals is how allowances are distributed to electric utilities. The most recent version of Lieberman-Warner would have distributed allowances to Nevada Power and Sierra both as fossil fuel generators and as load-serving entities. Another proposal in the House of Representatives would provide no free allowances to covered entities, and would auction all allowances instead.

3. Air Emissions Not Covered by a Cap-and-Trade Program

Emissions not covered by a cap-and-trade program include PM, NOx, VOC, CO, and mercury. For all of these emissions except CO, we develop estimated damage values that reflect health effects of exposure to PM, ozone, and mercury. Because CO emissions have effects that are very site-specific, we do not have sufficient information to develop estimated damage values for CO. Environmental costs associated with CO emissions are best determined during focused site-selection processes undertaken by utilities. (We have, however, calculated levels of CO emissions under the respective plans; Appendix A to this report provides these estimated CO emission levels.) We do not consider effects of NOx emissions on NO_2 concentrations because the U.S. does not quantify potential health or welfare effects for NO_2 (EPA 2005a). We do not consider lead emissions because electric generating units are not substantial emitters of lead (EPA 2003a).

Mercury emissions from generating units in Nevada and other states were scheduled to be covered by a national cap-and-trade program in 2010 under the U.S. EPA Clean Air Mercury Rule ("CAMR") (70 Fed. Reg. 28606). However, on February 8, 2008, the United States Court of Appeals for the D.C. Circuit overturned EPA's proposed regulation and found that a cap-and-trade program for mercury is not permissible under the Clean Air Act (see, e.g., Barringer 2008). In early February 2009, the Obama administration announced that it would drop the Bush administration's appeal to the Supreme Court on the issue and that it would promulgate regulations consistent with the D.C. Circuit's ruling (NY Times 2009). If future mercury regulations affect Nevada Power or Sierra resources, the regulations would be expected to decrease mercury emissions and involve additional compliance costs.

Chapter 3: Methods for Assessing Costs Related to Air Emissions

This chapter outlines two distinct methodologies for assessing the relevant environmental costs of air emissions (SO_2, CO_2, NOx, PM, VOC, and mercury). For emissions that will be covered by a cap-and-trade program—in this case, SO_2 and CO_2—we use projections of future allowance prices and the number of free allowances allocated to Nevada Power and Sierra units in conjunction with estimates of emissions to develop estimates of the net costs of emissions. For conventional emissions not covered by a cap-and-trade program, we use a damage function approach.

A. Methodology for Air Emissions Covered by a Cap-and-Trade Program

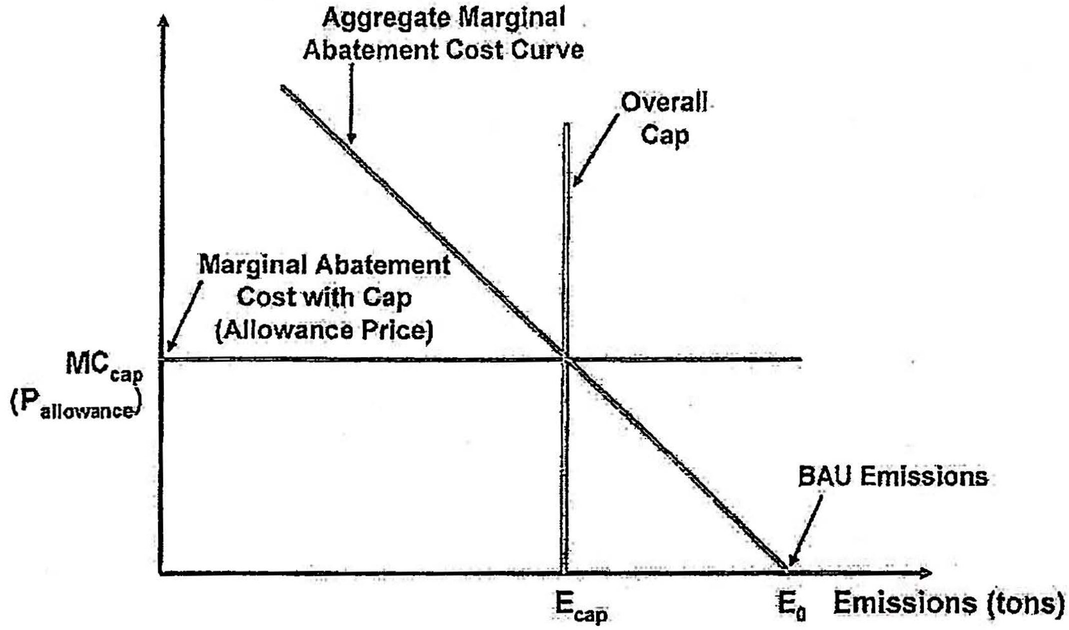
Emissions that are covered by a cap-and-trade program have market prices that reflect the marginal costs of emission reductions. Because emissions are capped, the overall levels of such emissions are constant. If one facility emits more of a covered emission, some other facility will emit less. Thus, Nevada Power and Sierra emissions do not affect the overall level of emissions. But these emissions do affect Nevada Power and Sierra from a financial perspective.

1. Overview of Cap-and-Trade Approach

A cap-and-trade program sets an overall cap on emissions and allows covered sources (e.g., generating units) to buy and sell allowances (i.e., rights to emit). Thus, increased emissions from one covered facility would be compensated for by decreased emissions at other covered facilities. In other words, because total emissions are "capped," total emissions from all covered facilities are constant.

Figure 2 below shows a conceptual framework for a cap-and-trade program. The figure shows baseline ("business-as-usual" or "BAU") emissions from the covered sources (i.e., total emissions without the program in place) as E_0. Under a cap-and-trade program, total emissions are limited to the cap, shown as E_{cap}. Figure 2 also shows a marginal cost curve for reducing emissions (i.e., the additional costs of more emissions reductions). The curve reflects the common situation in which some initial reductions are relatively inexpensive, but reductions become increasingly expensive as reductions increase.

Figure 2. Overview of Cap-and-Trade Program and Effect on Emissions



Under a well-functioning cap-and-trade program, the marginal cost per ton of reductions at the level of the cap will be equal to the market allowance price (i.e., $P_{allowance} = MC_{cap}$), the price that would be established in the market for emission allowances established under the cap-and-trade program. The marginal cost measures the increased cost of reducing (or the reduced cost of increasing) emissions by a single unit (e.g., one ton).

2. Implications for Assessing Costs of Emissions Covered by a Cap-and-Trade Program

Under a cap-and-trade program, an increase in emissions at a given facility or group of facilities would not lead to an *overall* increase in emissions from covered facilities because the cap would continue to be binding. Instead, other facilities would reduce emissions, and they would incur some costs to do so. The facilities undertaking emission reductions would be those facilities that could reduce emissions at a cost closest to the market allowance price for emissions. Facilities that could reduce emissions at a lower cost than the market price already would have done so, rather than paying the market price for those emissions; facilities that could only reduce emissions at a higher cost than the market price would prefer to pay the market price for those emissions. Thus, assuming an efficient market, the allowance price for emissions will equal the cost of reducing emissions by an additional small amount (the marginal cost of emission reductions).

Nevada Power and Sierra financial conditions will be affected by their emissions of pollutants covered by a cap-and-trade program because of the need to cover their emissions with allowances. The net cost in a particular year is equal to the amount needed to cover emissions (i.e., emissions times the allowance price) minus the value of the allowance allocation received for free (i.e., the allocation times the allowance price). Put another way, the annual financial costs to Nevada Power and Sierra would be equal to the net emissions (i.e., emissions minus allocation) times the allowance price.[9]

3. Use of Futures Prices to Estimate SO_2 Costs

In order to develop estimates of the costs associated with SO_2 emissions from NV Energy facilities, we obtained futures prices for SO_2 allowances from NYMEX. The relevant allowance market is the market for SO_2 allowances created by the Acid Rain Trading Program. This allowance market will also become the allowance market for CAIR when that program comes into effect in 2010. The net costs of SO_2 emissions also depend upon the allowances that Nevada Power and Sierra receive under the trading program. Thus, we also obtained information from Nevada Power on the free allocation of SO_2 allowances that its facilities and those of Sierra are expected to receive over the next 30 years.

We use the NYMEX futures prices, in combination with data on emission rates and dispatch information for Nevada Power and Sierra generating units, to develop estimates of the gross SO_2 costs for each plan. Futures prices are available for the years from 2009 to 2015. For subsequent years, we assume prices are constant (in real terms) at the 2015 price. We then subtract the value of Nevada Power and Sierra SO_2 allowance allocations under the acid rain trading program to develop net SO_2 costs in each year.

4. Use of Allowance Price Modeling to Estimate CO_2 Costs

A nationwide cap-and-trade program covering CO_2 and other GHG emissions seems likely to be developed in the next few years. In order to develop estimates of the costs associated with CO_2 emissions from NV Energy's facilities, we have used the National Energy Modeling System ("NEMS") to develop allowance price trajectories under three greenhouse gas cap-and-trade policy scenarios. NEMS is a detailed computable general equilibrium ("CGE") model developed by the U.S. Department of Energy's Energy Information Administration that considers both the supply-side and the demand-side for energy markets in the United States. Thus, for a given cap-and-trade policy, NEMS calculates the necessary allowance price trajectory and the changes that could occur in energy markets to meet the policy. The details of the NEMS model and the three modeled scenarios are presented in Appendix B.

In addition to the allowance prices forecasted by the modeling, the net costs of CO_2 emissions also depend upon the numbers of free allowances that Nevada Power and Sierra would receive under the trading program. We used the provisions of existing bills to create a wide range of scenarios for the free allocation of CO_2 allowances that Nevada Power and Sierra facilities could receive over the next 30 years. We also included an assumption that no free allowances would be

[9] As discussed below, this summary ignores some effects of a GHG cap-and-trade program on prices of fuels (e.g., natural gas and coal) and purchased power. These effects also will have financial effects on the Companies.

allocated (i.e., that the government would auction all allowances). The details of these allocation scenarios (None, Low and High) are also presented in Appendix B.

We use the projected allowance prices, in combination with data on emission rates and dispatch information for Nevada Power and Sierra generating units, to develop estimates of the gross CO_2 costs for each plan. As noted, we then subtract the value of Nevada Power and Sierra CO_2 allowance allocations under the different scenarios to develop net CO_2 costs in each year.

A national GHG cap-and-trade program would have impacts on other markets—notably natural gas and coal prices—that should be taken into account in a comprehensive assessment of the financial impacts. Our estimates include potential effects on fuel prices if emissions are regulated upstream and thus the costs of emissions are included in fuel prices, but our estimates do not include "demand effects" that would lead to other differences in fuel prices (e.g., if the cap-and-trade program leads to reduced demand for coal and thus lower coal prices). We would not expect that taking into account these "demand effects" would have any noticeable effect on the relative costs of the resource plans included in this Amendment.

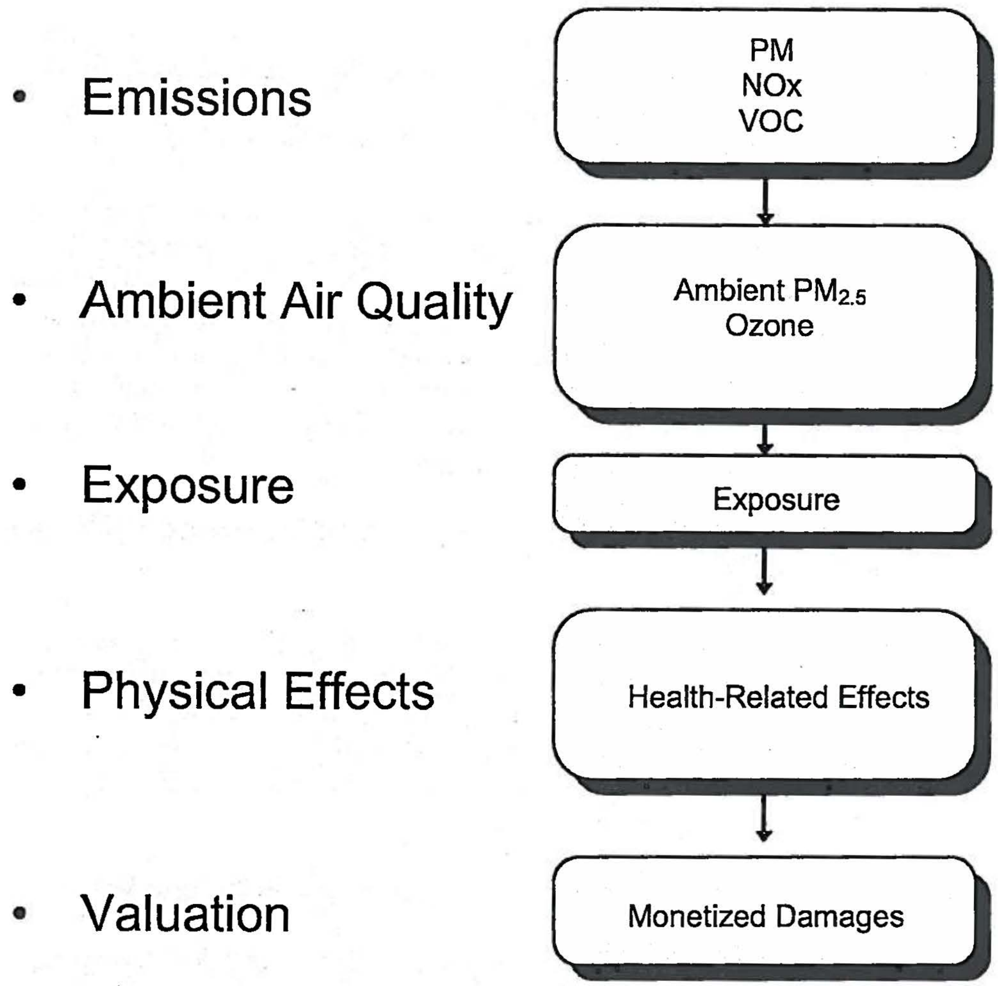
B. Methodology for Conventional Air Emissions Not Covered by a Cap-and-Trade Program

To develop estimates of the environmental costs of conventional air emissions other than SO_2, we utilize a damage value approach. The damage value approach begins with the premise that the conceptually correct measure of the value of a ton of pollutant is equal to the value of the damages that that ton causes. Damages can include effects on health, visibility, and agriculture. The conceptual and empirical foundations for this approach include extensive research by environmental scientists and economists over several decades.

1. Overview of Damage-Function Approach for PM, NOx, and VOC

We utilize the damage-function approach for three emissions—PM, NOx, and VOC. Figure 3 illustrates the steps involved in developing damage-based environmental costs for these emissions.

Figure 3. Conceptual Steps in Damage-Function Approach to Estimate Environmental Costs from Air Emissions



Source: Adapted from EPA 2005a.

a. Ambient Air Quality

PM, NOx, and VOC emissions contribute to ambient concentrations of ozone and PM. Ozone is formed by complicated atmospheric photochemical reactions involving VOC, NOx, and sunlight. Ambient PM concentrations arise from PM particles that are emitted directly and also from small-diameter particulates that are formed by chemical reactions in the air involving NOx. Because the health effects that provide estimated damage values depend on ambient concentrations of PM and ozone, not on direct emissions, the damage-function approach requires that direct air emissions be translated into ambient effects.

b. Exposure

The value of damages associated with ambient concentrations of PM or ozone depends on the number of people exposed to the pollutant. PM and ozone will have larger health effects in a populous area than in a rural area. Other effects, such as possible reductions in agricultural yields, also depend on (non-human) exposure.

c. Health and Welfare Effects

The relationship between exposure and health and welfare effects is the crucial element of the damage-function approach to assessing environmental costs. For health effects, such relationships typically are measured with concentration-response ("C-R") functions, which are based upon statistical studies from the epidemiology literature.[10] "C-R functions are equations that relate the change in the number of individuals in a population exhibiting a 'response' ... to a change in pollutant concentration experienced by that population" (EPA 1999, p. 52). The "responses" described by C-R functions are often referred to as health endpoints.

In general, C-R functions have the following mathematical form:

$$\Delta Health\ Effect = -\left[Baseline\ Incidence \cdot e^{-\beta \cdot \Delta Air\ Quality} - 1\right] \cdot Relevant\ Population,$$

where Δ*Health Effect* is the change in the number of cases observed of a particular health endpoint, Δ*Air Quality* is the change in ambient air quality in appropriate units (e.g., $\mu g/m^3$) for a given pollutant, *Baseline Incidence* is the baseline rate of the health endpoint in the exposed population, and the β parameter is an estimated coefficient for the relevant pollutant.

C-R functions translate changes in the numbers of people exposed to various ambient pollutant concentrations (Δ*Air Quality*) into changes in health effects (Δ*Health Effect*). Accurate application of these functions depends on consistency in the information on baseline incidence and relevant population. Specifically, the exposed population and baseline incidence rate used in calculating health effects must be consistent with the sample population used to estimate the relevant C-R function. If, for instance, a study only considers adults age 30 and over in estimating a C-R function, populations and baseline incidences for children should not be included in any use of that C-R function to estimate health effects from changes in ambient air quality.

The U.S. EPA notes that "epidemiological studies, by design, are unable to definitively prove a causal relationship between an exposure and a given health effect; they can only identify associations or correlations between exposure and the health outcome" (EPA 1999, p. D-7). Nonetheless, such studies generally provide the primary basis for developing C-R functions.

[10] In the case of non-health effects (such as effects on agricultural yield), these relationships are typically called "exposure-response" functions.

d. Valuation

Once incidences of health effects (or other effects, to the extent that they need to be considered) are determined, the values of those effects must be estimated to generate estimated damage values for direct air emissions. Over the past several decades, economists and other researchers have devised various methods for estimating how much people are willing to pay to reduce risks to health or premature mortality. Some of the methods rely upon the implicit tradeoffs that individuals make in daily decisions; for example, statistical models have been used to estimate the increased wages that workers demand in riskier occupations. Other methods rely upon direct surveys of representative individuals, the results of which may be analyzed to produce demand curves for reduced health or mortality risk.

2. Damages Associated with Mercury Emissions

Unlike ambient PM, mercury in the air is not associated with deleterious effects. Mercury is only associated with potential harmful effects when it is deposited on the ground or in bodies of water, from whence it makes its way into the food chain and is consumed by humans. The main mechanism by which emitted mercury causes health effects is through ingestion. Deposited mercury becomes concentrated in fish, which are then consumed by humans.

The estimated damage values for mercury were derived from EPA estimates of mercury damages per ounce from the CAMR Regulatory Impact Analysis (EPA 2005d). These estimates are based on valuation of the health effects of increased mercury concentration in fish on the neurological development of prenatally exposed children, including IQ changes due to exposure to mercury in fish.

Chapter 4: Costs Associated With Air Emissions

This chapter develops estimates of environmental and related costs associated with SO_2, CO_2, PM, NOx, VOC, and mercury emissions. As noted previously, SO_2 is covered by a cap-and-trade program and we assume that CO_2 will be as well, and thus we use allowance prices to determine the associated costs of these emissions. PM, NOx, and VOC emissions contribute to ambient concentrations of PM and ozone; mercury emissions, when deposited in the watershed, can be absorbed by fish and subsequently consumed by humans. The estimated damage values related to PM and ozone effects are based on emissions and air quality levels developed specifically for Nevada Power and Sierra facilities, supplemented with recent analyses of concentration-response functions and health effect valuations developed by the U.S. EPA in its regulatory impact assessments for CAIR (EPA 2005a) and for Best Available Retrofit Technology ("BART") for the Clean Air Visibility Rule (EPA 2005b). The estimated damage values for mercury are based on mercury intake, resulting health effects and valuations developed by the U.S. EPA in its regulatory impact assessments for CAMR (EPA 2005d).

A. Assessment of SO_2 Emissions Costs

This section provides an assessment of costs related to emissions of SO_2, which as noted are regulated by a cap-and-trade program.

1. Allowance Prices for SO_2

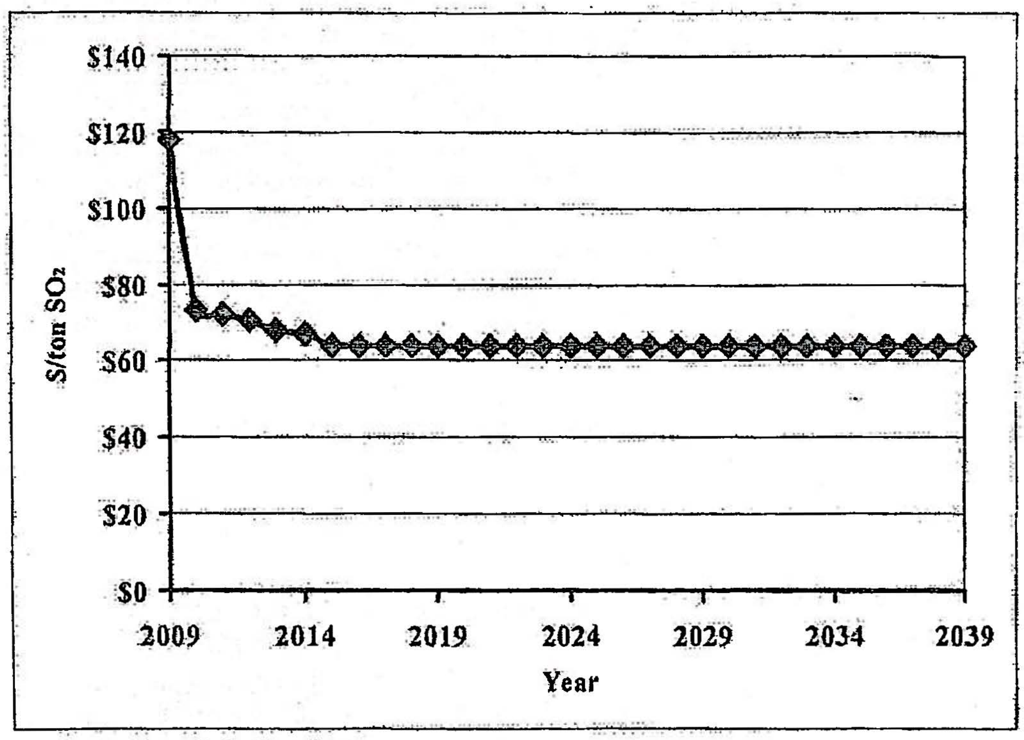
Title IV of the 1990 Clean Air Act mandates that virtually all electric steam generating stations participate in a cap-and-trade program for SO_2 emissions, known as the Acid Rain Trading Program (see Ellerman et al. 2003 for information on the Acid Rain Trading Program). Requirements to reduce SO_2 emissions are strengthened further by CAIR. Figure 4 displays the projected allowance prices for SO_2 in the western United States, which is outside the direct coverage of CAIR and where each allowance (of any vintage) covers one ton of emissions. These prices are based on NYMEX futures contracts from early February 2009. These prices[11] represent the current best estimates of the price of SO_2 allowances delivered at future dates. Since these futures are currently only trading through 2015, we have used the 2015 price for each year thereafter.

The sharp drop in the allowance price between 2009 and 2010 is the result of a feature of CAIR. Allowances from vintages 2010 through 2014 will only count towards one-half of one ton of emissions in the eastern CAIR region and, as a result, these allowance vintages are worth less to eastern sources than pre-2010 vintages. Although western sources are not affected by this change, they will be affected by the resulting changes in the national market prices. Eastern sources will require 2.86 allowances (per ton of emissions) from vintages 2015 on. While there is a small nominal drop in prices between 2014 and 2015, it is not the size one would expect due to

[11] NYMEX monthly futures have been averaged for each year and then changed from nominal dollars to 2008 dollars using the long-term inflation forecast from the "Fourth Quarter 2008 Survey of Professional Forecasters" from the Federal Reserve Bank of Philadelphia.

the change in the exchange rate. Futures prices in 2015 are undoubtedly being affected by the uncertainty in regulations because of the changes to CAIR required by the D.C. Circuit Court (as discussed in the previous chapter).

Figure 4. Projected SO_2 Allowance Prices



Note: All values in 2008 dollars.
Sources: NYMEX 2009 and NERA calculations as explained in text

2. Net Costs for SO_2

To calculate costs for SO_2 for each year of the forecast period, we utilize the SO_2 price forecast described above, as well as emission rates and heat input information for all of Nevada Power and Sierra's facilities in each year. (Note that the emission rates reflect the effects of control technologies that have been instituted at Nevada Power and Sierra facilities.) We then deduct from these gross SO_2 costs the value of Nevada Power and Sierra's SO_2 allowance allocation in each year. The allowance allocation is more than sufficient to cover Nevada Power and Sierra's SO_2 emissions, and thus net SO_2 costs are negative (i.e., there are net revenues). Table 3 provides the net present value of SO_2 costs for each plan (discounted at the 8.67 percent nominal discount rate used by Nevada Power in revenue requirement calculations).

Table 3. Present Values of Costs (millions) for SO_2 Emissions

Plan	SO_2 Costs	SO_2 Allocation Value	Net SO_2 Costs
Plan 1 (No ON Line)	$3.35	$22.10	-$18.75
Plan 2 (400 MW ON Line)	$3.36	$22.10	-$18.74
Plan 3 (600 MW ON Line)	$3.37	$22.10	-$18.74
Plan 4 (800 MW ON Line)	$3.37	$22.10	-$18.74

Notes: All values are present values for the period 2010-2039 discounted at 8.67 percent nominal (6.57 percent real after accounting for expected inflation rates over the period) as of January 1, 2009, in millions of 2008 dollars.
Net costs may differ from the sum of the columns due to independent rounding.
Source: NERA calculations as explained in text.

3. Differences in SO_2 Costs

Table 4 shows the differences in net SO_2 costs between the ON Line relative to Plan 1 (without the ON Line). Thus, the differences represent costs avoided by constructing the ON Line, with the level of avoided costs dependent upon the capacity of the ON Line. Note that the allocation does not affect the comparisons in this table because the allocation is based upon historical information.

Table 4. Differences in Present Values of Costs (millions) for SO_2 Emissions Relative to Plan 1.

Plan	SO_2 Costs
Plan 1 (No ON Line)	-
Plan 2 (400 MW ON Line)	$0.02
Plan 3 (600 MW ON Line)	$0.02
Plan 4 (800 MW ON Line)	$0.02

Notes: Entries for plans 2, 3 and 4 are differences between present value of plan in question and corresponding present value for Plan 1.

There is very little difference in SO_2 costs across the plans. The addition of the ON Line would result in emissions costs for SO_2 rising between $15,000 and $20,000, or 0.1 percent of the net SO_2 costs.

B. Assessment of CO_2 Emissions Costs

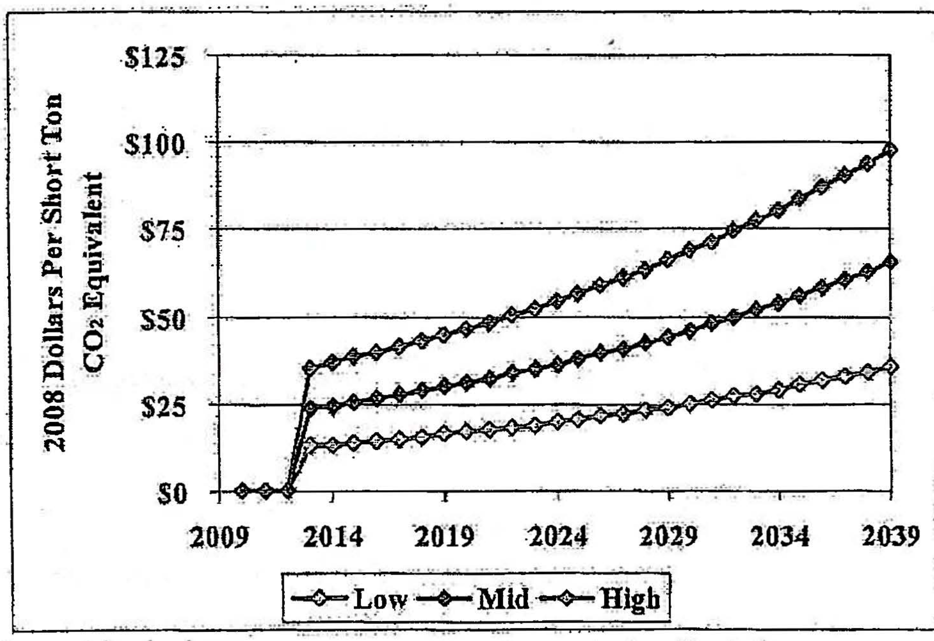
This section evaluates costs related to emissions of CO_2. As discussed above, estimates of costs associated with CO_2 emissions are subject to substantial uncertainties. We provide values for CO_2 emissions under three cap-and-trade scenarios and three allocation scenarios, resulting in a total of nine scenarios. These scenarios are discussed in Appendix B and build on several existing proposals in Congress.

1. Allowance Price Scenarios

As noted above, various GHG cap-and-trade proposals have been introduced in Congress with varying levels of stringency and other specific elements and thus varying potential allowance price trajectories. In light of the substantial uncertainties regarding the potential legislation and uncertainty surrounding the likely allowance prices that would result, we provide three alternative CO_2 allowance price scenarios that are based on allowance price modeling done using NEMS. Our intention is to provide a range of potential carbon price scenarios rather than to single out a specific CO_2 price trajectory.

Figure 5 provides the three estimates of projected allowance prices for CO_2. The NEMS modeling provides projections through 2030. We have assumed that prices would continue to grow at the prior years' growth rate in subsequent years of the planning horizon (i.e., through 2039). As noted previously, the details behind the development of these trajectories are described in Appendix B. A detailed description of NEMS is provided in Appendix C.

Figure 5. Projected CO_2 Allowance Prices



Notes: All values in 2008 dollars per short ton of CO_2 equivalent (CO_2e). To covert values to dollars per metric ton, multiply by 1.10.
Source: NERA modeling and calculations as explained in text

2. Gross CO_2 Costs

Table 5 summarizes the net present value of the gross costs associated with emissions of CO_2 for each of the four plans evaluated under each of the three CO_2 caps modeled. These costs are the products of the projected allowance prices and the projected emission levels, appropriately discounted (as provided in Appendix A to this report). Thus, gross CO_2 costs account for the direct liabilities of the Companies for CO_2 emissions, including the CO_2 emissions from NV Energy generating units and emissions associated with purchased electricity. The rationale for including emissions associated with purchased electricity is that the CO_2 costs of the marginal generating unit would be passed on in the wholesale power markets to power purchasers. Thus, NV Energy would pay higher prices for electricity by an estimated amount equal to the per-MWh CO_2 cost of the marginal generator.

We also note that these values do not reflect the effects on the costs of alternative plans of some changes in fuel prices resulting from the cap-and-trade program for CO_2. Moreover, because the CO_2 costs were not included in dispatch modeling, these costs likely overstate the true cost of CO_2 emissions, particularly in the high price trajectory case, because changes in dispatch would reduce CO_2 emissions.

Table 5. Present Values of Gross Costs (millions) for CO_2 Emissions under Three Price Scenarios

	CO_2 Prices		
Plan	**Low**	**Mid**	**High**
Plan 1 (No ON Line)	$3,888	$7,198	$10,744
Plan 2 (400 MW ON Line)	$3,876	$7,176	$10,710
Plan 3 (600 MW ON Line)	$3,874	$7,172	$10,705
Plan 4 (800 MW ON Line)	$3,873	$7,170	$10,702

Notes: All values are present values for the period 2010-2039 discounted at 8.67 percent nominal (6.57 percent real) as of January 1, 2009, in millions of 2008 dollars.
Source: NERA calculations as explained in text

3. Allowance Allocation Scenarios

As noted, we developed three allocation scenarios, which we term "none," "low," and "high." The "none" scenario assumes that 100 percent of allowances would be auctioned and thus that Nevada Power and Sierra would receive no free allocation; we include this scenario in order to provide a wide range of potential financial outcomes and because this feature has been proposed in Congress. The low and high scenarios reflect different assumptions regarding the level of free allocation. Both of these scenarios assume that historical information would be used to allocate allowances. We did not include a case in which allocations would be based upon updated information (e.g., 2020 allocation depends upon 2015 information) because developing such a case would require additional modeling and we believed that including these impacts would not affect the relative costs of the alternative resource plans.

Table 6 summarizes the net present values of total allocation to Nevada Power and Sierra for the nine different combinations of allocation scenarios and carbon scenarios. Since these values are only based on historical data, they are identical for each of the four plans. The potential value of the allocations received by the two Companies spans a wide range, from zero in the case of the auction scenario to almost $6 billion under the high price/high allocation scenario. The calculations behind these figures are provided in Appendix B.

Table 6. Range of Total Allocation Value for Nevada Power and Sierra

		CO_2 Prices		
		Low	Mid	High
Allocation Scenario	None	$0	$0	$0
	Low	$939	$1,595	$2,162
	High	$2,608	$4,327	$5,953

Notes: All values are present values for the period 2010-2039 discounted at 8.67 percent nominal (6.57 percent real) as of January 1, 2009, in millions of 2008 dollars.
Source: NERA calculations as explained in text

4. Net CO_2 Costs

Table 7 summarizes the present value of net costs associated with emissions of CO_2 for each of the four plans evaluated under a subset of allocation scenario-CO_2 price scenario combinations. Net CO_2 costs are the difference between gross costs and the value of the allowances allocated to Nevada Power and Sierra. Because we consider three allocation scenarios and three CO_2 price trajectories, as noted there are a total of nine possible cases for net CO_2 costs. To provide a simpler picture of the range of possible outcomes, we present only three cases here: low CO_2 prices paired with the high allocation scenario (lowest net costs), high CO_2 prices paired with the auction scenario (highest net costs), and mid CO_2 prices paired with the low allocation scenario (roughly intermediate net costs). The net costs for all nine possible combinations are presented in Appendix B.

Note that the range of possible net costs is wider than the range of possible gross costs. Combining the low CO_2 prices with high allocation results in net costs that are lower than gross costs, while combining the high CO_2 price scenario with the "none" scenario results in net costs that are equal to gross costs. Thus, the lowest net CO_2 costs for each plan under any scenario evaluated here are roughly $1.3 billion, whereas the highest net costs are roughly $10.7 billion. This range reflects the substantial uncertainties regarding the cost implications of a GHG cap-and-trade program for Nevada Power and Sierra.

Table 7. Present Values of Costs (millions) for CO_2 Emissions with Three Carbon Scenarios under Different Allocation Scenarios

	(1)	(2)	(3)
CO_2 Prices:	Low	Mid	High
Allocation Scenario:	High	Low	None
Plan 1 (No ON Line)	$1,280	$5,603	$10,744
Plan 2 (400 MW ON Line)	$1,268	$5,580	$10,710
Plan 3 (600 MW ON Line)	$1,266	$5,577	$10,705
Plan 4 (800 MW ON Line)	$1,265	$5,575	$10,702

Notes: All values are present values for the period 2010-2039 discounted at 8.67 percent nominal (6.57 percent real) as of January 1, 2009, in millions of 2008 dollars.
Source: NERA calculations as explained in text

5. Differences in CO_2 Costs

Table 8 shows the differences in CO_2 costs between each of the plans with the ON Line relative to Plan 1 (without the ON Line). Thus, the differences represent costs avoided by constructing the ON Line, with the level of avoided costs dependent upon the capacity of the ON Line. Note that it is not necessary to show allocation scenarios in this table because the difference in CO_2 costs is not affected by the allocation scenarios. (The allocation scenarios are based upon historical information and the expansion plans only differ in what resources are constructed in the future). Other allocation formulas, particularly those that include updating, could affect the differences in costs between the various plans, although in this case the differences would be minor.

Table 8. Differences in Present Values of Costs (millions) for CO_2 Emissions Relative to Plan 1.

	CO_2 Prices		
Plan	Low	Mid	High
Plan 1 (No ON Line)	-	-	-
Plan 2 (400 MW ON Line)	-$12	-$22	-$33
Plan 3 (600 MW ON Line)	-$14	-$26	-$38
Plan 4 (800 MW ON Line)	-$15	-$28	-$41

Notes: Entries for plans 2, 3 and 4 are differences between present value of plan in question and corresponding present value for Plan 1.

There is very little difference in CO_2 costs across the plans. The maximum difference shown in Table 8 is between Plan 4 and Plan 1 in the high case. However, at $41 million, this only represents 0.4% of the gross CO_2 costs for Plan 1 in the high case and 0.8% of net CO_2 costs in the high case with high allocation. Plan 3, the preferred plan, saves only slightly less in the high case ($38 million). Thus, although substantial uncertainty exists in terms of the impact of CO_2 regulation, these uncertainties do not have a substantial effect on differences in CO_2 costs among the expansion plans under consideration in this Amendment.

It is important to note that the ON Line will provide additional flexibility to locate new generation capacity, particularly new renewable capacity, that is not reflected in these calculations. Different portions of Nevada have very different characteristics for renewable resources, with solar resources (which tend to be more expensive renewable resources) relatively strong in the south and wind and geothermal resources (which tend to be less expensive resources) relatively strong in the north. The ON Line would give the Companies increased flexibility to reduce costs (including construction, operation and environmental costs) in the face of potential climate policy developments. If, for example, CO_2 allowance prices turned out to be relatively high, the ON Line could allow the companies to reduce their CO_2 emissions and total costs via the construction and operation of additional renewable resources in the north as a replacement for fossil-fuel generation from existing units or planned capacity additions in the south.

C. Damage Assessments for Emissions of NOx, VOC, PM and Mercury

The estimated damage values for NOx, VOC, and PM in this study are derived from estimated emission levels, relationships between emissions and ambient air quality, population exposure estimates, C-R functions, and values for various health effects. Damage values for mercury are estimated using a simple linear relationship between emissions and the damages they cause.

1. Emissions Resulting from Eleventh Amendment Plans

Nevada Power has performed dispatch modeling for each of the four plans considered in the Eleventh Amendment. From the output of this modeling, we have estimates for each plan of the annual heat input (in MMBtu) consumed by each generating unit (both existing units and potential new units) in the Nevada Power and Sierra systems from 2010 through 2039. Nevada Power also has developed estimated emission rates for most of these units, and recent emission rates for the remaining units can be found in the U.S. EPA's National Emissions Inventory ("NEI") database. With these two sets of information, we forecasted total emissions in each year under each plan. Appendix A to this report provides these forecasts, as well as details on the data sources used to develop them.

2. Emissions and Air Quality

In any particular case, the relationship between emissions and air quality depends on a number of factors, including generating unit characteristics, geographic location, and meteorology. To develop likely air quality impacts associated with the plans considered in the Eleventh Amendment, we rely on previous air quality results developed for Nevada Power (Harrison et al. 1993) and Sierra (Harrison et al. 1993a). Appendix E to this report provides details on these air quality modeling results and how we have applied them in this study.

3. Health Effects of Air Quality Changes

Application of the damage-function approach requires identifying the appropriate health and welfare endpoints potentially affected by changes in ambient PM and ozone concentrations, and developing valuations for effects on these endpoints. Statistical relationships between air quality changes and health effects are subject to much uncertainty, as are endpoint valuation estimates. The U.S. EPA recognizes in its recent analyses related to CAIR and BART that there are limitations to this approach:

> Although methods exist for quantifying the benefits associated with many of these human health and welfare categories, not all can be evaluated at this time because of limitations in methods and/or data (EPA 2005b, p. 4-2).

Both the CAIR and BART analyses include estimates of the health and welfare benefits of reducing emissions of NOx and thereby reducing ambient PM and ozone concentrations. The majority of these benefits come from reductions in premature mortality related to ambient PM concentrations. Indeed, as the U.S. EPA notes "[i]n any benefit analyses of air pollution regulations, estimation of pre-mature mortality accounts for 85 to 95 percent of total benefits" (EPA 2004, p. 9-203).

The CAIR and BART analyses provide a framework for identifying and valuing appropriate health and welfare endpoints for assessment of environmental costs in Nevada. In this study, we rely upon the estimates that have been developed by the U.S. EPA. Although we have not developed independent assessments of the validity of the U.S. EPA estimates, we do provide some discussion of the uncertainties regarding these effects in Appendix E.

Table 9. Health Effects Quantified in U.S. EPA Analyses and Used in This Study

Pollutant	Health Effect
Particulate matter	Premature mortality
	Infant mortality
	Chronic bronchitis
	Nonfatal heart attacks (myocardial infarction)
	Hospital admissions for respiratory causes
	Hospital admissions for cardiovascular causes
	Emergency room visits for asthmatics
	Acute bronchitis
	Lower respiratory symptoms
	Upper respiratory symptoms
	Asthma exacerbations
	Work loss days
	Minor restricted-activity days
Ozone	Hospital admissions for respiratory causes
	Emergency room visits for asthmatics
	Minor restricted-activity days
	School absence days

Source: EPA 2005a.

Table 9 lists the kinds of health effects quantified in the U.S. EPA analyses. Several health effects (such as school absence days) pertain to only a subset of the population. We use these health effects, and the values developed for them by the U.S. EPA, in our assessment of environmental costs. In keeping with the U.S. EPA analyses, we do not quantify welfare effects other than health effects. Appendix E to this report provides detailed information on the specific C-R functions and valuation estimates applied to these health endpoints.

In the case of mercury, the principal health effect considered by the EPA in its analysis is associated with prenatal exposure to high levels of mercury, which has been linked to impairment of neurological development. In quantifying these effects, we rely on EPA's Final Regulatory Impact Analysis (Final RIA) for the CAMR.

4. Estimated Environmental Costs for Emissions of NOx, VOC, PM and Mercury

Table 10 summarizes our estimates of the environmental costs associated with NOx, VOC, and PM, and mercury emissions for each of the four plans evaluated. These costs are in 2008 dollars and are calculated as present values as of January 1, 2009 using a nominal discount rate of 8.67 percent. VOC emissions could in principle affect ambient ozone concentrations. However, the air quality modeling results used in this study indicate that increased VOC emissions do not lead to greater ozone concentrations in Nevada (i.e., ozone concentrations in Nevada are almost exclusively driven by NOx emissions). Thus, the estimated environmental costs associated with VOC emissions are zero.

Table 10. Present Values of Environmental Costs (millions) for NOx, PM, VOC, and Mercury Emissions

Plan	NO_x	PM	VOC	Mercury	Total
Plan 1 (No ON Line)	$2.1	$69.0	$0.0	$1.6	$72.7
Plan 2 (400 MW ON Line)	$2.0	$68.9	$0.0	$1.6	$72.5
Plan 3 (600 MW ON Line)	$2.0	$68.9	$0.0	$1.6	$72.5
Plan 4 (800 MW ON Line)	$2.0	$68.9	$0.0	$1.6	$72.5

Notes: All values are present values for the period 2010-2039 discounted at 8.67 percent nominal discount rate (6.57 percent real discount rate) as of January 1, 2009, in millions of 2008 dollars.
Totals may differ from the sum of the columns due to independent rounding.

It is important to note that these estimates are subject to substantial uncertainties and are sensitive to various assumptions made by EPA in developing the underlying concentration-response functions and in valuing the health effects. Appendix E summarizes the key issues with respect to the largest cost component, PM-related mortality. EPA's estimates incorporate several assumptions that are conservative in the sense that they are likely to overstate the costs.

These quantitative estimates also do not include certain health and welfare effects that may be associated with these pollutants, but for which EPA concluded the available data were insufficient to quantify effects. As discussed in Appendix E, we have reviewed these effects and concluded that they are likely to be small relative to the quantified costs, and hence their exclusion is unlikely to have a material impact on environmental costs.

5. Differences in Environmental Costs for Emissions of NOx, VOC, PM and Mercury

Table 11 shows the differences in environmental costs associated with NOx, VOC, and PM, and mercury emissions between each of the plans with the ON Line relative to the Plan 1 (without the ON Line).

Table 11. Differences in Present Values of Environmental Costs (millions) for NOx, PM, VOC, and Mercury Emissions relative to Plan 1

Plan	NO_x	PM	VOC	Mercury	Total
Plan 1 (No ON Line)	-	-	-	-	-
Plan 2 (400 MW ON Line)	-$0.1	-$0.1	$0.0	$0.0	-$0.2
Plan 3 (600 MW ON Line)	-$0.1	-$0.1	$0.0	$0.0	-$0.2
Plan 4 (800 MW ON Line)	$0.0	-$0.2	$0.0	$0.0	-$0.2

Notes: Entries for plans 2, 3 and 4 are differences between present value of plan in question and corresponding present value for Plan 1.

The environmental costs of Plan 4 with the 800 MW ON Line are about $0.2 million lower than those of Plan 1, which does not have the ON Line. For a given expansion plan, the addition of the ON Line causes NOx and PM damages to decrease and mercury damage to increase slightly but always lowers the total environmental costs. The size of the ON Line can affect the differences in environmental costs in unpredictable ways because generation shifts among different sources depending on the size of the ON Line.

Chapter 5: Other Environmental Costs

While air emission effects appropriately receive the most attention in evaluations of the environmental costs from power generation, other environmental impacts also can be relevant. Indeed, the NAC lists two non-air pollution impacts—water use and land use—in the list of externalities to be considered in environmental assessments of plans.

We considered four categories of non-air environmental impacts: (1) water consumption; (2) water quality impacts; (3) solid waste disposal, including sludge and ash disposal; and (4) land use. For each category, we considered whether or not there might be significant differences in environmental costs among the plans considered in the Eleventh Amendment. We concluded there would not be.

A. Water Consumption

Nevada generating units draw their water from a variety of sources. For example, the El Dorado Energy Project in Boulder City purchases its water supply from the city, which, in turn, draws water from Lake Mead. The North Valmy Power Plant uses a network of deep wells located five to fifteen miles east of the plant site.[12]

Utilities pay for water purchased from local supply, generally at market prices. For example, in the Las Vegas valley, municipal water rates depend on meter size; a commercial operation using a twelve-inch meter would pay a service charge of about \$210 per month plus \$1.10 per thousand gallons for the first 850,000, then gradually more on a per-gallon basis up to \$3.48 for every thousand over 59.5 million gallons (Las Vegas Valley Water District 2008). Similarly, in Washoe County, a general service customer using a ten-inch meter pays a service fee of \$47 plus an additional charge depending on use: \$1.58 per thousand gallons if consuming up to 6.8 million per month, \$2.50 per thousand gallons if consuming between 6.8 million and 29.6 million, and \$2.91 per thousand gallons if consuming more than 29.6 million gallons (Truckee Meadows Water Authority 2008).

Groundwater, another source of water supply in Nevada, is governed by water rights. The State Engineer has decision-making authority with respect to the distribution of water rights (Nevada Division of Water Resources 2008). In particular, the State Engineer is required to consider whether the proposed use of water will "prove detrimental to the public interest" before allowing the provision of rights. Furthermore, water rights are treated as any other property and may be bought or sold.

We do not expect that the different plans considered in the Eleventh Amendment would result in very different amounts or environmental costs of water consumption. A more extensive analysis to determine potential environmental costs, if any, might be developed during permitting

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[12] This information comes from facility fact sheets from the Nevada Department of Conservation and Natural Resources Division of Environmental Protection (NVDEP 2008).

processes. Note that actual expenditures on water use for specific facilities would be included in the operating costs calculated for those facilities.

B. Water Quality Impacts

Generating units typically emit several water pollutants that could lead to damages to local surface or ground water quality. The Federal Clean Water Act establishes effluent standards for new generating units. Nevada applies these same water quality standards to all generating units, existing as well as new. However, facilities in the Nevada Power and Sierra systems do not release water effluent in surface waters, but rather use evaporation ponds to dispose of their liquid wastes. The impact of pollutants deposited in these evaporation ponds is largely dependent upon the method of containment utilized and the depth of adjacent ground water. The evaporation ponds for existing and new facilities in the Nevada Power and Sierra systems have double liners and monitoring equipment to detect any groundwater leakage. Thus, contamination of groundwater is unlikely. Moreover, because groundwater depth varies significantly by location, from a few feet to a few hundred feet (La Camera et al. 2005), water quality impacts are best examined on a site-specific basis. Actual expenditures on liquid waste disposal for specific facilities would be included in the operating costs calculated for those facilities. In any event, Nevada Power does not believe that there would be significant differences among the four plans in terms of water pollutants placed in the evaporation ponds.

C. Solid Waste

Different generating units often produce different amounts of solid waste during operation—and at different rates. For example, coal-fired technologies generally produce more solid waste than gas-fired technologies (EPA 2006a). Actual expenditures on solid waste disposal for specific facilities would be included in the operating costs calculated for those facilities. Potential environmental impacts from solid waste disposal would depend on surface depth of groundwater and would be best examined on a site-specific basis. However, the potential for environmental damages is low because all facilities in the Nevada Power and Sierra systems, and any other entities providing solid waste disposal services, must meet stringent federal standards for landfills. We do not expect that the different plans considered in the Eleventh Amendment would result in materially different amounts or environmental costs of solid waste disposal.

D. Land Use

Land used by generating units and transmission facilities includes not only land for the equipment, but also land for disposal of liquid and solid waste (whether this disposal takes place on site or elsewhere). Actual expenditures on land use for specific facilities would be included in the operating costs calculated for those facilities (and the upfront costs of land purchases for new facilities).

The ON Line route is located almost entirely on public lands managed by the United States Department of the Interior Bureau of Land Management ("BLM"). Very few private parcels are crossed by the line or proposed project access roads. The Companies estimate that they will have to enter negotiations with fewer than ten private landowners to acquire permanent or temporary use easements. The Companies are currently seeking the appropriate permits from the BLM for the use of public lands. A BLM Record of Decision ("ROD") is expected to be issued in the fourth quarter of 2009 and a Notice to Proceed ("NTP"), allowing the Companies to start construction, could be received in 2010.

Chapter 6: Economic Impacts of Electric Utility Resource Selection

This chapter considers the "economic benefits" or "impacts" of the plans considered in the Eleventh Amendment.

A. Overview of Nevada Regulations and "Economic Benefits"

The "economic benefits" defined in the NAC are traditionally referred to as "economic impacts" to distinguish them from other types of benefits. Benefits of public or private investments include the ability to produce various outputs, e.g., steel, electric power, and transportation services. Economic benefits or impacts account for the gains to a local or state economy from locating investments and expenditures within the jurisdiction.

1. Nevada Regulations

The Commission outlines a circumscribed role for analysis of economic impacts. The projected PWSC of a competing plan must be within 10 percent of the lowest PWSC among all plans considered before the NAC calls for analysis of the "economic benefits" of the competing plan. That means that the economic impacts may be used as a "tie breaker" rather than as the major determinant in evaluations of alternative plans.

The calculations of economic impacts are to include estimates of the portion of expenditures within the State of Nevada for the following five categories (NAC 704.9357):

1. Capital expenditures for land and facilities located within the State or equipment manufactured in the State;
2. The portion of the cost of materials, supplies and fuel purchased in the State;
3. Wages paid for work done within the State;
4. Taxes and fees paid to the State or subdivisions thereof; and
5. Fees paid for services performed within the State.

The NAC does not provide specific guidelines on how this information is to be used. The NAC notes that *the Commission*—not the utility—may adjust the social cost comparisons to consider "all, or only a portion, of the calculated economic benefit" (NAC 704.9357).

2. Background on Economic Impacts

Economic impacts, as traditionally evaluated, are not directly comparable to environmental or real resource costs associated with construction and operation of facilities (for power generation or any other industry). Rather, economic impacts are measures of economic activity within a region.

a. Contrast between Economic Impacts and Social Costs and Benefits

Economic impacts are not generally considered to be components of benefit-cost analyses of the social costs and benefits of public or private projects. In the context of benefit-cost analyses, benefits are the direct gains from a program or project. For a generating unit, the benefit is the energy output produced by the facility once it is operating. Costs are the value of the resources (including environmental costs) used to construct, operate, and maintain the facility.

Local or state expenditures and other economic impacts are thus not benefits in the context of a benefit-cost analysis. Indeed, economic impacts often are more appropriately thought of as components of the costs rather than the benefits. Thus, a project with greater economic impacts will often be one with greater resource costs. The actual economic impacts of any particular project depend on how the expenditures for the project are distributed within the state or locality and how local or state industries interact with one another.

b. Categories of Economic Impacts

In this study, we assess the overall effects of on the Nevada economy of each plan considered in the Eleventh Amendment. Our empirical assessment includes four metrics, all applied specifically to Nevada:

- industry value added (i.e., the value of goods and services provided by industries);
- employment;
- labor income; and
- tax payments.

c. Methodologies to Estimate Economic Benefits or Economic Impacts

Economic impact studies generally classify impacts into three categories:

1. *Direct* impacts are the expenditures from project activity itself—for example, expenditures on construction and operation of a generating unit.
2. *Indirect* impacts reflect changes in industry output for industries that are linked through supply and demand to a directly affected industry—for example, increased demand for raw metals due to construction of a generating unit.
3. *Induced* impacts represent the "multiplier" effects of direct and indirect expenditures as employees spend their wages on goods and services within a jurisdiction around a project

location—for example, increased expenditures on entertainment from new employees working at a new generating unit.

In the language of regional economics, direct expenditures typically represent "base" industries. Increases in the economic base of a region contribute to changes in overall regional economic activity through the combination of direct, indirect, and induced effects.

3. Techniques for Estimating Economic Impacts

The traditional means of estimating economic impacts is to use engineering or other estimates of the direct expenditures on construction or operation of a facility, and then use regional multipliers to estimate the indirect and induced economic contributions that follow these direct contributions.

The use of state and regional multipliers represents a simple and inexpensive method of estimating the economic contribution of a given project. This method begins with engineering or other estimates of the direct expenditures required for construction or operation of a facility. Regional multipliers based on input-output ("I/O") tables can then provide estimated indirect and induced economic effects.

One source of regional multipliers is the U.S. Department of Commerce Regional Input-Output Modeling System ("RIMS-II"). The heart of the model is a set of I/O relationships among different industries. These relationships show how industries are related to one another in terms of both inputs and outputs. Thus, they can predict how changes in one industry will affect demand for other industries (those that supply inputs to the industry in question). In addition, I/O models can be used to trace through the effects that result from changes in the incomes of workers in the affected industries.

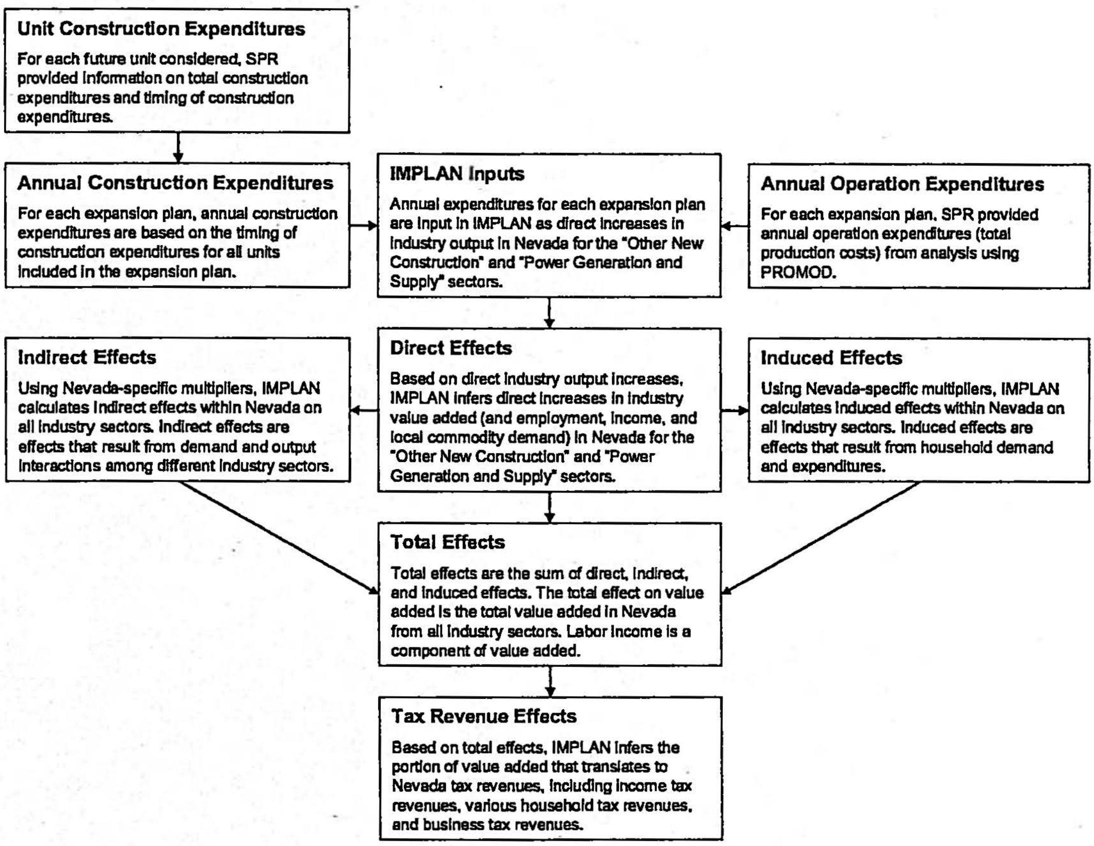
The RIMS-II model, derived from the national I/O table and from state and county-level modifications, provides three individual I/O matrices: employment, earnings, and total income multipliers. This technique has been documented by the Department of Commerce and has been used to estimate economic impacts in many circumstances. Typical applications of RIMS-II include determining the economic impacts of new public infrastructure projects, such as airports or highways, or large private investments, such as manufacturing plants or automotive assembly plants.

Another regional multiplier model, IMPLAN (IMpact analysis for PLANing), was originally developed by the University of Minnesota for use in the U.S. Forest Service Land Management Planning Unit in 1979 and is currently managed by the Minnesota IMPLAN Group, Inc. ("MIG"). IMPLAN provides an enhanced version of a simple I/O table and provides greater flexibility than the simple RIMS multipliers. IMPLAN contains over 500 industry sectors that can be manipulated to examine the economic impacts of projects. IMPLAN can generate regional accounts for single counties, groups of counties, single states or groups of states, or the entire United States. A model can be constructed in IMPLAN for any of these areas using companion data for that region.

B. Economic Impacts

This section provides our estimates of the economic impacts in Nevada of the plans considered in the Eleventh Amendment. We develop estimates using IMPLAN and include the appropriate multiplier estimates in our calculations.[13] Appendix F to this report provides an overview of IMPLAN. Appendix G to this report provides detailed results on the estimated economic impacts of each plan. Figure 6 illustrates the steps involved in our assessment of economic impacts.

Figure 6. Flowchart for Calculations of Economic Impacts



1. Background and Context for Economic Impacts

The construction and operation of generating units can have a substantial impact on the economy of the region where the facilities are located. Local jobs are created when a facility is built as a result of the increased demand for construction and other related personnel. Once operating, a generating unit requires personnel to operate and maintain the facility. It also generates jobs as a

[13] IMPLAN cannot account for some of the detailed effects of individual plans, including the different fractions of expenditures that are spent within Nevada based upon differences in fuel use or differences in the fractions of electricity that is purchased. Thus, results from IMPLAN may not fully reflect differences among the plans.

result of demand for additional goods and services required by the facility. Moreover, operation of generating units creates an induced, or multiplier, effect on the regional economy as employees earn and spend money within the area.

2. Economic Impacts of Plant Construction

The largest economic impacts from new generating units typically occur during the construction phase, although these impacts are often relatively short in duration. The construction of generating units leads to direct demand for labor and for goods. Engineering cost estimates typically provide estimated overall expenditures and details on the individual items included in these direct effects. Construction costs include payments for site preparation, physical plant (e.g., power plant buildings), support facilities, direct labor, and other costs. Our estimates of construction expenditures come from PWRR calculations developed by the Companies for each of the four plans.

a. Overview of "Construction of Other New Non-Residential Structures" Industry in Nevada

Our analysis of construction effects uses IMPLAN information regarding the "Construction of Other New Non-Residential Structures" industry in Nevada, which includes construction of new generating units, and other facilities. Table 12 summarizes the distribution of industry output for the sector. IMPLAN industry information is derived from data from the U.S. Bureau of Economic Analysis and the U.S. Bureau of the Census.

Table 12. Composition of Industry Output for the Nevada "Construction of Other New Non-Residential Structures" Sector

Source	% of Industry Output
Nevada labor income for construction sector	46.2%
Other "value added" for Nevada construction sector	3.6%
Purchases from other sectors in Nevada	18.3%
Purchases from other sectors outside Nevada	31.8%

Source: IMPLAN.

b. Construction Costs

Each plan considered in the Eleventh Amendment involves a different assumption about the construction of the ON Line. Table 13 shows the estimated total and net present value construction costs of the different plans. The net present value construction costs range from $4.6 billion to $5.0 billion. We input these expenditures (on an annual basis) into IMPLAN as industry output for the "Other New Construction" sector. IMPLAN data indicate that the "Other New Construction" sector in Nevada, considered as a commodity, is 100-percent supplied by Nevada industries (though 31.8 percent of this Nevada industry output comes from out-of-state commodities). So we apply the full estimated construction expenditures as industry output for the "Other New Construction" sector.

Table 13. Construction Expenditures (millions of dollars)

Expansion Plan	Total Expenditures	PV Expenditures
Plan 1	$11,861	$5,566
Plan 2	$12,315	$5,963
Plan 3	$12,315	$5,963
Plan 4	$12,405	$6,032

Note: All entries are present values for the period 2010-2039 discounted at 8.67 percent nominal (6.57 percent real) as of January 1, 2009, in millions of 2008 dollars.

c. Construction Impacts on the Nevada Economy

Table 14 shows the IMPLAN estimates of direct, indirect, and induced effects on industry value added in Nevada resulting from the construction expenditures in Table 13. Estimated construction impacts are the same for Plans 2 and 3 because neither involves incremental construction expenditures for Nevada Power or Sierra beyond what is common to all four plans; construction costs related to power purchase or the solar facility would be reflected in operating costs for Nevada Power and Sierra.

Table 14. Direct, Indirect, and Induced Effects of Construction Expenditures on Industry Value Added in Nevada (millions of dollars)

Expansion Plan	Direct Effect	Indirect Effect	Induced Effect	Total Effect
Plan 1	$2,775	$848	$993	$4,615
Plan 2	$2,973	$908	$1,063	$4,944
Plan 3	$2,973	$908	$1,063	$4,944
Plan 4	$3,007	$918	$1,076	$5,001

Note: All entries are present values for the period 2010-2039 discounted at 8.67 percent nominal (6.57 percent real) as of January 1, 2009, in millions of 2008 dollars.

The indirect effects capture inter-industry purchases of materials and services related to the direct effects. For example, some (but not all) direct construction expenditures go to local sub-contractors, who in turn purchase materials from local building supply stores. Induced effects reflect increased personal consumption expenditures. For example, the construction of a power generation facility initially requires labor to clear and prepare a building site. Laborers for this task spend part (but not necessarily all) of their wages on Nevada products and services, such as food, housing, and health care. Providing food, housing, and health care services in turn requires other local products and services.

Table 15 shows the IMPLAN estimates of overall effects on the Nevada economy of the construction expenditures under each plan considered in the Eleventh Amendment.

Table 15. Economic Impacts from Construction Expenditures

Expansion Plan	Industry Value Added (million 2008$, NPV)	Employment (Employee-Years)	Labor Income (million 2008$, NPV)	State Tax Revenues (million 2008$, NPV)
Plan 1	$4,615	142,366	$3,751	$236
Plan 2	$4,944	147,821	$4,018	$253
Plan 3	$4,944	147,821	$4,018	$253
Plan 4	$5,001	148,900	$4,064	$255

Note: All entries are present values for the period 2010-2039 discounted at 8.67 percent nominal (6.57 percent real) as of January 1, 2009, in millions of 2008 dollars.

3. Economic Impacts of Plant Operation

From the production cost modeling performed by Nevada Power for each of the plans, we have information on annual production cost expenditures, which include expenditures on labor, parts, fuel, purchased power, and any other components of operating costs.

a. Background on "Electric Power Generation, Transmission, and Distribution" Industry in Nevada

Our analysis of operation effects uses IMPLAN assumptions regarding the "Electric Power Generation, Transmission, and Distribution" industry in Nevada. Table 16 summarizes the distribution of industry.output for the sector.

Table 16. Composition of Industry Output for the Nevada "Electric Power Generation, Transmission, and Distribution" Sector

Source	% of Industry Output
Nevada labor income for power sector	20.1%
Other "value added" for Nevada power sector	51.8%
Purchases from other sectors in Nevada	5.5%
Purchases from other sectors outside Nevada	22.6%

Source: IMPLAN.

b. Operation Expenditures

Table 17 shows the total and net present value expenditures for plant operation under the plans. The net present value of operation costs range from $34.2 billion to $34.5 billion. As with the construction expenditures, we input the operation expenditures into IMPLAN on an annual basis. IMPLAN data indicate that the "Power Generation and Supply" sector in Nevada, considered as a commodity, on average is 71.1 percent supplied by Nevada industry. So we apply 71.1 percent of the estimated operation expenditures to industry output for the "Power Generation and Supply" sector.

Table 17. Operation Expenditures (millions of dollars)

Expansion Plan	Total Expenditures	NPV Expenditures
Plan 1	$98,157	$34,487
Plan 2	$97,559	$34,292
Plan 3	$97,458	$34,263
Plan 4	$97,393	$34,245

Note: All entries are present values for the period 2010-2039 discounted at 8.67 percent nominal (6.57 percent real) as of January 1, 2009, in millions of 2008 dollars.

c. Operation Impacts on the Nevada Economy

Table 18 shows the IMPLAN estimates of direct, indirect, and induced effects on industry value added in Nevada from the operation expenditures in Table 17.

Table 18. Direct, Indirect, and Induced Effects of Operation Expenditures on Industry Value Added in Nevada (millions of dollars)

Expansion Plan	Direct Effect	Indirect Effect	Induced Effect	Total Effect
Plan 1	$13,864	$1,337	$1,479	$16,680
Plan 2	$13,786	$1,329	$1,471	$16,585
Plan 3	$13,774	$1,328	$1,469	$16,571
Plan 4	$13,767	$1,327	$1,469	$16,563

Note: All entries are present values for the period 2010-2039 discounted at 8.67 percent nominal (6.57 percent real) as of January 1, 2009, in millions of 2008 dollars.

Table 19 shows the IMPLAN estimates of overall effects on the Nevada economy of the operation expenditures under each plan considered in the Eleventh Amendment.

Table 19. Economic Impacts from Operation Expenditures

Expansion Plan	Industry Value Added (million 2008$, NPV)	Employment (Employee-Years)	Labor Income (million 2008$, NPV)	State Tax Revenues (million 2008$, NPV)
Plan 1	$16,680	193,285	$5,605	$2,542
Plan 2	$16,585	192,107	$5,573	$2,528
Plan 3	$16,571	191,909	$5,568	$2,526
Plan 4	$16,563	191,781	$5,565	$2,524

Note: All entries are present values for the period 2010-2039 discounted at 8.67 percent nominal (6.57 percent real) as of January 1, 2009, in millions of 2008 dollars.

The IMPLAN model may lead to an overstatement of the impacts of purchased power, because it applies average figures for the fraction of operational expenditures that are in-state. Here, however, because the incremental power would come primarily from out-of-state generation units, the average figure used in the IMPLAN model is too high. Modifying the model to account for this fact would reduce the impacts associated with purchased power.

4. Total Economic Impacts

Table 20 shows the combined effects of the construction and operation expenditures for each of the plans considered in the Eleventh Amendment. Combined effects on Nevada industry value added range from about $21.3 billion to about $21.6 billion.

Table 20. Economic Impacts from Construction and Operation Expenditures Combined

Expansion Plan	Industry Value Added (million 2008$, NPV)	Employment (Employee-Years)	Labor Income (million 2008$, NPV)	State Tax Revenues (million 2008$, NPV)
Plan 1	$21,295	335,651	$9,356	$2,778
Plan 2	$21,529	339,928	$9,591	$2,780
Plan 3	$21,516	339,730	$9,586	$2,778
Plan 4	$21,564	340,682	$9,630	$2,780

Note: All entries are present values for the period 2010-2039 discounted at 8.67 percent nominal (6.57 percent real) as of January 1, 2009, in millions of 2008 dollars.

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Appendix A: Air Emissions under Eleventh Amendment Plans

This appendix provides information on the expected emissions (measured in short tons except for mercury, which is measured in ounces) under each of the four plans considered in the Eleventh Amendment. The estimates are primarily based on information from production cost modeling performed by NV Energy and information from NV Energy on actual and expected emission rates for relevant generating units. We also rely on the U.S. EPA's EGRIDS database for emission factors for units that are included in NV Energy's production cost/dispatch modeling but are not owned by Nevada Power or Sierra Pacific (e.g., Las Vegas cogeneration units).

The production cost modeling provided expected annual heat input for each unit in the Sierra and Nevada Power systems under each plan. For each relevant unit owned by Nevada Power or Sierra in the output from the production cost modeling, NV Energy provided emission rates (per unit of heat input) for SO_2, NOx, CO, PM, VOC, CO_2 and mercury. We supplemented these emission rates with emission rate data for specific units from the U.S. EPA.[14] The product of annual heat input and emission rates gives annual emissions for each unit—and total annual emissions for each plan from units in the Nevada Power and Sierra systems.

The production cost modeling also provided expected annual amounts (MWh) of market energy purchases under each plan. Because likely sources of externally purchased power are unknown (and, generally, unknowable), we developed representative emission rates for purchased energy. NV Energy provided us with an estimate of the percentage of hours that each of three generation types (combined cycle gas turbine, non-combined cycle gas, and coal) is on the margin for various years throughout the forecast period. Using this data, as well as data from the U.S. EPA's EGRIDS database (provided by NV Energy), we developed estimated emission factors for market power purchases. Emissions associated with power purchases were modeled as though they were emitted in Nevada, in accordance with regulatory requirements.

A. Carbon Dioxide

Table A-1 summarizes expected CO_2 emissions under the four plans. Information on GHG allowance allocation scenarios is in Appendix B.

[14] EIA 2007a and 1994. The rate used for coal generation is the electricity sector rate for Nevada.

Table A-1. Emissions of Carbon Dioxide (short tons)

Year	Plan 1	Plan 2	Plan 3	Plan 4
2010	17,780,057	17,780,057	17,780,057	17,780,057
2011	17,269,101	17,269,101	17,269,101	17,269,101
2012	17,721,004	17,720,613	17,720,613	17,720,613
2013	18,107,652	18,111,976	18,111,615	18,112,417
2014	18,495,702	18,477,335	18,474,320	18,473,720
2015	19,449,496	19,487,899	19,488,625	19,488,111
2016	20,198,483	20,216,329	20,223,367	20,223,424
2017	19,216,733	19,174,038	19,172,579	19,173,311
2018	19,264,349	19,189,313	19,187,807	19,188,809
2019	19,756,174	19,707,575	19,698,794	19,697,692
2020	20,122,874	20,103,523	20,103,720	20,097,174
2021	19,850,559	19,786,043	19,791,323	19,788,806
2022	19,472,678	19,416,461	19,406,499	19,405,551
2023	19,362,149	19,314,271	19,314,719	19,311,955
2024	18,974,272	18,873,449	18,857,722	18,850,075
2025	18,745,927	18,639,361	18,624,164	18,618,261
2026	18,026,922	17,926,111	17,916,771	17,898,708
2027	18,002,112	17,919,347	17,898,965	17,889,971
2028	18,527,844	18,435,064	18,415,710	18,400,614
2029	18,868,003	18,774,261	18,759,413	18,739,859
2030	19,076,530	18,983,778	18,956,895	18,937,069
2031	19,486,418	19,394,859	19,375,287	19,365,536
2032	19,857,907	19,767,139	19,755,511	19,745,016
2033	20,271,755	20,170,597	20,147,364	20,138,301
2034	20,654,147	20,551,291	20,536,178	20,535,024
2035	21,069,607	20,988,091	20,970,984	20,962,785
2036	21,620,030	21,512,780	21,502,172	21,492,943
2037	21,802,475	21,708,241	21,685,833	21,685,473
2038	22,273,422	22,185,844	22,170,755	22,161,366
2039	22,759,598	22,697,944	22,689,166	22,681,309

Source: NERA Calculations as described in text

B. Nitrogen Oxides

Table A-2 summarizes expected NOx emissions under the four plans.

Table A-2. Emissions of Nitrogen Oxides (short tons)

Year	Plan 1	Plan 2	Plan 3	Plan 4
2010	15,650	15,650	15,650	15,650
2011	14,236	14,236	14,236	14,236
2012	13,991	13,989	13,989	13,989
2013	14,688	14,727	14,730	14,731
2014	15,140	15,058	15,053	15,046
2015	16,952	17,036	17,050	17,054
2016	17,948	17,984	18,004	18,008
2017	14,405	14,294	14,297	14,299
2018	13,792	13,580	13,576	13,580
2019	13,993	13,910	13,894	13,909
2020	13,709	13,824	13,847	13,852
2021	12,662	12,758	12,820	12,838
2022	10,726	10,800	10,805	10,822
2023	10,117	10,186	10,232	10,260
2024	8,289	8,270	8,271	8,296
2025	7,257	7,234	7,250	7,274
2026	3,732	3,661	3,672	3,672
2027	2,473	2,370	2,360	2,370
2028	2,546	2,476	2,475	2,492
2029	2,602	2,544	2,544	2,568
2030	2,722	2,645	2,638	2,642
2031	2,744	2,672	2,667	2,694
2032	2,768	2,712	2,687	2,709
2033	2,945	2,872	2,862	2,882
2034	3,024	2,943	2,939	2,963
2035	3,085	3,019	3,034	3,031
2036	3,271	3,209	3,215	3,231
2037	3,298	3,238	3,244	3,244
2038	3,441	3,398	3,412	3,421
2039	3,693	3,665	3,674	3,674

Source: NERA Calculations as described in text

C. Particulate Matter

Table A-3 summarizes expected PM emissions under the four plans. The emissions shown are PM_{10} emissions. Because the estimated damage values for PM emissions in this study are related to $PM_{2.5}$, we translate these emissions into effects on $PM_{2.5}$ concentrations.

Table A-3. Emissions of Particulate Matter (short tons)

Year	Plan 1	Plan 2	Plan 3	Plan 4
2010	1,056	1,056	1,056	1,056
2011	988	988	988	988
2012	989	989	989	989
2013	988	990	989	989
2014	1,009	1,007	1,007	1,006
2015	1,087	1,096	1,096	1,096
2016	1,167	1,172	1,172	1,172
2017	930	927	927	927
2018	928	924	924	924
2019	946	943	943	943
2020	973	972	972	971
2021	954	951	951	951
2022	961	958	957	958
2023	930	927	927	927
2024	904	896	895	895
2025	873	867	866	865
2026	793	787	787	785
2027	770	764	762	761
2028	793	787	786	785
2029	808	802	801	801
2030	818	812	810	809
2031	834	829	827	826
2032	852	846	845	845
2033	872	866	865	864
2034	890	882	881	881
2035	910	903	902	901
2036	937	929	928	927
2037	946	939	937	937
2038	967	961	959	958
2039	989	984	983	982

Source: NERA Calculations as described in text

D. Sulfur Dioxide

Table A-4 summarizes expected SO_2 emissions under the four plans as well as the yearly allowance allocations.

Table A-4. Emissions of Sulfur Dioxide and Allowance Allocation (short tons)

Year	Plan 1	Plan 2	Plan 3	Plan 4	Allocation
2010	5,350	5,350	5,350	5,350	17,145
2011	5,023	5,023	5,023	5,023	17,145
2012	4,764	4,764	4,764	4,764	17,146
2013	5,923	5,961	5,970	5,972	26,711
2014	5,949	5,968	5,974	5,977	28,706
2015	6,529	6,569	6,577	6,577	28,706
2016	6,668	6,711	6,717	6,718	28,706
2017	6,487	6,495	6,491	6,492	28,706
2018	6,044	6,036	6,040	6,041	28,706
2019	6,332	6,396	6,390	6,392	28,735
2020	5,984	6,087	6,097	6,097	28,706
2021	5,744	5,792	5,801	5,802	28,706
2022	2,301	2,338	2,336	2,341	28,706
2023	2,150	2,191	2,205	2,208	28,706
2024	1,417	1,422	1,422	1,422	28,706
2025	1,277	1,283	1,283	1,283	28,706
2026	198	198	198	198	28,706
2027	26	25	25	25	28,706
2028	26	26	26	26	28,706
2029	27	26	26	26	28,706
2030	26	26	26	26	28,706
2031	27	27	27	26	28,214
2032	27	27	27	27	28,214
2033	27	27	27	26	28,214
2034	28	27	27	27	28,214
2035	27	27	27	27	28,214
2036	29	28	28	28	28,214
2037	28	28	28	28	28,214
2038	30	29	28	28	28,214
2039	31	30	30	30	28,214

Source: NERA Calculations as described in text

E. Mercury

Table A-5 summarizes expected mercury emissions under the four plans.

Table A-5. Emissions of Mercury (ounces)

Year	Plan 1	Plan 2	Plan 3	Plan 4
2010	1,376	1,376	1,376	1,376
2011	1,230	1,230	1,230	1,230
2012	1,159	1,159	1,159	1,159
2013	1,168	1,177	1,176	1,176
2014	1,215	1,219	1,218	1,217
2015	1,370	1,397	1,396	1,396
2016	1,510	1,528	1,530	1,529
2017	1,013	1,012	1,013	1,013
2018	980	979	979	979
2019	1,009	1,007	1,007	1,007
2020	1,000	1,007	1,008	1,008
2021	909	912	915	916
2022	864	872	872	872
2023	782	787	790	792
2024	602	598	598	599
2025	444	440	441	442
2026	248	244	244	243
2027	71	65	64	64
2028	74	69	69	70
2029	75	72	72	73
2030	82	77	77	77
2031	74	70	69	70
2032	74	71	70	71
2033	82	78	78	79
2034	84	80	80	82
2035	86	83	84	84
2036	94	91	91	92
2037	95	92	92	92
2038	100	98	99	100
2039	112	111	111	111

Source: NERA Calculations as described in text

F. Carbon Monoxide

Because CO emissions have effects that are very site-specific, we do not have sufficient information to develop estimated damage values for CO. Environmental costs associated with CO emissions are best determined during focused site-selection processes undertaken by utilities. We have, however, calculated expected levels of CO emissions under the plans. Table A-6 provides these expected emissions.

Table A-6. Emissions of Carbon Monoxide under Plans (short tons)

Year	Plan 1	Plan 2	Plan 3	Plan 4
2010	2,825	2,825	2,825	2,825
2011	2,677	2,677	2,677	2,677
2012	2,618	2,618	2,618	2,618
2013	2,951	2,941	2,946	2,946
2014	2,913	2,888	2,891	2,892
2015	3,025	3,007	3,011	3,011
2016	3,056	3,027	3,031	3,030
2017	2,984	2,957	2,957	2,958
2018	2,794	2,745	2,742	2,742
2019	2,849	2,809	2,807	2,808
2020	2,788	2,779	2,782	2,781
2021	2,682	2,672	2,680	2,683
2022	1,674	1,671	1,668	1,669
2023	1,093	1,074	1,074	1,077
2024	783	750	748	749
2025	758	728	727	727
2026	578	547	542	535
2027	521	480	469	466
2028	538	505	498	499
2029	547	518	511	513
2030	569	534	529	525
2031	580	546	537	539
2032	577	550	541	545
2033	621	588	582	584
2034	638	605	601	605
2035	636	605	607	604
2036	695	666	663	664
2037	698	670	668	666
2038	734	710	710	708
2039	813	794	794	791

Source: NERA Calculations as described in text

References

U.S. Energy Information Administration. 1994. *Quarterly Coal Report, January-April 2994*. Washington, D.C.: EIA, August. http://www.eia.doe.gov/cneaf/coal/quarterly/co2_article/co2.html, accessed June 11, 2007.

U.S. Energy Information Administration. 2007a. *Electric Power Annual 2000 Volume II*. Table A3. Washington, D.C.: EIA, January. http://www.eia.doe.gov/cneaf/electricity/epav2/html_tables/epav2ta3p1.html, accessed June 11, 2007.

Appendix B: Modeling of GHG Cap-and-Trade Price Scenarios and Allocation Scenarios

This appendix details the CO_2 allowance price modeling and allowance allocation scenarios.

A. Modeling of GHG Cap-and-Trade Scenarios

In order to develop estimates of the costs associated with CO_2 emissions from each of NV Energy's expansion plans, we have used the National Energy Modeling System ("NEMS") to model three greenhouse gas cap-and-trade policy scenarios. This appendix provides information on the scenarios that were developed. Appendix C provides further details on NEMS.

1. Reference Case

NEMS was developed by the Energy Information Administration ("EIA"), an independent statistical agency in the Department of Energy, and has used by the EIA to model many potential energy and environmental policies, including the Lieberman-Warner and Bingaman-Specter proposals.

The first step in developing greenhouse gas cap-and-trade policy scenarios is defining a reference case. The reference case was based on the recent revision to NEMS performed by the EIA for the 2009 Annual Energy Outlook Early Release. We made two modifications to the AEO 2009 to develop our reference case:

- We included a Renewable Portfolio Standard with a 15 percent renewables target (on a generation basis excluding existing hydropower) by 2020 (based on proposal from Senator Bingaman in 2007[15]); and

- Henry Hub natural gas prices were calibrated to NV Energy's base case Henry Hub gas prices. This was done to ensure consistency between the CO_2 policy modeling and the rest of the analysis performed by NV Energy.

2. Cap-and-Trade Scenarios

We then modeled three cap-and-trade policy scenarios using NEMS. Each policy scenario differed from then reference case only in the inclusion of a cap-and-trade program for CO_2.

a. Cap Trajectories

The main difference between the three scenarios (Low, Mid and High) is the cap trajectory on greenhouse gases, as shown in Figure B-1. For comparison, emissions from the reference case for the covered sectors are also shown. The difference between the reference case emissions and the cap is the required emissions reduction for each scenario.

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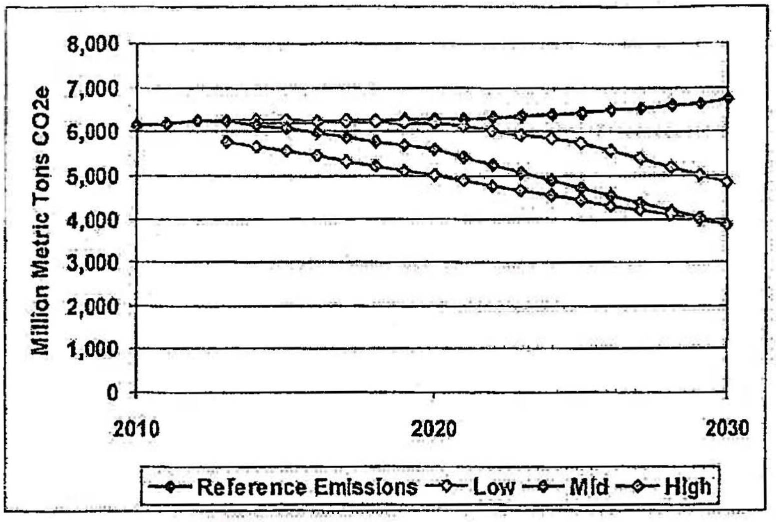
[15] See S.A. 1537 in References.

Figure B-1. GHG Caps for Three Scenarios and Reference Emissions



Source: NERA modeling and calculations as explained in text

All three cap trajectories start in 2013. The "Low" cap is based on the cap from the Bingaman-Specter bill. It starts at reference emissions[16] in 2013 and declines linearly to the actual 2020 Bingaman-Specter cap, then follows the cap from the Bingaman-Specter bill from 2020 to 2030. The "High" cap trajectory is based on the cap from Lieberman-Warner. It begins at the actual starting Lieberman-Warner cap in 2013 and declines linearly to the actual Lieberman-Warner cap in 2030. The "Mid" cap trajectory is a blend of the two, starting at the "Low" cap, declining linearly to an average of the two caps in 2020 and then declining linearly to the "High" cap in 2030.

b. Other Cap-and-Trade Elements

As noted previously, the cap alone does not fully specify the parameters of a cap-and-trade program. The following assumptions were made across all three cases:

- Limit on annual offset[17] use of 25 percent of the annual cap;
- The CCS bonus that provides bonus allowances for each ton of carbon dioxide sequestered, starting at 2.0 allowances in 2016 and gradually declining to 0.5 allowances in 2030[18]; and

[16] In order to estimate reference emissions, the AEO 2009 version of NEMS was calibrated to NV Energy's base Henry Hub gas prices and a 15% national RPS was also included. The national RPS appears to be similarly likely to be passed in the next two years.

[17] Domestic offsets are limited to 15 percent of the cap and international credits and offsets to 10 percent of the cap.

[18] There is also a limit of approximately 3.5 billion allowances on the total number of allowances that can be distributed under this provision. In any year in which this limit would be reached, the remaining pool would be pro-rated across eligible facilities.

- 4 percent real escalation rate for GHG allowance prices (MIT 2005).

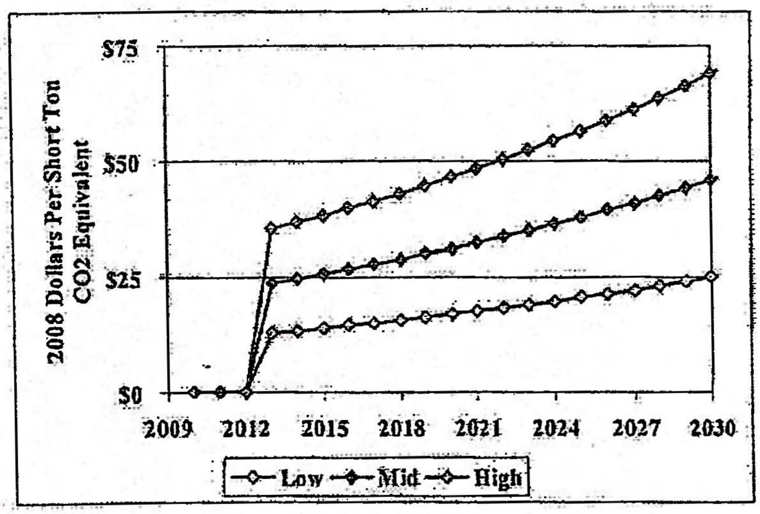
In addition to these policy assumptions, the following restrictions were implemented in order to reflect other likely practical constraints and considerations:,

- Limit of 45 GW of incremental nuclear capacity by 2030 (Dept. of Energy 2008);
- Yearly limit of 4 GW of incremental wind capacity in 2009 which increases linearly to a yearly limit of 18 GW of incremental wind capacity in 2018 and thereafter (Dept. of Energy 2008a); and
- Ending bank balance of 5 billion metric tons of allowances in 2030 in order to simulate stringent targets past 2030 (EIA 2008)

3. Allowance Price Trajectories

Figure B-2 shows the modeled price trajectories based upon compliance with the greenhouse gas cap-and-trade programs described above.

Figure B-2. Modeled Allowance Price Trajectories for Three Scenarios



Source: NERA modeling and calculations as explained in text

B. CO_2 Allowance Allocation Scenarios and Allocation Value

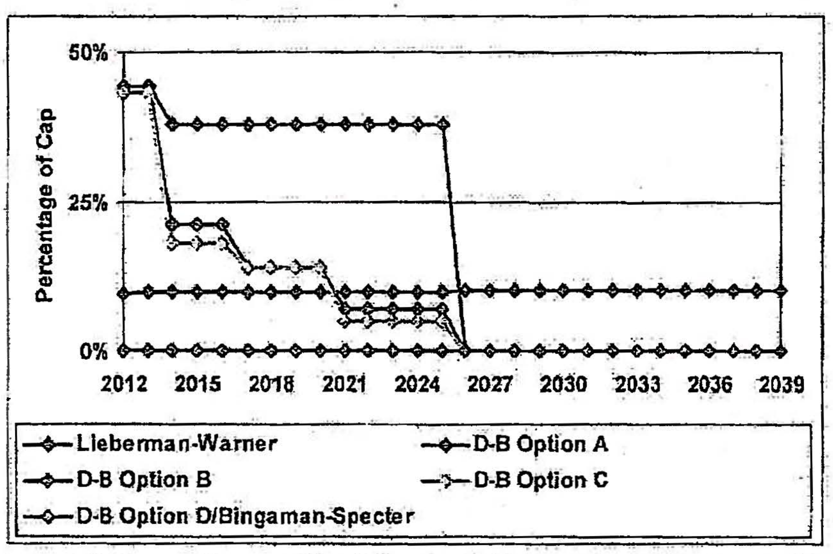
The financial impacts also depend upon the allocation that Nevada Power and Sierra would receive.

1. Background on CO_2 Allowance Allocation Scenarios in Congressional Proposals

In general, there have been two separate types of allowance allocations included in the various Congressional proposals that would be relevant to Nevada Power and Sierra: (1) allocation to fossil fuel generators; and (2) allocation to electricity distribution companies. Several congressional bills have included detailed allocation proposals, notably including the Lieberman-Warner Climate Security Act, the "Bingaman-Specter" Low Carbon Economy Act and the Dingell-Boucher discussion draft. In the case of the Dingell-Boucher draft, four detailed allocation alternatives were developed.

Figure B-3 shows the proposed percentage of the cap allocated to electricity distribution companies in the various bills.

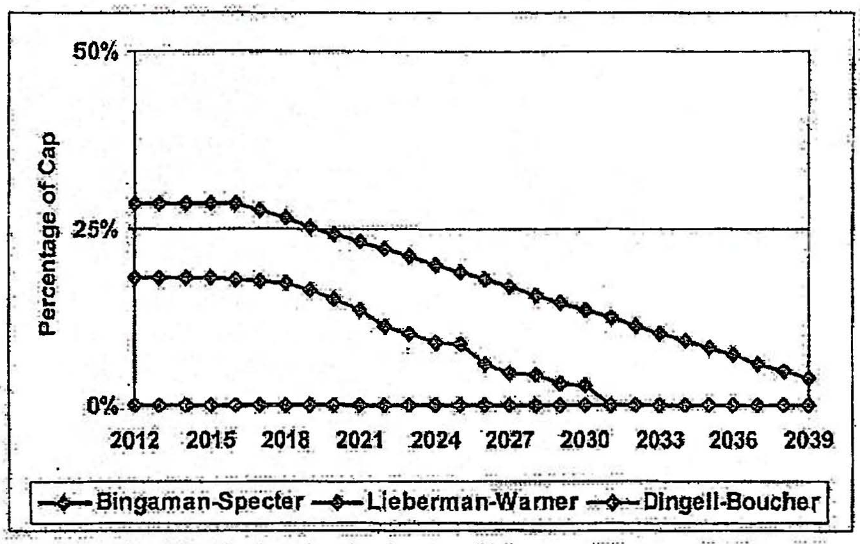
Figure B-3. Percentage of Cap Allocated to Electricity Distribution Companies



Source: Bingaman-Specter, Dingell-Boucher, Lieberman-Warner and NERA Calculations

Figure B-4 shows the proposed percentage of the cap allocated to fossil fuel generators in the various bills. Note that while Dingell-Boucher would not give allocation to any fossil fuel generation facilities owned by regulated entities, it would provide an allocation to coal-fired units that are not owned by regulated entities.

Figure B-4. Percentage of Cap Allocated to Fossil Fuel Generators

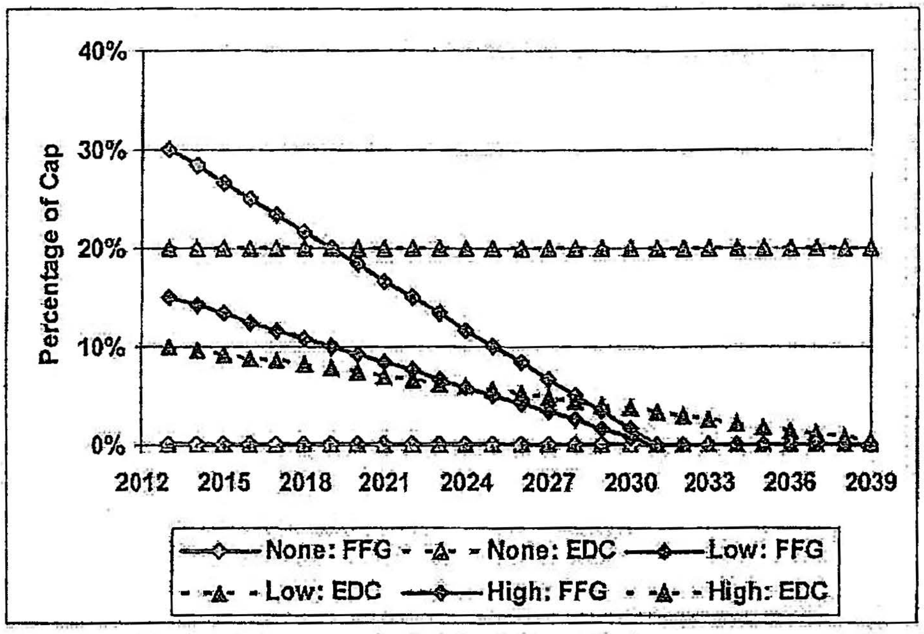


Source: Bingaman-Specter, Dingell-Boucher, Lieberman-Warner and NERA Calculations

2. Allocation Scenarios

Based on these bills, we developed two allocation scenarios to cover a range of possible allocation outcomes for the electric power sector in general. In addition, we included a scenario in which all allowances would be auctioned, which would mean no free allocation to Nevada Power and Sierra (or any other entity), in order to provide a wide range of possible outcomes. This approach (100 percent auctioning) has been proposed in the House of Representatives (Markey). The three scenarios (None, Low, and High) are shown in Figure B-5, with the allocation in each year shown as a percentage of the total cap. The allocation levels are shown separately for electric distribution companies (EDC) and fossil fuel generators (FFG).

Figure B-5. Allocation Scenarios for Fossil Fuel Generators and Electricity Distribution Companies



Notes: FFG- Fossil Fuel Generation, EDC- Electricity Distribution Company
Source: NERA as explained in text

3. Allocations Based Upon Alternative Allocation Scenarios

In order to translate these sector level shares into specific allocations for Nevada Power and Sierra, we must estimate the share of the total allocation pool for EDCs and FFGs that would go to the Companies. There are several possible bases to use for allocating allowances to FFGs, including emissions, heat input, or generation. Moreover, the basis could be historical ("grandfathering") or modified over time to reflect new information ("updated"). For the allocation scenarios analyzed here, we use historical emissions as the basis for allocation to FFGs. Historical emissions have been the most frequently used basis for allocation in past cap-and-trade programs (including the EU ETS and acid rain trading programs) and in Congressional proposals. Moreover, assessing the effects of updated allocations would require additional NEMS modeling.

The bases most frequently used to allocate to EDC's include emissions, load, and customers/service area population. In order to calculate the allowance allocation that Nevada Power and Sierra would receive under each of our three scenarios, we used data on emissions and load available from public sources, including FERC Form 1 filings by the Companies and data on national load and electric power sector emissions from EIA. NV Energy emissions were calculated from fuel use data in the FERC Form 1. Table B-1 shows historical national and NV Energy (combined Nevada Power and Sierra) data from 2005 to 2007. Recent congressional bills have proposed that historical allocation be based on the three years before the passage of the bill. Note that national data for 2008 will not be available until later this year and thus our analyses are based upon the three year period from 2005 to 2007. Based upon these data, the Companies would receive 0.41 percent of fossil fuel generator allocation and 0.81 percent of electricity distribution company allocation.

Table B-1. Historical NV Energy and National Emissions and Load Data

		Emissions from Generation (1)	Load (2)
NV Energy	2005	9.22	29.05
	2006	9.48	29.83
	2007	10.44	30.66
	Average	9.72	29.85
National	2005	2,397.36	3,660.97
	2006	2,364.06	3,669.92
	2007	2,433.44	3,764.56
	Average	2,398.29	3,698.48
NV Energy	Average %	0.41%	0.81%

Notes: (1) Million Metric Tons CO_2 equivalent
(2) Terawatt-hours
Source: EIA 2008,EIA 2009, FERC Form 1 and NERA calculations as explained in text

4. CO_2 Allowance Allocation Value under Alternative Scenarios

Table B-2 summarizes the net present values of allocation to Nevada Power and Sierra as electricity distribution companies for the nine different combinations of allocation scenarios and CO_2 price scenarios. These values are the products of the projected allowance prices and the projected allocation levels, appropriately discounted. Since these values are based on historical data, they are identical for each of the four plans.

Table B-2. Electricity Distribution Company Allocation Value for Nevada Power and Sierra

		CO_2 Prices		
		Low	Mid	High
Allocation Scenario	None	\$0	\$0	\$0
	Low	\$598	\$1,007	\$1,371
	High	\$1,925	\$3,151	\$4,371

Notes: All values are present values for the period 2010-2039 discounted at 8.67 percent nominal (6.57 percent real) as of January 1, 2009, in millions of 2008 dollars.
Source: NERA calculations as explained in text

Table B-3 summarizes the net present values of allocation to Nevada Power and Sierra as fossil fuel generators for the nine different combinations of allocation scenarios and CO_2 price scenarios. These values are the products of the projected allowance prices and the projected allocation levels, appropriately discounted. Since these values are only based on historical data, they are identical for each of the four plans.

Table B-3. Fossil Fuel Generator Allocation Value for Nevada Power and Sierra

		CO_2 Prices		
		Low	Mid	High
Allocation Scenario	None	$0	$0	$0
	Low	$341	$588	$791
	High	$683	$1,176	$1,582

Notes: All values are present values for the period 2010-2039 discounted at 8.67 percent nominal (6.57 percent real) as of January 1, 2009, in millions of 2008 dollars.
Source: NERA calculations as explained in text

Table B-4 summarizes the net present values of total allocation to Nevada Power and Sierra for the nine different combinations of allocation scenarios and carbon scenarios. These values are the sum of corresponding entries in Table B-2 and Table B-3. Since these values are only based on historical data, they are identical for each of the four plans.

Table B-4. Total Allocation Value for Nevada Power and Sierra

		CO_2 Prices		
		Low	Mid	High
Allocation Scenario	None	$0	$0	$0
	Low	$939	$1,595	$2,162
	High	$2,608	$4,327	$5,953

Notes: All values are present values for the period 2010-2039 discounted at 8.67 percent nominal (6.57 percent real) as of January 1, 2009, in millions of 2008 dollars.
Source: NERA calculations as explained in text

C. Net CO_2 Costs for All Scenarios

Table B-5, B-6 and B-7 shows net CO_2 costs across all nine CO_2 price scenario and allocation scenario combinations.

Table B-5. Net CO_2 Costs for All Scenarios

	(1)	(2)	(3)
CO_2 Prices:	Low	Mid	High
Allocation Scenario:	None	None	None
Plan 1 (No ON Line)	$3,888	$7,198	$10,744
Plan 2 (400 MW ON Line)	$3,876	$7,176	$10,710
Plan 3 (600 MW ON Line)	$3,874	$7,172	$10,705
Plan 4 (800 MW ON Line)	$3,873	$7,170	$10,702

Notes: All values are present values for the period 2010-2039 discounted at 8.67 percent nominal (6.57 percent real) as of January 1, 2009, in millions of 2008 dollars.
Source: NERA calculations as explained in text

Table B-6. Net CO_2 Costs for All Scenarios (Cont.)

	(1)	(2)	(3)
CO_2 Prices:	Low	Mid	High
Allocation Scenario:	Low	Low	Low
Plan 1 (No ON Line)	$2,949	$5,603	$8,581
Plan 2 (400 MW ON Line)	$2,937	$5,580	$8,548
Plan 3 (600 MW ON Line)	$2,935	$5,577	$8,543
Plan 4 (800 MW ON Line)	$2,934	$5,575	$8,540

Notes: All values are present values for the period 2010-2039 discounted at 8.67 percent nominal (6.57 percent real) as of January 1, 2009, in millions of 2008 dollars.
Source: NERA calculations as explained in text

Table B-7. Net CO_2 Costs for All Scenarios (Cont.)

	(1)	(2)	(3)
CO_2 Prices:	Low	Mid	High
Allocation Scenario:	High	High	High
Plan 1 (No ON Line)	$1,280	$2,871	$4,791
Plan 2 (400 MW ON Line)	$1,268	$2,848	$4,757
Plan 3 (600 MW ON Line)	$1,266	$2,845	$4,752
Plan 4 (800 MW ON Line)	$1,265	$2,843	$4,749

Notes: All values are present values for the period 2010-2039 discounted at 8.67 percent nominal (6.57 percent real) as of January 1, 2009, in millions of 2008 dollars.
Source: NERA calculations as explained in text

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Appendix C: NEMS Documentation

This appendix provides details on the National Energy Modeling System ("NEMS"). The text and figures are adapted from documentation developed by the EIA for the 2008 Annual Energy Outlook[19].

1. The National Energy Modeling System

NEMS is developed and maintained by the Office of Integrated Analysis and Forecasting of the Energy Information Administration (EIA) to provide projections of domestic energy-economy markets in the long term and perform policy analyses requested by decision-makers in the White House, U.S. Congress, offices within the Department of Energy, including DOE Program Offices, and other government agencies. These projections are also used by analysts and planners in other government agencies and outside organizations.

The time horizon of NEMS is approximately 25 years, the period in which the structure of the economy and the nature of energy markets are sufficiently understood that it is possible to represent considerable structural and regional detail. Because of the diverse nature of energy supply, demand, and conversion in the United States, NEMS supports regional modeling and analysis in order to represent the regional differences in energy markets, to provide policy impacts at the regional level, and to portray transportation flows. The level of regional detail for the end-use demand modules is the nine Census divisions. Other regional structures include production and consumption regions specific to oil, natural gas, and coal supply and distribution, the North American Electric Reliability Council (NERC) regions and sub-regions for electricity, and the Petroleum Administration for Defense Districts (PADDs) for refineries.

For each fuel and consuming sector, NEMS balances the energy supply and demand, accounting for the economic competition between the various energy fuels and sources. NEMS is organized and implemented as a modular system (as shown in Figure C-1 below).

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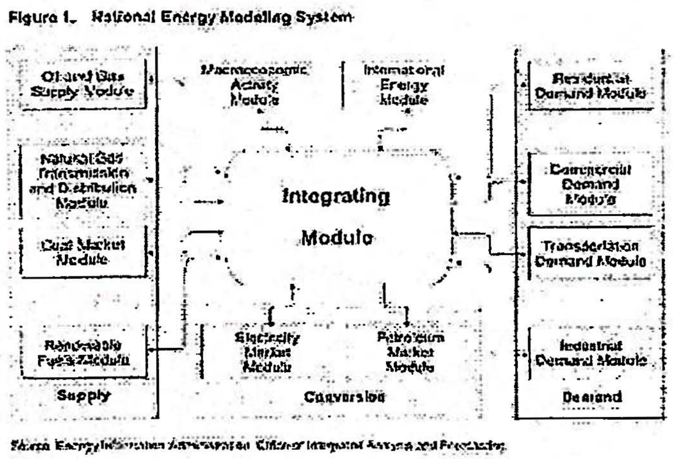
[19] U.S. Energy Information Administration. June 2008. *Assumptions to the Annual Energy Outlook 2008*. http://www.eia.doe.gov/oiaf/aeo/assumption/introduction.html, accessed February 17, 2009.

Figure C-1. Overall Structure of NEMS



Notes:
Source: EIA 2008

The modules represent each of the fuel supply markets, conversion sectors, and end-use consumption sectors of the energy system. NEMS also includes a macroeconomic and an international module. The primary flows of information between each of these modules are the delivered prices of energy to the end user and the quantities consumed by product, region, and sector. The delivered prices of fuel encompass all the activities necessary to produce, import, and transport fuels to the end user. The information flows also include other data such as economic activity, domestic production, and international petroleum supply availability.

The integrating module of NEMS controls the execution of each of the component modules. To facilitate modularity, the components do not pass information to each other directly but communicate through a central data storage location. This modular design provides the capability to execute modules individually, thus allowing decentralized development of the system and independent analysis and testing of individual modules. This modularity allows use of the methodology and level of detail most appropriate for each energy sector. NEMS solves by calling each supply, conversion, and end-use demand module in sequence until the delivered prices of energy and the quantities demanded have converged within tolerance, thus achieving an economic equilibrium of supply and demand in the consuming sectors. Solution is reached annually through the projection horizon. Other variables are also evaluated for convergence such as petroleum product imports, crude oil imports, and several macroeconomic indicators.

Each NEMS component also represents the impact and cost of Federal legislation and regulation that affect the sector and reports key emissions. NEMS generally reflects all current legislation and regulation that are defined sufficiently to be modeled as of December 31, 2008, such as the Energy Independence and Security Act of 2007, the Energy Policy Act of 2005, the Working Families Tax Relief Act of 2004, and the America Jobs Creation Act of 2004, and the costs of compliance with regulations such as the Mobile Source Air Toxics rule released by the Environmental Protection Agency on February 9, 2007 that establishes controls on gasoline, passenger vehicles, and portable fuel containers designed to significantly reduce emissions of benzene and other hazardous air pollutants. The NEMS components also reflect selected State legislation and regulations where implementing regulations are clear. The potential impacts of pending or proposed Federal and State legislation, regulations, or standards—or of sections of legislation that have been enacted but that require funds or implementing regulations that have not been provided or specified—are not reflected in NEMS.

2. Component Modules

The component modules of NEMS represent the individual supply, demand, and conversion sectors of domestic energy markets and also include international and macroeconomic modules. In general, the modules interact through values representing the prices of energy delivered to the consuming sectors and the quantities of end-use energy consumption. This section provides brief summaries of each of the modules.

a. Macroeconomic Activity Module

The Macroeconomic Activity Module (MAM) provides a set of macroeconomic drivers to the energy modules, and there is a macroeconomic feedback mechanism within NEMS. Key macroeconomic variables used in the energy modules include gross domestic product (GDP), disposable income, value of industrial shipments, new housing starts, new light-duty vehicle sales, interest rates, and employment. The module uses the following models from Global Insight, Inc. (GII): Macroeconomic Model of the U.S. Economy, National Industry Model, and National Employment Model. In addition, EIA has constructed a Regional Economic and Industry Model to project regional economic drivers and a Commercial Floorspace Model to project 13 floorspace types in 9 Census divisions. The accounting framework for industrial value of shipments uses the North American Industry Classification System (NAICS).

b. International Module

The International Module represents the response of world oil markets (supply and demand) to assumed world oil prices. The results/outputs of the module are a set of crude oil and product supply curves that are available to U.S. markets for each case/scenario analyzed. The petroleum import supply curves are made available to U.S. markets through the Petroleum Market Module (PMM) of NEMS in the form of 5 categories of imported crude oil and 17 international petroleum products, including supply curves for oxygenates and unfinished oils. The supply-curve calculations are based on historical market data and a world oil supply/demand balance, which is developed from reduced form models of international liquids supply and demand, current investment trends in exploration and development, and long-term resource economics for 221 countries/territories. The oil production estimates include both conventional and unconventional supply recovery technologies.

c. Residential and Commercial Demand Modules

The Residential Demand Module projects energy consumption in the residential sector by housing type and end use, based on delivered energy prices, the menu of equipment available, the availability of renewable sources of energy, and housing starts. The Commercial Demand Module projects energy consumption in the commercial sector by building type and non-building uses of energy and by category of end use, based on delivered prices of energy, availability of renewable sources of energy, and macroeconomic variables representing interest rates and floor space construction.

Both modules estimate the equipment stock for the major end-use services, incorporating assessments of advanced technologies, including representations of renewable energy technologies and the effects of both building shell and appliance standards, including the recently enacted provisions of the EISA2007. The Commercial Demand Module incorporates combined heat and power (CHP) technology. The modules also include projections of distributed generation. Both modules incorporate changes to "normal" heating and cooling degree-days by Census division, based on a 10-year average and on State-level population projections. The Residential Demand Module projects that the average square footage of both new construction and existing structures increase based on trends in the size of new construction and the remodeling of existing homes.

d. Industrial Demand Module

The Industrial Demand Module projects the consumption of energy for heat and power and for feedstocks and raw materials in each of 21 industries, subject to the delivered prices of energy and macroeconomic variables representing employment and the value of shipments for each industry. As noted in the description of the Macroeconomic Activity Module, the value of shipments is based on NAICS. The industries are classified into three groups—energy-intensive manufacturing, non-energy-intensive manufacturing, and non-manufacturing. Of the 8 energy-intensive industries, 7 are modeled in the Industrial Demand Module, with components for boiler/steam/cogeneration, buildings, and process/assembly use of energy. Bulk chemicals are further disaggregated to organic, inorganic, resins, and agricultural chemicals. A generalized representation of cogeneration and a recycling component are also included. The use of energy for petroleum refining is modeled in the PMM, and the projected consumption is included in the industrial totals.

e. Transportation Demand Module

The Transportation Demand Module projects consumption of fuels in the transportation sector, including petroleum products, electricity, methanol, ethanol, compressed natural gas, and hydrogen, by transportation mode, vehicle vintage, and size class, subject to delivered prices of energy fuels and macroeconomic variables representing disposable personal income, GDP, population, interest rates, and industrial shipments. Fleet vehicles are represented separately to allow analysis of the Energy Policy Act of 1992 (EPACT1992) and other legislation and legislative proposals. EPACT2005 is used to assess the impact of tax credits on the purchase of hybrid gas-electric, alternative-fuel, and fuel-cell vehicles. The module also includes a component to assess the penetration of alternative-fuel vehicles. The CAFE and biofuel representation in the module reflect the provisions in the EISA2007.

The air transportation component explicitly represents air travel in domestic and non U.S. markets and includes the industry practice of parking aircraft in both domestic and international markets to reduce operating costs and the movement of aircraft from passenger to cargo markets as aircraft ages. For air freight shipments, the model represents regional fuel use in narrow-body and wide-body aircraft. An infrastructure constraint limits overall growth in passenger and freight air travel to levels commensurate with industry-projected infrastructure expansion and capacity growth.

f. Electricity Market Module

The Electricity Market Module (EMM) represents generation, transmission, and pricing of electricity, subject to delivered prices for coal, petroleum products, natural gas, and biofuels; costs of generation by all generation plants, including capital costs; macroeconomic variables for costs of capital and domestic investment; enforced environmental emissions laws and regulations; and electricity load shapes and demand. There are three primary sub-modules—capacity planning, fuel dispatching, and finance and pricing. Non-utility generation, distributed generation, and transmission and trade are modeled in the planning and dispatching sub-modules. The levelized cost of uranium fuel for nuclear generation is incorporated directly in the EMM.

All specifically identified CAAA90 compliance options that have been promulgated by the EPA are explicitly represented in the capacity expansion and dispatch decisions; those that have not been promulgated (e.g., fine particulate proposals) are not incorporated. All financial incentives for power generation expansion and dispatch specifically identified in EPACT2005 have been implemented. Several States, primarily in the Northeast, have recently enacted air emission regulations that affect the electricity generation sector. Where firm State compliance plans have been announced, regulations are represented in NEMS. The Regional Greenhouse Gas Initiative, a cooperative effort by ten states in the Northeast to reduce greenhouse gases, is also included in the latest version of NEMS.

g. Renewable Fuels Module

The Renewable Fuels Module (RFM) includes sub-modules representing renewable resource supply and technology input information for central-station, grid-connected electricity generation technologies, including conventional hydroelectricity, biomass (wood, energy crops, and biomass co-firing), geothermal, landfill gas, solar thermal electricity, solar photovoltaics (PV), and wind energy. The RFM contains renewable resource supply estimates representing the regional opportunities for renewable energy development. Investment tax credits for renewable fuels are incorporated, as currently legislated in EPACT1992 and EPACT2005. EPACT1992 provides a 10-percent tax credit for business investment in solar energy (thermal non-power uses as well as power uses) and geothermal power; those credits have no expiration date.

h. Oil and Gas Supply Module

The Oil and Gas Supply Module (OGSM) represents domestic crude oil and natural gas supply within an integrated framework that captures the interrelationships among the various sources of supply: onshore, offshore, and Alaska by both conventional and unconventional techniques, including natural gas recovery from coalbeds and low-permeability formations of sandstone and shale. The framework analyzes cash flow and profitability to compute investment and drilling for each of the supply sources, based on the prices for crude oil and natural gas, the domestic recoverable resource base, and the state of technology. Oil and gas production functions are computed for 12 supply regions, including 3 offshore and 3 Alaskan regions. The module also represents foreign sources of natural gas, including pipeline imports and exports to Canada and Mexico, and liquefied natural gas (LNG) imports and exports.

Crude oil production quantities are input to the Petroleum Market Module (PMM) in NEMS for conversion and blending into refined petroleum products. Supply curves for natural gas are input to the Natural Gas Transmission and Distribution Module (NGTDM) for use in determining natural gas prices and quantities. International LNG supply sources and options for construction of new regasification terminals in Canada, Mexico, and the United States as well as expansions of existing U.S. regasification terminals are represented, based on the projected regional costs associated with international natural gas supply, liquefaction, transportation, and regasification and world natural gas market conditions.

i. Natural Gas Transmission and Distribution Module

The Natural Gas Transmission and Distribution Module (NGTDM) represents the transmission, distribution, and pricing of natural gas, subject to end-use demand for natural gas and the availability of domestic natural gas and natural gas traded on the international market. The module tracks the flows of natural gas and determines the associated capacity expansion requirements in an aggregate pipeline network, connecting the domestic and foreign supply regions with 12 demand regions. The flow of natural gas is determined for both a peak and off-peak period in the year. Key components of pipeline and distributor tariffs are included in separate pricing algorithms.

j. Petroleum Market Module

The Petroleum Market Module (PMM) projects prices of petroleum products, crude oil and product import activity, and domestic refinery operations (including fuel consumption), subject to the demand for petroleum products, the availability and price of imported petroleum, and the domestic production of crude oil, natural gas liquids, and biofuels (ethanol, biodiesel, biobutanol, etc.). The module represents refining activities in the five PADDs. It explicitly models the requirements of the EISA2007, the CAAA90, and the costs of automotive fuels, such as conventional and reformulated gasoline, and includes biofuels production for blending in gasoline and diesel

NEMS contains regulations that limit the sulfur content of all non-road and locomotive/marine diesel to 15 ppm by mid-2012. The module also reflects the renewable fuels standard (RFS) in the EISA2007 that requires the use of 36 billion gallons per year of biofuels by 2022 with corn ethanol limited to 15 billon gallons per year. Demand growth and regulatory changes necessitate capacity expansion for refinery processing units. End-use prices are based on the marginal costs of production, plus markups representing product marketing and distribution costs and State and Federal taxes.4 Refinery capacity expansion at existing sites is permitted in all five refining regions modeled.

Fuel ethanol and biodiesel are included in the PMM, because they are commonly blended into petroleum products. The module allows ethanol blending into gasoline at 10 percent by volume or less (E10), as well as E85, a blend of up to 85 percent ethanol by volume. Ethanol is produced primarily in the Midwest from corn or other starchy crops, and may also be produced from cellulosic material, such as switchgrass and poplar, in the future. Biodiesel is produced from seed oil, imported palm oil, animal fats, or yellow grease (primarily, recycled cooking oil).

Both domestic and imported ethanol count toward the RFS. Domestic ethanol production is modeled from two feedstocks: corn and cellulosic materials. Corn-based ethanol plants are numerous (more than 100 in operation, producing more than 5 billion gallons annually) and are based on a well-known technology that converts sugar into ethanol. Ethanol from cellulosic sources is a new technology with no pilot plants in operation. However, the U.S. Department of Energy has awarded grants (up to $385 million) in 2007 to construct capacity totaling 147 million gallons per year. AEO2008 assumes that this capacity will be operational in 2012. Imported ethanol may be produced from cane sugar or bagasse, the cellulosic byproduct of sugar milling. The sources of ethanol are modeled to compete on an economic basis and to meet the EISA2007 renewable fuels mandate.

Fuels produced by gasification and Fischer-Tropsch synthesis are modeled in the PMM, based on their economics relative to competing feedstocks and products. The three processes modeled are coal-to-liquids (CTL), gas-to-liquids (GTL), and biomass-to-liquids (BTL). CTL facilities are likely to be built at locations close to coal supply and water sources, where liquid products and surplus electricity could also be distributed to nearby demand regions. GTL facilities may be built in Alaska but would compete with the Alaska Natural Gas Transportation System for available natural gas resources. BTL facilities are likely to be built where there are large supplies of biomass such as crop residue and forestry waste. Since the BTL process uses cellulosic feedstocks, it is also modeled as a choice to meet the EISA2007 cellulosic biofuels requirement.

k. Coal Market Module

The Coal Market Module (CMM) simulates mining, transportation, and pricing of coal, subject to end-use demand for coal differentiated by heat and sulfur content. U.S. coal production is represented in the CMM by 40 separate supply curves—differentiated by region, mine type, coal rank, and sulfur content. The coal supply curves include a response to capacity utilization of mines, mining capacity, labor productivity, and factor input costs (mining equipment, mining labor, and fuel requirements). Projections of U.S. coal distribution are determined by minimizing the cost of coal supplied, given coal demands by demand region and sector, accounting for minemouth prices, transportation costs, existing coal supply contracts, and sulfur and mercury allowance costs. Over the projection horizon, coal transportation costs in the CMM are projected to vary in response to changes in railroad productivity and the cost of rail transportation equipment and diesel fuel.

The CMM produces projections of U.S. steam and metallurgical coal exports and imports, in the context of world coal trade. The CMM determines the pattern of world coal trade flows that minimizes the production and transportation costs of meeting a specified set of regional world coal import demands, subject to constraints on export capacities and trade flows. The international coal market component of the module computes trade in 3 types of coal for 17 export and 20 import regions. U.S. coal production and distribution are computed for 14 supply and 14 demand regions.

Appendix D: Air Quality Modeling

This appendix provides information on the air quality modeling results used in the development of estimated damage values for this study. The air quality modeling results rely upon previous analyses developed by Systems Applications International for Nevada Power ("Nevada Power Air Analyses") and Sierra ("Sierra Air Analyses"), representing the most complete data set available for Nevada. The Nevada Power Air Analyses and the Sierra Air Analyses are discussed in Harrison et al. (1993) and Harrison et al. (1993a), respectively.

A. Information on Air Quality Modeling

1. Stack Parameters

The Nevada Power Air Analyses and the Sierra Air Analyses assessed potential air quality impacts for various technologies at different locations. In the analyses, each electricity-generating technology had a unique set of stack characteristics that produced a unique set of air quality effects. The analyses applied data on stack parameters including height, diameter, temperature, and exit velocity to assess the effects of emissions on air quality. The different facilities and stack characteristics considered are summarized in Table D-1 and Table D-2. The tables show that similar facilities and stack characteristics were evaluated in both analyses.

Table D-1. Stack Parameters Used for Dispersion Modeling in Nevada Power Air Analyses

Type of Facility	Stack ht. (m)	Stack diam. (m)	Stack temp. (K)	Exit vel. (m/s)
Coal with Fluidized Bed 100-140 MW	76.00	3.00	410.0	27.43
Coal with Fluidized Bed 280-320 MW	122.00	4.66	410.0	27.43
Coal with Gasification 100-140 MW	76.00	4.48	400.0	27.43
Coal with Gasification 280-320 MW	122.00	8.10	400.0	27.43
Combined Cycle natural gas/oil 100-140 MW	70.10	3.47	421.3	18.44
Combined Cycle natural gas/oil 280-320 MW	87.33	4.88	408.0	18.90
Combustion Turbine with natural gas/oil 70-100 MW	19.10	4.10	803.4	37.60
Pulverized Coal w/scrub 100-140 MW	76.35	3.66	418.0	19.51
Pulverized Coal w/scrub 280-320 MW	121.92	4.88	408.0	22.86
Reciprocating Engine with diesel	15.24	1.30	783.0	45.70

Source: Harrison et al. (1993).

Table D-2. Stack Parameters Used for Dispersion Modeling in Sierra Air Analyses

Type of Facility	Stack ht. (m)	Stack diam. (m)	Stack temp. (K)	Exit vel. (m/s)
Coal with Fluidized Bed 100-140 MW	76	3.00	410	27.50
Coal with Fluidized Bed 280-320 MW	122	4.90	408	22.90
Integrated Gasification Combined Cycle 100-140 MW	92	4.04	394	16.08
Combined Cycle natural gas/oil 100-140 MW	70	3.50	426	18.50
Combustion Turbine with natural gas/oil 70-100 MW	16.8	4.30	796	50.88
Pulverized Coal w/scrub 100-140 MW	76	3.70	420	19.30
Pulverized Coal w/scrub 280-320 MW	122	4.70	410	22.90
Reciprocating Engine with diesel	15.24	1.30	783	45.70

Source: Harrison et al. (1993a).

2. Locations

The air quality modeling determined the air quality impacts for alternative technologies at various locations, with effects varying based on meteorology and terrain.

Three locations were considered in the Nevada Power Air Analyses:

- *McCarren*, a site in Las Vegas Valley;
- *Desert Rock*, a site northwest of Las Vegas; and
- *Harry Allen near Garnet*, a site northwest of Las Vegas.

Four locations were considered in the Sierra Air Analyses:

- *Tracy Power Station*, an industrialized site about 15 miles from Reno with very complex terrain;
- *Stead*, an urban, mixed land-use site with moderately complex terrain;
- *Ft. Churchill Power Station*, a rural, agricultural site with moderately complex terrain; and
- *North Valmy Power Station*, a remote site with moderately complex terrain.

Thus, a total of seven locations were considered in the air quality modeling analyses.

3. Modeling Methodology

The air quality modeling involved organizing receptor locations on a Cartesian coordinate system with a domain size of 100 km x 100 km. For each of the plants and locations considered, associated stack parameters and emissions were placed at the center of the modeling domain. Incorporating meteorological data relevant to the specific locations, two models estimated concentrations of pollutants within the modeling domain. One model predicted concentrations of ambient PM_{10} (made up of primary PM_{10}, nitrates, and sulfates) arising from emissions of PM_{10}, NOx, and SO_2. Another model predicted ozone concentrations arising from NOx and VOC emissions and the interaction of those emissions with other ambient conditions.

4. Modeling Results and Application to Environmental Cost Assessment

Both the Nevada Power Air Analyses and the Sierra Air Analyses yielded estimates of increased annual average ambient concentrations arising from one additional ton of pollutant for each modeling site and technology combination,[20] in other words, average ambient concentration changes per ton of emitted pollutant. Ambient concentration effects were modeled for ozone, PM_{10}, sulfates, nitrates, SO_2, and NO_2.[21] Thus, we can readily apply these air quality results to information on estimated tons of emissions (for different generating units, for the different relevant pollutants) to calculate ambient air quality effects under the plans considered in the Eleventh Amendment. Within the damage-function approach used in this study to develop estimated damage values for emissions not covered by a cap-and-trade program, the 1993 air quality results are only applied in the calculation of changes in ambient concentrations; the other aspects of the damage-function approach incorporate updated county-specific information related to the plans.

5. Specific Assumptions on Air Emissions

We develop estimated damage values for relevant emissions for a set of representative facilities in Nevada. Table D-3 summarizes the representative facilities and indicates which air quality analysis is relevant for each facility. For some facilities, we use average results from multiple applicable air quality analyses. When applying the air quality analyses to the representative facilities, we use information specific to each facility—such as size and stack structure—to develop appropriate estimates from the air quality analyses of the relevant relationship between ambient air quality and emissions.

[20] With the exception of ozone, which is measured in parts per billion, the other concentration changes are measured in $\mu g/m^3$.

[21] The estimated damage values for PM in this study focus on effects from $PM_{2.5}$, not PM_{10}. Thus we must convert effects on ambient PM_{10} concentrations to effects on ambient $PM_{2.5}$ concentrations. There does not appear to be consensus on the appropriate ratio but several documents (e.g., Parliamentary Assembly of the Council of Europe (1998), Swedish NGO Secretariat on Acid Rain (2006)) suggest that $PM_{2.5}$ concentration levels are around 60 to 70 percent of PM_{10} levels. We assumed a 65 percent ratio of $PM_{2.5}$ levels to PM_{10} levels for this study.

Table D-3. Representative Facilities and Application of Air Quality Analyses

Representative Facility		Air Quality Analysis Used
Type	Location	
Combustion Turbine	Clark County	Harry Allen (Nevada Power Air Analyses)
	Clark County	McCarren (Nevada Power Air Analyses)
Combined Cycle	Clark County	Harry Allen (Nevada Power Air Analyses)
	Clark County	McCarren (Nevada Power Air Analyses)
Coal	Clark County	Harry Allen (Nevada Power Air Analyses)
Combustion Turbine	Storey County	Tracy Power Station (Sierra Air Analyses)
Combined Cycle	Storey County	Tracy Power Station (Sierra Air Analyses)
Steam Turbine	Storey County	Tracy Power Station (Sierra Air Analyses)
Coal	White Pine County	North Valmy Power Station (Sierra Air Analyses)
IGCC	White Pine County	North Valmy Power Station (Sierra Air Analyses)
Steam Turbine	Lyon County	Ft. Churchill Power Station (Sierra Air Analyses)
Combustion Turbine	Humboldt County	North Valmy Power Station (Sierra Air Analyses)
Coal	Humboldt County	North Valmy Power Station (Sierra Air Analyses)
Coal	Elko County	North Valmy Power Station (Sierra Air Analyses)
Coal	Navajo Station	North Valmy Power Station (Sierra Air Analyses)

Source: Nevada Power and Sierra 1993 air quality modeling.

B. Summary of Air Quality Modeling Results

Table D-4 provides the air quality modeling results used in this study from the Nevada Power Air Analyses and the Sierra Air Analyses. These data provide the information necessary for the development of estimated damage values for relevant emissions for representative facilities.

Table D-4. Increases in Concentrations of Ambient Pollutants per Ton of Emitted Pollutant (μg/m³/ton)

Location	Type of Facility	Stack ht. (m)	Primary PM_{10}	Sulfates	Nitrates	SO_2	NO_2	Ozone (ppb)
Harry Allen (Nevada Power Air Analyses)								
Clark County	Combined Cycle	70	2.81E-5	0.30E-5	0.89E-7*	1.25E-5	0.28E-5	0.08E-7*
	Combined Cycle	87	2.46E-5	0.28E-5	0.89E-7*	1.19E-5	0.26E-5	0.08E-7*
	Combustion Turbine	19	2.77E-5	0.32E-5	0.89E-7*	1.36E-5	0.30E-5	0.08E-7*
	Pulverized Coal w/scrub	76	1.92E-5	0.30E-5	0.89E-7*	0.80E-5	0.20E-5	0.08E-7*
	Pulverized Coal w/scrub	122	1.54E-5	0.27E-5	0.89E-7*	0.71E-5	0.18E-5	0.08E-7*
McCarren (Nevada Power Air Analyses)								
Clark County	Combined Cycle	70	1.55E-5	0.30E-5	0.44E-7*	1.25E-5	0.28E-5	0.01E-6*
	Combined Cycle	87	1.47E-5	0.28E-5	0.44E-7*	1.19E-5	0.26E-5	0.01E-6*
	Combustion Turbine	19	1.68E-5	0.32E-5	0.44E-7*	1.36E-5	0.30E-5	0.01E-6*
	Pulverized Coal w/scrub	76	1.09E-5	0.30E-5	0.44E-7*	0.80E-5	0.20E-5	0.01E-6*
	Pulverized Coal w/scrub	122	0.98E-5	0.27E-5	0.44E-7*	0.71E-5	0.18E-5	0.01E-6*
Tracy Power Station (Sierra Air Analyses)								
Storey County	Combustion Turbine	16.8	2.69E-5	1.17E-5	4.06E-7	2.09E-5	8.06E-6	1.60E-5
	Combined Cycle	70	5.51E-5	3.37E-5	1.21E-6	3.78E-5	1.65E-5	1.60E-5
	Steam Turbine+	16.8	2.69E-5	1.17E-5	4.06E-7	2.09E-5	8.06E-6	1.60E-5
North Valmy Power Station (Sierra Air Analyses)								
White Pine, Humboldt, and Elko Counties and Navajo Nation	Combustion Turbine	16.8	4.00E-5	1.65E-5	7.46E-7	3.15E-5	1.20E-5	3.20E-5
	Pulverized Coal w/scrub	76	5.44E-5	2.85E-5	1.34E-6	3.97E-5	1.63E-5	3.20E-5
	Pulverized Coal w/scrub	122	2.57E-5	1.16E-5	5.34E-7	1.98E-5	7.71E-6	3.20E-5
	Integrated Gasification Combined Cycle	92	5.30E-5	2.78E-5	1.30E-6	3.87E-5	1.59E-5	3.20E-5
Ft. Churchill Power Station (Sierra Air Analyses)								
Lyon County	Steam Turbine+	16.8	4.51E-5	2.68E-5	9.18E-7	3.14E-5	1.35E-5	1.60E-5

Source: Harrison et al. (1993, 1993a).
* Based upon averages for different facilities
\+ Based upon combustion turbine results

The results of the Nevada Power Air Analyses and the Sierra Air Analyses suggest that the contribution of VOC emissions to ozone formation in Nevada is zero; thus changes in ozone concentrations are entirely due to NOx emissions.

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Appendix E: Health Effects and Damage Values

This appendix provides details on the estimation and valuation of health effects used in the development of estimated damage values for this study. We rely upon materials developed by the U.S. EPA for major elements of the damage-function calculations. The Appendix also discusses uncertainties and omitted categories in the EPA calculations. We conclude that taking into account the omitted categories would not have any significant effect on the environmental cost values and that the environmental costs calculated are conservative (i.e., tend to overstate costs) in light of the major uncertainties.

A. Concentration-Response Functions

In general, C-R functions for health effects have the following mathematical form (a "log-linear" relationship):

$$\Delta Health\ Effect = -\left[Baseline\ Incidence \cdot e^{-\beta \cdot \Delta Air\,Quality} - 1\right] \cdot Relevant\ Population\,,$$

where "Δ*Health Effect*" is the change in the number of cases observed of the given health endpoint, Δ*Air Quality* is the change in ambient air quality in appropriate units for a given pollutant, "*Baseline Incidence*" is the baseline rate of the health endpoint in the exposed population (among the relevant population), and the β parameter is the coefficient of the relevant pollutant. The relevant population is the specific population (e.g., only adults) for which the C-R is estimated.

Some C-R functions have a "logistic" form (a variation on the more typical "log-linear" relationship):

$$\Delta Health\ Effect = -\frac{Incidence}{((1 - Incidence)\cdot e^{-\beta \cdot \Delta Air\,Quality} + Incidence) - Incidence} \cdot Relevant\ Population$$

The basic logistic equation depends on the same variables as a basic log-linear equation. However, the logistic form often includes additional parameters, such as duration of symptoms. Exposures to PM and ozone that are associated with various health and welfare effects have been quantified (and subsequently valued) using different C-R functions.

B. Health Effects Related to PM and Ozone

PM is a general category of emissions accounting for both solid particles and liquid droplets found in the air. Some particles are large or dark enough to be seen as soot or smoke. Others are so small they can be detected only with an electron microscope. $PM_{2.5}$ refers to particles that are less than or equal to 2.5 micrometers (µm) in diameter. PM_{10} refers to particles that are less than or equal to 10 µm in diameter. PM can result from primary emissions and secondary atmospheric formation. Secondary particles are formed in the atmosphere from primary gaseous emissions, including SO_2 emissions and NOx emissions. Generally, $PM_{2.5}$ is composed mostly of secondary particles, and PM_{10} is composed mostly of primary particles. When breathed, particles can accumulate in the respiratory system and lead to health effects. These health effects are broadly classified as premature mortality effects and morbidity effects. In the U.S. EPA analyses relied upon for this study, the relevant quantified and valued PM-related health effects are with $PM_{2.5}$. Thus, for the health effects and damage values considered in this study, PM refers to $PM_{2.5}$. And the relevant ambient PM concentrations resulting from PM emissions are $PM_{2.5}$ concentrations.

Ozone is formed when NOx and VOC emissions react in the presence of sunlight. Children, people with lung diseases such as asthma, and people who work or exercise outside are susceptible, through exposure to ozone, to potential adverse effects such as damage to lung tissue and reduction in lung function.

Estimated health effects associated with exposure to PM or ozone are typically quantified using statistical (epidemiological) studies or C-R functions. The U.S. EPA has cited several C-R functions (usually published in public health journals) in various reports examining benefits of reduced emissions. Different estimated C-R functions have different strengths and weaknesses. Often, several studies–not necessarily performed using easily comparable methodologies–can be used as the basis for an estimation of health effects. However, results may differ greatly depending among individual studies. Even within a single study, there may be considerable statistical uncertainty about the magnitude of an estimated health effect.

Table E-1 summarizes the health effects and associated C-R functions used in this study. These effects are based upon EPA methodology in regulatory impact assessments (see EPA 2005a, 2005b). We have not assessed the epidemiological, economic, and statistical studies and assumptions that lie behind the EPA methodology. To estimate health effects for this study, we apply the relevant C-R functions to ambient air quality effects under each of the plans considered in the Eleventh Amendment. Due to limited air quality modeling results, we make several assumptions. For example, the C-R function developed for PM-related emergency room visits considers the twenty-four hour daily PM average, but the air quality modeling results used in this study only provide information on annual average PM concentrations. We assume that these two metrics are approximately the same. We made similar assumptions for ozone concentrations in cases where the relevant C-R functions used five- or eight-hour daily ozone averages (because the air quality modeling results used in this study only provide information on one-hour daily ozone averages).

Table E-1. Summary of Pollutant, Health Endpoints, and Source Study Information

Ambient Pollutant/Endpoint	Beta	Functional Form	Pollutant Metric	Study Author(s)	Study Population
Particulate Matter					
Premature Mortality	0.006015	log-linear	Annual Average	Pope et al 2002	30 and older
Infant Mortality	0.003922	logistic	Annual Average	Woodruff et al. 1997	under 1
Chronic Bronchitis	0.0137	logistic	Annual Average	Abbey et al. 1995	27 and older
Non-fatal Heart Attacks	0.024121	logistic	24-hr Daily Average	Peters et al. 2001	Adults
Upper Respiratory Symptoms	0.0036	logistic	24-hr Daily Average	Pope et al. 1991	Asthmatics, 9 to 11 years
Lower Respiratory Symptoms	0.019012	logistic	24-hr Daily Average	Schwartz and Neas 2000	7 to 14 years
Hospital Admissions (Respiratory)					
Asthma-related ER Visit	0.014712	log-linear	24-hr Daily Average	Norris et al. 1999	Under 18
Chronic Obstructive Pulmonary Disease	0.001833	log-linear	24-hr Daily Average	Moolgavkar 2003	65 and older
Chronic Obstructive Pulmonary Disease	0.0022	log-linear	24-hr Daily Average	Moolgavkar 2000	18 to 64
Pneumonia	0.003979	log-linear	24-hr Daily Average	Ito 2003	Over 65
Asthma	0.003324	log-linear	24-hr Daily Average	Sheppard 2003	Under 65
Hospital Admissions (Cardiovascular)					
All Cardiovascular	0.000389	log-linear	24-hr Daily Average	Moolgavkar 2003	65 and older
All Cardiovascular	0.0009	log-linear	24-hr Daily Average	Moolgavkar 2000	18 to 64
Asthma Exacerbation					
Shortness of Breath	0.003177	logistic	24-hr Daily Average	Ostro et al. 2001	African American asthmatics 6 to 18 years
Wheeze	0.002565	logistic	24-hr Daily Average	Ostro et al. 2001	African American asthmatics 6 to 18 years
Cough	0.003177	logistic	24-hr Daily Average	Ostro et al. 2001	African American asthmatics 6 to 18 years
Acute Bronchitis	0.027212	logistic	Annual Average	Dockery et al. 1996	8 to 12 years
Work Loss Days	0.0046	log-linear	24-hr Daily Average	Ostro 1987	18 to 65 years
Minor Restricted Activity Days	0.00741	log-linear	24-hr Daily Average	Ostro and Rothschild 1989	18 to 65
Ozone					
Hospital Admissions (Respiratory)					
All Respiratory	0.002652	log-linear	24-hr Daily Average	Schwartz 1995	65 and older
All Respiratory	0.006607	log-linear	24-hr Daily Average	Burnett et al. 2001	Under 2
Emergency Room Visit for Asthma	0.0443	other	5-hr Daily Average	Weisel et al. 1995	All ages
Minor Restricted Activity Days	0.0022	log-linear	1-hr Daily Max (Avg Δ)	Ostro and Rothchild 1989	18 to 65
School Absence Days	0.00755	other	8-hr Daily Ave.	Gilliland et al. 2001	9 to 10 years

Source: Adapted from EPA 2005a and EPA BenMAP.

1. Premature Mortality Effects

Assessment of the potential impacts of ambient PM concentrations on mortality has been, and continues to be, controversial in the scientific community. The controversy relates to the relationship between exposure and the levels of PM concentrations, as well as to the value that should be attached to any change in premature mortality. Differences in these two critical relationships can lead to very wide differences in the damages attributed to changes in ambient PM concentrations.

Several studies (Pope et al. (1995), Pope et al. (2002), Krewski et al. (2000)) show an association between exposure to particulates and mortality, especially in older persons and also those with cardiovascular and lung diseases. Table E-2 shows a PM-related mortality distribution by age based upon the U.S. EPA analyses of potential reductions in PM under the Clean Air Act (EPA 1999, p. 62). The table shows that a large percentage (almost 80 percent) affected are those aged 65 and older. The table also provides corresponding life expectancies for the various age groups.

Table E-2. PM-Related Mortality Distribution by Age in EPA Clean Air Act Analyses, Based on Pope et al. (1995)

Age Group	Proportion of Premature Mortality	Life Expectancy
30-34	1%	48
35-44	4%	38
45-54	6%	29
55-64	12%	21
65-74	24%	14
75-84	30%	9
85+	24%	6

Source: EPA 1999, p. 62

The U.S. EPA BART and CAIR analyses apply results from a cohort study to quantify the relationship between exposure to PM and mortality. Cohort (long-term) studies follow a group of people over extended periods and document their health status. A time-series (short-term) study follows people over short pollution episodes and correlates health effects with daily pollution levels. Based upon associations between daily changes in PM concentrations and daily changes in mortality rates, results from short-term studies have also been used to quantify the relationship between PM and mortality. Although both short-term and long-term studies have found a correlation between ambient PM concentrations and increased mortality rates, the use of long-term study results is now preferred for assessing these effects (see e.g., EPA 1999).

Currently, the U.S. EPA applies results of the Pope et al. (2002) cohort study as the basis for its primary mortality rate estimates for adults. According to U.S. EPA, this study is a significant improvement over previous long-term studies as it controls for individual-level variables such as health status, income, smoking, and diet (EPA 2005a). The Pope et al. (2002) study is therefore the basis for our assessment of potential premature mortality effects. In addition to premature adult mortality effects, the U.S. EPA recently included estimates of infant mortality in their primary estimates of health effects. These results rely on a study by Woodruff et al. (1997) that evaluated the relationship between post-neonatal infant mortality and PM. We include this effect in our analysis.

2. Morbidity Effects

Both PM and ozone have been linked to adverse health effects other than premature mortality, including respiratory and cardiovascular health effects. As with mortality effects, groups that appear to be at greatest risk include the elderly and individuals with cardiopulmonary diseases such as asthma (see, for example, EPA 2004). Among the various non-fatal health effects associated with PM or ozone, chronic bronchitis and heart attacks are the most serious. The U.S. EPA uses results from Abbey et al. (1995) and Peters et al. (2001), respectively, to quantify these health effects. Health effects requiring hospital admissions and other non-hospital related health effects are other endpoints that are also considered by the U.S. EPA.

For some of these endpoints, there is often more than one study that has estimated a relevant C-R function. In such cases, the U.S. EPA generally pools the different results using a weighting procedure. Because we could not determine the specifics of the U.S. EPA pooling methodology, we adopt the following approach when evaluating endpoints with more than one available C-R function (among studies identified by the U.S. EPA): first, we identify C-R functions that apply an air quality metric closest to the effects measured in the air quality modeling results used in this study; second, if more than one C-R function is still relevant, we use the study that examined the widest age group and disease classification coverage. For example, for cardiovascular disorders requiring hospitalizations, we used the C-R function from the Moolgavkar (2003) study, which covered all cardiovascular-related diseases, instead of the Ito (2003) study that considered only congestive heart failure, dysrhythmia, and ischemic heart-disease health effects.

3. Application of C-R Functions

To develop estimated health effects for the plans considered in the Eleventh Amendment, we combine the C-R functions for the suite of quantified health effects with ambient air quality effects for a set of representative facilities in Nevada. For each representative facility, for each health effect we develop baseline incidence rates and relevant population estimates. For this information, we relied on the U.S. EPA BenMAP program.[22] BenMAP (the Environmental Benefits Mapping and Analysis Program) contains an extensive database of national and, in some cases, county level data on disease incidence rates and populations. The software also provides detailed information on the C-R functions used in this study. We updated the population estimates in BenMAP using county-level data from the 2000 U.S. Census and population projections developed by Woods & Poole Economics, Inc. (The U.S. EPA analyses also rely on these two sources.)

The air quality results, which are inputs to the C-R functions, are calculated based upon different modeling domains or grids, which are 100km by 100km for the various plants considered within the different plans. Thus, based upon the relevant domain, we develop the appropriate population estimates covered within the domain. We rely on detailed population data at the Census Tract level using the 2000 U.S. Census. The Census Tract level data was obtained from a Census "Gazetteer" file, which, according to the available documentation, was created by public request.[23] We narrowed the data down to Nevada and to the relevant counties within the State. Based upon the relevant air quality modeling locations, we applied conservative assumptions when developing the relevant population estimates; although the 1993 air quality model results covered a 100km by 100km range, we generally assumed a conservative range (and thus a larger population). For example, we assumed the entire White Pine County population and assumed all of Storey County, Washoe County, Carson City, and Lyon County (apart from the southernmost Census Tract) when calculating damages.

Both Nevada Power and Sierra purchase power generated by other entities, both within and outside the state of Nevada. NAC 703.9359 requires that environmental costs from sources outside the State be included as part of the resource plan assessment. However, the generator of power purchased on the open market is usually unknown. We have treated purchased power

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[22] EPA considers BenMAP the "premier tool for estimating benefits associated with air pollution reduction strategies" (http://www.epa.gov/ttn/ecas/models/benmapfactsheet.pdf).

[23] See http://www.census.gov/geo/www/gazetteer/places2k.html

similarly, whether it be sourced under contract from a known location, or purchased on the open (interstate) market. Our analysis assumes that such energy purchases would be provided by plants at the margin. Nevada Power and Sierra have provided us with forecasts of the types of plants that will be on the margin in different years based on their purchased power projections. We use this information to develop per-ton damage values for energy purchases: (a weighted average of the damage values calculated for specific units in Nevada—since the actual location, relevant population, baseline incidence rates, and other factors is unknown for any energy purchases). We apply this information, along with the air quality results, to develop an estimate of the air quality impact of this purchased power as if it were all generated in Nevada.

4. Adjustment Factor for Population Growth

Because the plans extend to future years, our analysis also considers population growth. Population growth would increase the number of people exposed to ambient pollutants and therefore increase the total potential number of incidences associated with these pollutants. To capture this dynamic effect, we use Nevada population forecasts developed by Woods & Poole Economics, Inc. in their *2006 State Profile* for Nevada. The Woods & Poole dataset extends to the year 2030. In order to assess health effects up to and including the year 2039 – the analysis period for this study – we extrapolate the Woods & Poole population forecast data to 2038, using the same overall growth rate that is reflected in the data for the period between 2007 and 2030.

5. Valuation: Dollar Value of Health Effects

The final step in the damage-function approach involves developing dollar estimates for the various health effects discussed above. For these valuations, we rely on the dollar estimates developed by the EPA in its CAIR/BART assessment.

a. Premature Mortality and Value of Statistical Life

Over the past several decades, various methods have been devised to estimate how much people are willing to pay to reduce risks to life (and health). Some of the methods rely upon the implicit tradeoffs that individuals make in daily decisions; for example, statistical models have been used to estimate the increased wages that workers demand in riskier occupations. Other methods rely on direct surveys of representative individuals, the results of which may be analyzed to produce demand curves for reduced mortality risk.

Several of EPA's analyses find that premature mortality accounts for over 80 percent of potential impacts (e.g., EPA (1997), EPA (1999), EPA (2004), EPA (2005a), etc.). In these analyses, the EPA applied the concept "value of statistical life" or VSL to value this health effect. Another concept—value of statistical life-year ("VSLY")—has also been applied in past analyses. The VSL measure does not attempt to value life itself, but instead represents the value of a small change in mortality risk, aggregated over the affected population.

The EPA assumes that the mean VSL is \$5.5 million in 1999 dollars based upon a distribution of VSL estimates that range from \$1 to \$10 million. Because the majority of VSL studies (in particular, wage-risk studies) were developed in the 1990s or previous decades, the EPA assumes that the VSL value is at 1990 income levels. This value is about $7.1 million in current (2008) dollars. As discussed below, the EPA scales this VSL estimate to reflect future income levels. We rely upon EPA's methodology in our calculations. However, it is important to note that there is much uncertainty regarding the appropriate VSL figure for air quality-related assessments. Indeed, VSL estimates found in the wage-risk literature have ranged from "less than $100,000 to more than $25 million" (Mrozek and Taylor 2002). Two recent meta-analyses, a statistical method of combining different valuation estimates, have found VSL estimates that range from $1.5 million to $2.5 million (1998$) (Mrozek and Taylor 2002) and $5.5 million to $7.6 million (2000$) (Viscusi and Aldy 2003).[24] The results of these two studies, which the EPA relies upon to develop its VSL figure, are based on wage-risk estimates.

The range of results suggests that there is much uncertainty surrounding the "correct" or appropriate VSL estimate. Note that Mrozek and Taylor's VSL estimates are at the lower end of the range and widely regarded as the "best summary of measures of VSL to date" (Krupnick 2002, p. 278). Mrozek and Taylor conclude that "previously applied VSL estimates in benefit/cost analyses of regulatory actions, may overstate the value…by 50 percent or more" (p. 255). Their results account for the "Leigh effect" which suggests an upward bias if inter-industry wage differentials are not distinguished from risk (see Leigh (1995)). The Mrozek and Taylor meta-analysis explicitly controls for broad industry and occupation classifications. The authors conclude that large wage-risk VSL estimates are "likely to reflect the lack of attention this literature has given to the control of unobserved determinants of wages at the industry level" (Mrozek and Taylor 2002, p. 270). An important implication is that lower VSL estimates would result in lower valuations of premature mortality effects and thus, lower damages.

Another complication pertaining to valuing statistical lives is that the majority of "lives" affected by environmental programs are the lives of older people and people with chronically impaired health. However, the VSL estimates developed in the wage-risk and in the contingent valuation (CV) literature in general have focused on measuring the value that healthy, prime-aged adults place on reducing their risk of dying. Freeman (2003) notes that the practice of applying VSL estimates from wage-risk and CV studies has come under increasing criticism because it fails to adequately reflect different factors that individuals place on risk reductions.

> Perhaps the most important of these is the age of the population at risk. The wage-risk studies that figure so importantly in the VSLs used by most analysts reflect the WTPs [willingness to pay] of a group of healthy, mostly male individuals at working age. The mean age of the workers included is typically around 40. If the population affected by an environmental policy is mostly older and if WTP depends on age and years of life at risk, then the VSL based on wage-risk studies could be unrepresentative of the WTP of the affected population (Freeman 2003, p. 319).

[24] These estimates pertain to a U.S. sample. Mrozek and Taylor did not report a U.S. and non-U.S. "best estimate" while Viscusi and Aldy report a U.S. and non-U.S. value of $5.0 to $6.2 million (2000 $)

Thus, there is substantial concern that application of these VSL estimates might not be appropriate for air pollution mortality. For example, the OMB (2003a) notes that analysts "should not use a VSL estimate without considering whether it is appropriate for the size and type of risks addressed by your rule. Studies aimed at deriving VSL values for middle-aged populations are not necessarily applicable to rules that address lifesaving among children or the elderly" (68 Fed. Reg. p. 5521).

Because of these concerns and limitations, there have been substantial arguments for applying a different measure when valuing air pollution-related mortality. These concerns have been raised by Krupnick et al. (2002), Rabl (2003), ExternE (2005), and others who argue that the value of a statistical life-year is a more appropriate measure.[25] The OMB also recognizes the significance of this approach and in its draft *2003 Report to Congress on Guidelines for Regulatory Analysis*, the OMB encouraged federal agencies to provide estimates of both VSL and VSLY when evaluating programs that reduce premature mortality. "In all instances, whether or not you are able to develop ideal estimates, agencies should consider providing estimates of both VSL and VSLY, while recognizing the developing states of knowledge in this area" (OMB 2003a). This view was reiterated in the OMB's Circular A-4 on regulatory analysis (OMB 2003). We discuss the VSLY concept below.

b. Premature Mortality and Value of Statistical Life-Year

The VSL approach focuses on the number of statistical lives affected (i.e., saved or lost). This approach gives equal weight to all lives, regardless of their remaining length or quality. Thus, for example, it does not distinguish between the death of a young, healthy person who can otherwise expect to live many years longer, and the death of a very ill, elderly person who can otherwise expect to live only a few more days or weeks. Indeed, as noted earlier, the majority of "statistical lives" saved are those of the elderly and/or ill. The EPA's (1999) Clean Air Act analyses note:

> The health science literature on air pollution indicates that several human characteristics affect the degree to which mortality risk affects an individual. For example, some age groups are more susceptible to air pollution than others (e.g., the elderly and children). Health status prior to exposure also affects susceptibility – at risk individuals include those who have suffered strokes or are suffering from cardiovascular disease and angina (Rowlatt, et al. 1998). (EPA 1999, p. H-3).

To deal with this issue, a number of researchers have argued that a more appropriate measure is the *years* of life saved since VSL estimates are not necessarily appropriate for valuing air pollution-related mortality (see e.g., Krupnick et al. 2002, EPA 2000, OMB 2003a, Rabl 2003,

[25] Because several studies have argued that a more appropriate measure is the "loss of life expectancy" or "years of life lost," another term that is used to "value" this measure is the value of a life-year ("VOLY") (e.g., see Rabl 2003, ExternE 2005).

ExternE 2005[26]). The following is a summary from the ExternE (2005) report that outlines several reasons why the VSL approach may be inappropriate:

- it does not make sense to add the number of deaths due to different contributing causes (such as air pollution, smoking or lack of exercise) because one would end up with numbers far in excess of total mortality;

- the number of deaths fails to take into account a crucial aspect for the monetary valuation, namely the magnitude of the loss of life per death, very different between typical air pollution deaths and typical accidents;

- in contrast to primary causes of death (such as accidents), the total number of premature deaths attributable to air pollution is not observable;

- the method that has been used for calculating the number of deaths for cohort studies is wrong (ExternE 2005, p. 85-86).

Adjusting for years of life saved has considerable intuitive appeal. It also may have a substantial impact on comparisons between different programs. Most of the VSL studies (i.e., wage-risk studies) are based on occupational risks for which the average years of life lost is on the order of 35 to 40 years per fatality. While fatality from motor vehicle accidents causes a similar loss of life years, lives lost to particulates (or other air pollutants) are likely to involve considerably older individuals, with relatively few remaining years of life. Those who lose their lives to pollution exposure also may be less healthy than the average person in their age groups, which would mean that the years of life lost would be smaller yet.[27]

Similar to VSL estimates, there is substantial uncertainty about the appropriate value to attach to a life year. Two methods have been used to derive VSLY estimates: one method applies a constant VSLY estimate while the other a non-constant VSLY estimate (i.e., older individuals are given a larger VSLY than younger individuals). Both approaches have been applied in recent EPA analyses (e.g., EPA 1997, EPA 1999, EPA 2003). As noted in the report, application of VSLY estimates can reduce premature mortality damages substantially.

c. Morbidity

The other main valuation component relates to morbidity effects. The values used to monetize the various morbidity effects are based upon either the cost-of-illness ("COI") approach or the contingent valuation approach. The cost-of-illness approach measures the costs of medical

[26] The ExternE (Externalities of Energy) project was launched in 1991 and financed by the European Commission DG Research within the Joule programme. The project evaluates external costs associated with airborne pollutants from power plants and the development of an impact pathway approach for evaluating these costs (http://www.externe.info/, http://externe.jrc.es/overview.html).

[27] According to the EPA, the VSLY approach has been applied for many years by the U.S. Food and Drug Administration (EPA 2003).

treatment and lost wages while the CV approach asks individuals to state the amounts that they would be willing to pay to avoid specified conditions. Although the cost-of-illness approach is the best defined, it is also limited because it does not incorporate any willingness-to-pay to avoid discomfort associated with symptoms or illnesses. Contingent valuation surveys are able to provide a more inclusive measure of the value of reducing the risk of illness. Although some economists remain skeptical of some attributes of this methodology, the causes of many of these concerns are mitigated when dealing with relatively common conditions, provided, as always, that the proposed changes are defined clearly and realistically for the survey's respondents. The value estimates per health effect are based upon EPA's recent analyses and summarized in Table E-3 (in addition to the VSL estimate).

Table E-3. Unit Values Used for Economic Valuation of Health Effects (1999$)

	Value per Incidence of Health Endpoint (1999$)				
Health Endpoint	**1990 Income Level**	**2010 Income Level**	**2015 Income Level**	**2020 Income Level**	**2030 Income Level**
Premature Mortality (VSL)	$5,500,000	$6,000,000	$6,400,000	$6,600,000	$6,800,000
Chronic Bronchitis	$340,000	$380,000	$400,000	$420,000	$430,000
Non-fatal Myocardial Infarction	$82,564	$82,564	$82,564	$82,564	$82,564
Hospital Admissions:					
Chronic Obstructive Pulmonary Diseas	$12,378	$12,378	$12,378	$12,378	$12,378
Pneumonia	$14,693	$14,693	$14,693	$14,693	$14,693
Asthma Admissions	$6,634	$6,634	$6,634	$6,634	$6,634
All Cardiovascular	$18,387	$18,387	$18,387	$18,387	$18,387
Emergency Room Visits for Asthma	$286	$286	$286	$286	$286
Ailments Not Requiring Hospitalization:					
Upper Respiratory Symptoms	$25	$25	$25	$27	$27
Lower Respiratory Symptoms	$16	$16	$16	$17	$17
Asthma Exacerbations	$42	$42	$42	$45	$45
Acute Bronchitis	$360	$360	$360	$380	$390
Work and Activity Related:					
Work Loss Days			median income/50/5		
School Absence Days	$75	$75	$75	$75	$75
Minor Restricted Activity Days	$51	$52	$53	$54	$55

Source: EPA 2004 (NR-T4), EPA 2005a (CAIR)

Table E-4 provides these values in current (2008) dollars.

Table E-4. Unit Values Used for Economic Valuation of Health Effects (2008$)

	Value per Incidence of Health Endpoint (2008$)				
Health Endpoint	**1990 Income Level**	**2010 Income Level**	**2015 Income Level**	**2020 Income Level**	**2030 Income Level**
Premature Mortality (VSL)	$7,107,842	$7,754,010	$8,270,944	$8,529,411	$8,787,878
Chronic Bronchitis	$439,394	$491,087	$516,934	$542,781	$555,704
Non-fatal Myocardial Infarction	$106,700	$106,700	$106,700	$106,700	$106,700
Hospital Admissions:					
Chronic Obstructive Pulmonary Disease	$15,997	$15,997	$15,997	$15,997	$15,997
Pneumonia	$18,988	$18,988	$18,988	$18,988	$18,988
Asthma Admissions	$8,573	$8,573	$8,573	$8,573	$8,573
All Cardiovascular	$23,762	$23,762	$23,762	$23,762	$23,762
Emergency Room Visits for Asthma	$370	$370	$370	$370	$370
Ailments Not Requiring Hospitalization:					
Upper Respiratory Symptoms	$32	$32	$32	$35	$35
Lower Respiratory Symptoms	$21	$21	$21	$22	$22
Asthma Exacerbations	$54	$54	$54	$58	$58
Acute Bronchitis	$465	$465	$465	$491	$504
Work and Activity Related:					
Work Loss Days			median income/250		
School Absence Days	$97	$97	$97	$97	$97
Minor Restricted Activity Days	$66	$67	$68	$70	$71

d. Adjustment Factor for Income Growth

Table E-3 and Table E-4 show that the values used for some effects are adjusted for income growth in future years. According to the EPA, there is substantial evidence that the income elasticity of willingness to pay ("WTP") for health risk reductions is positive. This implies that, as real income increases, the WTP for health improvements also increases. Similar to the EPA, our analysis also takes into account future real income growth. The EPA's CAIR/BART and Nonroad Diesel RIAs provide the different values by income levels. We combine this information and develop compound annual growth rate ("CAGR") estimates between the different reference years to interpolate the intermediate years which are then applied to the respective health effects. For years 2031 – 2039, we use the CAGR for income growth occurring between 2020 and 2030 to extrapolate income growth to the year 2039.

C. Uncertainties in Quantified Health Effects

Any quantification of health effects associated with emissions is subject to substantial uncertainty. Because premature mortality effects tend to dominate environmental costs calculated using the damage-function approach, the major components of the overall uncertainty associated with the damage-based environmental cost estimates in our study are the estimated linkage between ambient PM concentrations and premature mortality and the estimated value of premature mortality.

1. Relationship between Ambient PM Concentrations and Premature Mortality

The U.S. EPA has categorized and described four major areas of uncertainty for this estimated linkage (EPA 2005a):

- ***Causality*** **-** Epidemiological studies, by design, cannot prove causation—only correlation. Any causal relationship between exposure to elevated PM and premature mortality is an *assumption* based on the observed correlation between PM and mortality reported in the scientific literature. Various factors relevant to the examination of health effects (including, for example, emission levels for different pollutants) tend to be correlated with each other. For example, if an epidemiological study does not control for other pollutants (or other causal factors) when analyzing the effects of PM, the study may not completely accurately identify the sources of observed effects or their relative importance.

- ***Shape of Concentration-Response Function*** **-** Although use of log-linear or logistic functional forms for C-R functions is standard practice, there is no guarantee about the extent to which these functional forms are valid across varying levels of exposure to pollutants. Some U.S. EPA analyses have discussed the possibility of a "threshold" effect; that is, air pollution levels below a certain threshold may have no associated adverse health effects (EPA 1999). The U.S. EPA notes that the "possible existence of an effect threshold is a very important scientific question and issue" for air quality related analyses (EPA 2005a, p.4-43). The U.S. EPA currently assumes C-R functions with no thresholds throughout the range of exposure to pollutants that are relevant to its analyses. However, if thresholds do indeed exist, damage values estimated with such C-R functions could be overestimated.

- ***Lagged Effect on Mortality*** **-** The scientific literature suggests the existence of a time lag effect between changes in PM exposure and premature mortality. This effect is unquantified, but is believed to be dependent on the kind of exposure. Because benefits or damages occurring in the future (relative to incidences of PM exposure) are subject to discounting, the time lag effect assumed in analyses of the relationship between PM and mortality is particularly important. EPA describes the potential lag effect as follows.

  > There is no specific scientific evidence of the existence or structure of a PM effects lag. However, current scientific literature on adverse health effects similar to those associated with PM (e.g., smoking-related disease) and the difference in the effect size between chronic exposure studies and daily mortality studies suggests that all incidences of premature mortality reduction associated with a given incremental change in PM exposure probably would not occur in the same year as the exposure reduction. The smoking-related literature also implies that lags of up to a few years or longer are plausible (EPA 2005a, p.4-45).

  The U.S. EPA has applied several different lag structures in its recent analyses. For example, in the 1999 Clean Air Act analysis, it assumed that exposure-related mortality occurred over a five year period (starting with an exposure incident), with 25 percent occurring in the first year, 25 percent in the second year, and 16.7 percent in each of the remaining three years. In the CAIR and BART analyses, the U.S. EPA assumed a different segmented mortality lag structure where 30 percent occurred in the first year, 50 percent occurred evenly over years 2 through 5, and 20 percent occurred evenly over years 6 through 20. According to the U.S. EPA, this lag structure is intended to reflect short-term mortality in the first year, cardiopulmonary mortality in the middle segment, and long-term lung disease and lung cancer in the final segment (EPA 2005a). The assumed lag structure does not change the total estimated mortality; only the timing. Our analysis uses the mortality lag structure applied in the CAIR and BART analyses.

- ***Variability in Study Results due to Regional Differences in PM composition-*** An important source of uncertainty in the damage-function approach arises from variability in the results of different studies evaluating the relationship between PM and mortality. According to the U.S. EPA, this variability may reflect regionally-specific C-R functions resulting from regional differences in the physical and chemical composition of PM (EPA 2005a). Although the U.S. EPA acknowledges the potential effects of regional differences, given limited information on such differences, it applies the same C-R function everywhere in its analyses.

2. Valuation of Premature Mortality

Given the importance of the estimated value of statistical life, the U.S. EPA has often developed sensitivity analyses for VSL that either consider how an alternative VSL estimate would affect estimated damage values or apply an estimated value of statistical life-year ("VSLY"), a measure that differs from VSL, when valuing mortality effects. These alternative valuation estimates could reduce estimated damage values substantially. For example, application of VSLY in the U.S. EPA assessment of the Clean Air Act resulted in "estimates that are almost 50 percent lower than … primary estimates of benefits due to avoided pre-mature mortality" (EPA 1999, p. H-37).

D. Non-Quantified Potential Environmental Costs Related to Air Emissions

Both the U.S. EPA and the U.S. Office of Management and Budget ("U.S. OMB") note that, in assessments of environmental costs, it is important to identify non-quantified effects and consider their implications for the estimated results (EPA 2000 and OMB 2003). The damage-function-based environmental cost estimates, in accordance with methodologies developed by the EPA in its recent assessments, exclude some components of environmental costs.

1. Non-Quantified Health Effects

Table E-5 summarizes the health-related effects associated with ambient PM and ozone concentrations that are identified but not quantified in the U.S. EPA CAIR analysis. According to U.S. EPA, these effects (among others) were not quantified "because of current limitations in methods or available data" (EPA 2005a, p. 4-2). Although the inclusion of non-quantified effects would tend to increase estimated costs, the magnitude of such an increase is highly uncertain. The U.S. EPA notes that unmonetized PM-related health effects may be small relative to quantified effects (due to the overwhelming importance of PM-related premature mortality effects, which are quantified) (EPA 2005a, p.4-22).

Table E-5. Non-Quantified Health Effects

Pollutant	Non-quantified Health Effect - Changes in:
Particulate matter	Premature mortality: short-term exposures[a]
	Low birth weight
	Pulmonary function
	Chronic respiratory diseases other than chronic bronchitis
	Nonasthma respiratory emergency room visits
	Subchronic bronchitis cases
	UVb exposure (+/-)
Ozone	Premature mortality[b]
	Chronic respiratory damage
	Premature aging of the lungs
	Nonasthma respiratory emergency room visits
	Asthma attacks
	Acute respiratory symptoms
	Cardiovascular emergency room visits
	Increased expsoure to UVb

Notes: (a) Potential short-term effects not captured in cohort study.
(b) Some evidence suggests that short-term exposure to ozone may affect daily premature mortality.
Source: EPA 2005a.

2. Other Excluded Welfare Effects

Several non-health welfare effects have been associated with ambient PM and ozone concentrations. These effects include visibility effects, damages to property (e.g., soiling), agricultural yield effects, and ecosystem effects. However, quantification of these effects can be difficult or even impracticable. The U.S. EPA BART and CAIR analyses quantify reductions in recreational visibility related to PM in Southeastern Class I areas as well as reductions in decreased outdoor worker productivity related to ozone.

The U.S. EPA analyses consider two categories of visibility effects: recreational visibility and residential visibility. According to the U.S. EPA, recreational visibility effects pertain to visibility changes that occur specifically in federal Class I areas (areas targeted for visibility improvement under the U.S. EPA Regional Haze Program) while residential visibility effects are effects that occur in areas not listed as federal Class I areas (e.g., urban, suburban, and rural areas, and non-Class I recreational areas). Although the U.S. EPA analyses consider these two categories, they only quantify recreational visibility effects, citing a lack of reliable residential visibility values.

Only two existing studies provide defensible monetary estimates of the value of visibility changes. One is a study on residential visibility conducted in 1990 (McClelland et al., 1993) and the other is a 1988 survey on recreational visibility

> value (Chestnut and Rowe, 1990a; 1990b). Although there are a number of other studies in the literature, they were conducted in the early 1980s and did not use methods that are considered defensible by current standards. Both the Chestnut and Rowe and McClelland et al. studies use the CV method. Consistent with SAB [Science Advisory Board] advice, EPA has designated the McClelland et al. study as significantly less reliable for regulatory benefit-cost analysis, although it does provide useful estimates on the order of magnitude of residential visibility benefits (EPA-SAB-COUNCILADV-00-002, 1999). *Residential visibility benefits are not calculated for this analysis.* (Emphasis added, EPA 2005a, p. 4-66 to 4-67)

Given limitations on data, we have not quantified recreational or residential visibility effects, but we believe that these effects are not likely to be significant relative to the environmental costs we have quantified. To the extent that the emissions considered in this study would affect visibility in Class I areas, the environmental cost estimates would be somewhat understated.

We also have not quantified effects on outdoor worker productivity related to ozone, in part because we do not have sufficient data. In particular, the standard C-R function[28] for this effect requires several additional air quality measures beyond those available for our analyses. Moreover, the standard C-R function measures worker productivity among outdoor farm workers exposed to ozone. Because farm output in Nevada is limited, this potential effect is likely to be small.

In addition to effects on visibility and outdoor worker productivity, other potential welfare effects could include changes in expenditures related to cleaning and household maintenance from household soiling. The U.S. EPA does not quantify this effect in its primary benefits analyses.[29]

> Previous EPA benefits analyses have been able to provide quantitative estimates of household soiling damage. Consistent with SAB [Science Advisory Board] advice, we determined that the existing data (based on consumer expenditures from the early 1970s) are too out of date to provide a reliable estimate of current household soiling damages (EPA-SAB-COUNCIL-ADV-98-003, 1998) (EPA 2005a, p.4-72)

The U.S. EPA also considers effects of emissions on the health and stability of ecosystems, but recognizes that these potential effects are "poorly understood and difficult to measure" (EPA 2005a, p. 4-73). Thus we have not quantified these potential effects. Related to effects on ecosystems are potential effects on agricultural yield. In particular, ozone exposure has been associated with reductions in crop and forest yields. Previous studies conducted in southern Nevada (Harrison et al. 1993) and northern Nevada (Harrison et al. 1993a) have found either no

[28] The U.S. EPA uses results from Crocker and Horst (Crocker and Horst 1981).

[29] The U.S. EPA considers this effect in a sensitivity analysis but cautions against its use on the grounds of potential unreliability of the relevant estimated values.

discernible or negligible effects on agricultural yield resulting from ambient ozone concentrations in Nevada.

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Appendix F: IMPLAN Documentation

This appendix provides details on the IMPLAN model. The text and tables are from IMPLAN documentation developed by MIG.[30]

A. Introduction to IMPLAN

Input-output accounting describes commodity flows from producers to intermediate and final consumers. The total industry purchases of commodities, services, employment compensation, value added, and imports are equal to the value of the commodities produced.

Purchases for final use (final demand) drive the model. Industries produce goods and services for final demand and purchase goods and services from other producers. These other producers, in turn, purchase goods and services. This buying of goods and services (indirect purchases) continues until leakages from the region (imports and value added) stop the cycle.

These indirect and induced effects (the effects of household spending) can be mathematically derived. The derivation is called the Leontief inverse. The resulting sets of multipliers describe the change of output for each and every regional industry caused by a one dollar change in final demand for any given industry.

Creating regional input-output models require a tremendous amount of data. The costs of surveying industries within each region to derive a list of commodity purchases (production functions) are prohibitive. IMPLAN was developed as a cost-effective means to develop regional input-output models. The IMPLAN accounts closely follow the accounting conventions used in the "Input-Output Study of the U.S. Economy" by the Bureau of Economic Analysis (1980) and the rectangular format recommended by the United Nations.

The IMPLAN system was designed to serve three functions: 1) data retrieval, 2) data reduction and model development, and 3) impact analysis. Comprehensive and detailed data coverage of the entire U.S. by county, and the ability to incorporate user-supplied data at each stage of the model building process, provides a high degree of flexibility both in terms of geographic coverage and model formulation.

The IMPLAN database, created by MIG, Inc., consists of two major parts: 1) a national-level technology matrix and 2) estimates of sectorial activity for final demand, final payments, industry output and employment for each county in the U.S. along with state and national totals. New databases are developed annually by MIG, Inc.

IMPLAN easily allows the user to do the following:

- Develop his/her own multiplier tables;

[30] Lindall, Scott A. and Douglas C. Olson. 2006. *The IMPLAN Input-Output System*. Minnesota IMPLAN Group. http://www.implan.com/library/documents/implan_io_system_description.pdf, accessed June 25, 2006.

- Develop a complete set of SAM (Social Accounting Matrix) accounts;
- Change any component of the system, production functions, trade flows, or database;
- Generate type I, II, or any true SAM multiplier internalizing household, government, and/or investment activities;
- Create custom impact analysis by entering final demand changes;
- Obtain any report in the system to examine the model's assumptions and calculations.

There are two components to the IMPLAN system, the software and databases. The databases provide all information to create regional IMPLAN models. The software performs the calculations and provides an interface for the user to make final demand changes.

B. IMPLAN Databases

Each database has information for these components for all 508 industrial sectors in the IMPLAN model.

Employment is total wage and salary and self employed jobs in a region. In the 1985 database, employment was measured as full-time equivalent jobs. This meant that total employment in a region would generally be below most published estimates since these are generally full-time and part-time. In the 1990 and subsequent databases, employment includes both full-time and part-time workers. Employment in the 1990 and subsequent databases are measured in total jobs.

There are four sub-components for Value Added. These are:

1. Employee Compensation;
2. Proprietary Income;
3. Other Property Type Income;
4. Indirect Business Taxes.

Employee compensation is wage and salary payments as well as benefits including health and life insurance, retirement payments, and any other non-cash compensation. This provides a measure of income to workers who are paid by employers.

Proprietary income consists of payments received by self-employed individuals as income. This would be recorded on Federal Tax Form 1040C. This includes income received by private business owners, doctors, lawyers, and so forth. Any income a person receives for payment of self-employed work is counted here.

Other property type income consists of payments from rents royalties and dividends. This includes payments to individuals in the form of rents received on property, royalties from contracts, and dividends paid by corporations. This also includes corporate profits earned by corporations.

Indirect business taxes consist primarily of excise and sales taxes paid by individuals to businesses. These taxes are collected during the normal operation of these businesses but do not include taxes on profit or income.

Goods and services purchased for their ultimate use by an end user are called **final demands.** For a region this would include exports as that is a final use for that product. In an input-output framework, final demands are allocated to producing industries with margins allocated to the service sectors (transportation, wholesale and retail trade, insurance) associated with providing that good to the final user. Thus final demands are in producer prices.

There are 13 sub-components for Final Demands. These are:

1. Personal Consumption Expenditures (PCE) - nine income levels;
2. Federal Government Military Purchases;
3. Federal Government Non-Military Purchases;
4. Federal Government Capital Formation Purchases;
5. State and Local Government Non-Education Purchases;
6. State and Local Government Education Purchases;
7. State and Local Government Capital Formation Purchases;
8. Inventory Purchases;
9. Capital Formation;
10. Foreign Exports;
11. State and Local Government Sales;
12. Federal Government Sales;
13. Inventory Sales.

All final demands in the original data are on a commodity basis. The distinction between industries and commodities is as follows from the 1972 I-O Definitions and Conventions Manual:

- An input-output industry is a grouping of establishments, as classified by SIC;
- An input-output commodity consists of the characteristic products of the corresponding I-O industry wherever made.

There are several industries that have no commodities. This is a result of departures from the strict SIC classification of industries. Also, some commodities have no associated industry. An example of this is non-comparable imports.

Personal consumption expenditures (PCE) consist of payments by individuals/households to industries for goods and services used for personal consumption. Individuals tend to buy little directly from industries other than retail trade. However, in an input-output table, purchases made by individuals for final consumption are shown as payments made directly to the industry producing the good. PCE is the largest component of final demand.

Federal Government purchases are divided between military, non-military uses and capital formation. Federal military purchases are those made to support the national defense. Goods range from food for troops to missile launchers. Non-military purchases are made to supply all other government functions. Payments made to other governmental units are transfers and are not included in Federal Government purchases.

State and local government purchases are divided between public education, non-education and capital formation. Public education purchases are for elementary, high school, and higher education. Non-education purchases are for all other government activities. These include state government operations, operations including police protection and sanitation. Private sector education purchases are not counted here. Private education purchases show up in IMPLAN sectors 495 and 496.

Inventory purchases are made when industries do not sell all output created in one year. This is generally the case. Each year, a portion of output goes to inventory. Inventory sales occur when industries sell more than they produce and need to deplete inventory. Inventory purchases and sales generally involve goods producing industries (e.g., agriculture, mining, and manufacturing).

Capital formation are private expenditures made to obtain capital equipment. The dollar values in the IMPLAN database are expenditures made to an industrial sector producing the capital equipment. The values are not expenditures by the industrial sector.

Foreign Exports are demands made to industries for goods for export beyond national borders. These represent goods and services demanded by foreign parties. Domestic exports are calculated during the IMPLAN model creation and are not part of the database.

The national **transactions matrix** is based on the most current National Bureau of Economic Analysis Benchmark Input-Output Model. It is resectored to IMPLAN industrial sectoring. We use our IMPLAN data for the current year to update the most recent National Benchmark study.

The components of the IMPLAN database are part of the social accounts of the region under study. Social accounts show the flow of commodities from industry to producers and institutional consumers. Also shown is the consumption of factors of production, i.e., workers, owners of capital and imports from outside of the region.

The IMPLAN database and software provides the information and capability to estimate a complete set of social accounts for a local area. The complete set of social accounts is then converted to the industry by industry formulation of input/output accounts and ultimately the predictive Leontief multipliers.

Table F-1 illustrates the nature of the IMPLAN accounts. The initial data set is "use" of commodity by industry and the "make" of commodities by industry. These flows are from the national input-output model. For each data set, final demands, value added, output, and employment was developed. Employment is in addition to the traditional social accounts.

Table F-1. Relationships Among IMPLAN Accounts

	Industry	Commodity	Factors	Institution	Exports	Total
Industry		*Make*				Total Industry Output
Commodity	*Use*			*Consumption*	*Exports*	Total Commodity Output
Factors	*Value Added*				*Exports*	Total Factor Income
Institution	*Sales & Taxes*	*Sales*	*Distribution*	*Transfers*	*Exports*	Total Institutional Income
Imports	*Imports*		*Imports*	*Imports*	*Trans-Shipment*	Total Imports
TOTAL	Total Industry Outlay	Total Commodity Outlay	Total Factor Outlay	Total Institutional Expenditures	Total Exports	

Source: Minnesota IMPLAN Group.

To create a regional I/O model, the regional data is combined with the national structural matrices to form the regional multipliers. In the first step, the software creates the regional study area file by combining the states or counties selected by the user.

From the initial study area data, the software regionalizes the national structural matrices by eliminating industries that do not exist, and adjust for value added to total industry output ratios. Imports are then estimated via the regional purchase coefficients or RPC's.

An RPC represents the proportion of the total supply of a good or service required to meet a particular industry's intermediate demands and final demands that are produced locally. For example, an RPC value of 0.8 for the commodity "fish" means that 80 percent of the demand for fish (by fish processors, fish wholesalers, foreign exports, and others) is provided by local fishermen. The remainder, 20 percent, is imported.

Once RPC's are derived, imports are calculated using the minimum of the RPC or supply/demand pool. The regional final demands and use matrix are then multiplied by the resulting RPC coefficients. This creates a set of matrices and final demands that are free of imports.

Domestic exports are the residual of regional production not locally consumed. The result is a balanced set of regional economic accounts.

The I/O accounts are developed next. The regional use matrix and final demands are converted from commodity to industry basis. The subsequent inversion of the I/O accounts provides an import-free Leontief matrix of multipliers.

C. IMPLAN Multipliers

The notion of a multiplier rests upon the difference between the initial effect of a change in final demand and the total effects of that change. Total effects can be calculated either as direct and indirect effects, or as direct, indirect, and induced effects. Direct effects are production changes associated with the immediate effects or final demand changes. Indirect effects area production changes in backward-linked industries cause by the changing input needs of directly affected industries (for example, additional purchases to produce additional output). Induced effects are the changes in regional household spending patterns caused by changes in household income generated from the direct and indirect effects.

Five different sets of multipliers are estimated by IMPLAN corresponding to five measures of regional economic activity; total industry output, personal income, total income, value added, and employment. For each set of multipliers, four types of multipliers are generated, Type I, Type II, Type SAM and Type III.

1. Type I Multipliers

A Type I multiplier is the direct effect, produced by a change in final demand, plus the indirect effect divided by the direct effect. Increased demands are assumed to lead to increased employment and population with the average income level remaining constant. The Leontief inverse (Type I multipliers matrix) is derived by inverting the direct coefficients matrix. The result is a matrix of total requirement coefficients, the amount each industry must produce in order for the purchasing industry to deliver one dollar's worth of output to final demand.

2. Type II Multipliers

Type II multipliers incorporate "induced" effects resulting from the household expenditures from new labor income. The linear relationship between labor income and household expenditure can be customized in the IMPLAN Professional® software:

1. The default relationship is PCE (personal consumption expenditures) and total household expenditures. Each dollar of work-place based income is spent based on the SAM relationship generated by IMPLAN.

2. The second possibility is a RIMS II style of Type II multiplier, where PCE is adjusted to represent only the spending of the disposable income portion of labor income. In this way there is a direct one-to-one relationship to labor income and PCE. Then a ratio, which the user can specify, is applied to convert total income to disposable income before the rounds of induced effects are calculated.

3. Type SAM Multipliers

Type SAM multipliers are the direct, indirect, and induced effects where the induced effect is based on information in the social account matrix. This relationship accounts for social security and income tax leakage, institution savings, and commuting. It also accounts for inter-institutional transfers. This multiplier is flexible in that you can include any institutions you want. In other words, if you want to create a model closed to households and state and local government, you can. If you select this option, an additional dialog box with be displayed allowing you to select the institutions you want to include.

4. Output Multipliers

This report shows the total industry output multipliers and per-capita personal consumption expenditures. Output multipliers can be used to gauge the interdependence of sectors; the larger the output multiplier, the greater the interdependence of the sector on the rest of the regional economy. A Type I entry represents the value of production (from direct and indirect effects) required from all sectors by a particular sector to deliver one dollar's worth of output. Type II, SAM and III adds in the induced requirements.

> Example: If a Type I multiplier for the Dairy Farm industry is 1.0943, for each dollar of output produced by the Dairy Farm sector, 0.0943 dollars worth of indirect output is generated in other local industries. If the Type SAM Dairy Farm multiplier is 1.3140, 0.3140 dollars of indirect and induced output is generated in other local industries. The induced output would be 1.3140 - 1.0943 or 0.2197 dollars for each dollar of output produced by the Dairy Farm sector.

5. Labor Income Multipliers

The labor income multiplier report shows the direct, indirect, and induced employee compensation plus proprietor income effects generated per dollar of output. The Type I personal income multiplier is the direct and indirect employee compensation plus proprietor income divided by the direct income. The Type II, Type SAM and Type III multiplier adds the induced effects component.

> Example: If, the Type I multiplier for the Dairy Farm sector is 1.4761 and the Type SAM multiplier is 2.7067 then for each dollar of direct income generated by this industry, 0.4761 dollars of indirect and 1.2306 dollars of induced income are generated.

6. Employee Compensation Multipliers

Employee compensation represents all payroll costs of wage and salary workers. The Type I, Type SAM, Type II or Type III total income multipliers are listed in this report along with the direct, indirect, and induced total income effects generated from the production of one dollar's output.

7. Proprietor Income Multipliers

Proprietor Income is the income earned by the owners of a private- non-incorporated business - i.e., the self-employed. The Type I, Type SAM, Type II or Type III total income multipliers are listed in this report along with the direct, indirect, and induced total income effects generated from the production of one dollar's output.

8. Other Property Type Income Multipliers

Other property type income represents corporate income, rental income and interest. The Type I and Type II/Type SAM/Type III total income multipliers are listed in this report along with the direct, indirect, and induced total income effects generated from the production of one dollar's output.

9. Value Added Multipliers

Type I and Type II/Type SAM/Type III Value Added multipliers are listed in this report along with the direct, indirect, and induced Value Added effects generated from the production of one dollar or output. Value Added includes: employee compensation, proprietary income, other property type income, and indirect business taxes.

10. Employment Multipliers

Type I and Type II/Type SAM/Type III employment multipliers are listed in this report along with the direct, indirect, and induced employment effects from the production of one million dollars of output. Employment is in terms of full-time and part-time jobs.

> Example: if a Dairy Farm Type I employment multiplier is 1.1158, for each job created directly by the dairy farm industry, 0.1158 jobs are created indirectly.

Appendix G: Detailed IMPLAN Results

This appendix provides detailed results from the IMPLAN analysis of the plans.

A. Construction Expenditures for Individual Units and Transmission Lines

Table G-1. Timing of Construction Expenditures (2008 dollars) for Proposed Units and Lines

Project Name		Distribution of Construction Expenditures		
Eastern Nevada Microwave				
Type	Line	2007	2.7%	$521
Online Date	2010	2008	3.1%	$596
Constr. Cost	$19,477	2009	4.4%	$850
		2010	63.8%	$12,428
		2011	26.1%	$5,083
			100.0%	$19,477
Harry Allen 484 MW Combined Cycle				
Type	484 MW CC			
Online Date	2011	2008	15.7%	$104,985
Constr. Cost	$668,597	2009	45.8%	$306,118
		2010	36.7%	$245,157
		2011	1.8%	$12,338
			100.0%	$668,597
Transmission Line (RS to HA) W PS		2007	0.4%	$1,965
		2008	0.4%	$1,960
Type	500 kV Line	2009	1.3%	$6,831
Online Date	2012	2010	4.7%	$24,767
Constr. Cost	$527,284	2011	38.3%	$202,092
		2012	54.1%	$285,134
		2013	0.8%	$4,290
			100.0%	$527,041
Transmission Line (RS to HA) WO PS				
		2007	0.4%	$1,965
		2008	0.4%	$1,960
Type	500 kV Line	2009	1.9%	$8,323
Online Date	2012	2010	9.6%	$42,316
Constr. Cost	$440,581	2011	59.9%	$263,821
		2012	27.7%	$121,951
		2013	0.0%	$0
			100%	$440,337
NPC - 544 MW Combined Cycle				
Type	544 MW CC			
Online Date	2015			
Constr. Cost	$720,566	2012	15.7%	$113,145
		2013	45.8%	$329,912
		2014	36.7%	$0
		2015	1.8%	$13,297
			100.0%	$456,354

Table G-1. Timing of Construction Expenditures for Proposed Units (cont.)

Project Name		Distribution of Construction Expenditures		
NPC - Three 75 MW LMS 100 Units				
Type	3x75 MW Gas Turbine			
Online Date	2016			
Constr. Cost	$367,806	2014	38.4%	$141,121
		2015	55.5%	$204,276
		2016	6.1%	$22,409
			100.0%	$367,806
SPPC - Two 75 MW LMS 100 Units				
Type	2x75 MW Gas Turbine			
Online Date	2016			
Constr. Cost	$245,204	2014	38.4%	$94,081
		2015	55.5%	$136,184
		2016	6.1%	$14,939
			100.0%	$245,204
NPC - 544 MW Combined Cycle				
Type	544 MW CC			
Online Date	2017	2014	15.7%	$113,145
Constr. Cost	$720,566	2015	45.8%	$329,912
		2016	36.7%	$264,212
		2017	1.8%	$13,297
			100.0%	$720,566
NPC - 544 MW Combined Cycle				
Type	544 MW CC			
Online Date	2018	2015	15.7%	$113,145
Constr. Cost	$720,566	2016	45.8%	$329,912
		2017	36.7%	$264,212
		2018	1.8%	$13,297
			100.0%	$720,566
SPPC - 541 MW Combined Cycle				
Type	541 MW CC			
Online Date	2019	2016	15.7%	$113,145
Constr. Cost	$720,566	2017	45.8%	$329,912
		2018	36.7%	$264,212
		2019	1.8%	$13,297
			100.0%	$720,566

Table G-1. Timing of Construction Expenditures (2008 dollars) for Proposed Units (cont.)

Project Name		Distribution of Construction Expenditures		
NPC - Six 75 MW LMS 100 Units				
Type	6x75 MW Gas Turbine			
Online Date	2020			
Constr. Cost	$704,206	2018	38.4%	$270,193
		2019	55.5%	$391,108
		2020	6.1%	$42,904
			100.0%	$704,206
NPC - 544 MW Combined Cycle				
Type	544 MW CC			
Online Date	2022	2019	15.7%	$113,145
Constr. Cost	$720,566	2020	45.8%	$329,912
		2021	36.7%	$264,212
		2022	1.8%	$13,297
			100.0%	$720,566
NPC - Six 75 MW LMS 100 Units				
Type	6x75 MW Gas Turbine			
Online Date	2024			
Constr. Cost	$704,206	2022	38.4%	$270,193
		2023	55.5%	$391,108
		2024	6.1%	$42,904
			100.0%	$704,206
SPPC - 541 MW Combined Cycle				
Type	541 MW CC			
Online Date	2023	2020	15.7%	$113,145
Constr. Cost	$720,566	2021	45.8%	$329,912
		2022	36.7%	$264,212
		2023	1.8%	$13,297
			100.0%	$720,566
NPC - 544 MW Combined Cycle				
Type	544 MW CC			
Online Date	2026	2023	15.7%	$113,145
Constr. Cost	$720,566	2024	45.8%	$329,912
		2025	36.7%	$264,212
		2026	1.8%	$13,297
			100.0%	$720,566
SPPC - 541 MW Combined Cycle				
Type	541 MW CC			
Online Date	2026	2023	15.7%	$113,145
Constr. Cost	$720,566	2024	45.8%	$329,912
		2025	36.7%	$264,212
		2026	1.8%	$13,297
			100.0%	$720,566
NPC - 544 MW Combined Cycle				
Type	544 MW CC			
Online Date	2027	2024	15.7%	$113,145
Constr. Cost	$720,566	2025	45.8%	$329,912
		2026	36.7%	$264,212
		2027	1.8%	$13,297
			100.0%	$720,566
NPC - 544 MW Combined Cycle				
Type	544 MW CC			
Online Date	2030	2027	15.7%	$113,145
Constr. Cost	$720,566	2028	45.8%	$329,912
		2029	36.7%	$264,212
		2030	1.8%	$13,297
			100.0%	$720,566

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Table G-1. Timing of Construction Expenditures (2008 dollars) for Proposed Units (cont.)

Project Name		Distribution of Construction Expenditures		
NPC - Six 75 MW LMS 100 Units				
Type	6x75 MW Gas Turbine			
Online Date	2031	2028	0.0%	$0
Constr. Cost	$704,206	2029	38.4%	$270,193
		2030	55.5%	$391,108
		2031	6.1%	$42,904
			100.0%	$704,206
NPC - 544 MW Combined Cycle				
Type	544 MW CC			
Online Date	2034	2031	15.7%	$113,145
Constr. Cost	$720,566	2032	45.8%	$329,912
		2033	36.7%	$264,212
		2034	1.8%	$13,297
			100.0%	$720,566
NPC - 544 MW Combined Cycle				
Type	544 MW CC			
Online Date	2036	2033	15.7%	$113,145
Constr. Cost	$720,566	2034	45.8%	$329,912
		2035	36.7%	$264,212
		2036	1.8%	$13,297
			100.0%	$720,566

B. Annual Expenditures for Construction and Operations Sectors

1. Plan 1

Table G-2. Annual Expenditures (thousands of 2008 dollars) under Plan 1

Year	Industry Output Increase for "Other New Construction" Sector	Industry Output Increase for "Power Generation and Supply" Sector	Units/Lines Starting Construction	Units/Lines Starting Operation
2010	$245,198	$1,627,572		
2011	$12,340	$1,725,442		*HACC 484 MW CC '11*
2012	$113,164	$1,819,169	*NPC 544 MW CC '15*	
2013	$329,967	$1,818,722		
2014	$612,662	$1,873,686	*NPC 3x75 MW LMS100 '16, SPPC 2x75 MW LMS100 '16, NPC 544 MW CC '17*	
2015	$796,946	$1,991,487	*NPC 544 MW CC '18*	*NPC 544 MW CC '15*
2016	$744,741	$2,128,317	*SPPC 541 MW CC '19*	*NPC 3x75 MW LMS100 '16, SPPC 2x75 MW LMS100 '16*
2017	$607,522	$2,313,610		*NPC 544 MW CC '17*
2018	$547,793	$2,333,205	*NPC 6x75 MW LMS100 '20*	*NPC 544 MW CC '18*
2019	$517,636	$2,432,163	*NPC 544 MW CC '22*	*SPPC 541 MW CC '19*
2020	$486,042	$2,315,238	*SPPC 541 MW CC '23*	*NPC 6x75 MW LMS100 '20*
2021	$594,223	$2,238,192		
2022	$547,793	$2,275,686	*NPC 6x75 MW LMS100 '24*	*NPC 544 MW CC '22*
2023	$630,800	$2,464,447	*NPC 544 MW CC '26, SPPC 541 MW CC '26*	*SPPC 541 MW CC '23*
2024	$816,009	$2,613,539	*NPC 544 MW CC '27*	*NPC 6x75 MW LMS100 '24*
2025	$858,479	$2,874,626		
2026	$290,854	$3,049,036		*NPC 544 MW CC '26, SPPC 541 MW CC '26*
2027	$126,463	$3,242,634	*NPC 544 MW CC '30*	*NPC 544 MW CC '27*
2028	$329,967	$3,467,358		
2029	$534,494	$3,688,181	*NPC 6x75 MW LMS100 '31*	
2030	$404,473	$3,844,698		*NPC 544 MW CC '30*
2031	$156,075	$4,050,423	*NPC 544 MW CC '34*	*NPC 6x75 MW LMS100 '31*
2032	$329,967	$4,294,462		
2033	$377,420	$4,499,401	*NPC 544 MW CC '36*	
2034	$343,266	$4,660,237		*NPC 544 MW CC '34*
2035	$264,256	$4,889,708		
2036	$13,299	$5,077,855		*NPC 544 MW CC '36*
2037	$0	$5,298,583		
2038	$0	$5,560,488		
2039	$0	$5,794,159		
Sum	$11,631,849	$96,262,325		
PV	$5,459,064	$33,821,251		

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2. Plan 2

Table G-3. Annual Expenditures (thousands of 2008 dollars) under Plan 2

Year	Industry Output Increase for "Other New Construction" Sector	Industry Output Increase for "Power Generation and Supply" Sector	Units/Lines Starting Construction	Units/Lines Starting Operation
2010	$305,853	$1,659,603		*E Nevada Microwave '10*
2011	$286,825	$1,759,399		*HACC 484 MW CC '11*
2012	$239,763	$1,849,020	*NPC 544 MW CC '15*	*RS to HA 500 kV Line WO PS '12*
2013	$336,461	$1,845,462		
2014	$624,719	$1,899,578	*NPC 3x75 MW LMS100 '16, SPPC 2x75 MW LMS100 '16, NPC 544 MW CC '17*	
2015	$812,630	$2,019,787	*NPC 544 MW CC '18*	*NPC 544 MW CC '15*
2016	$759,398	$2,157,765	*SPPC 541 MW CC '19*	*NPC 3x75 MW LMS100 '16, SPPC 2x75 MW LMS100 '16*
2017	$619,478	$2,345,706		*NPC 544 MW CC '17*
2018	$558,573	$2,361,940	*NPC 6x75 MW LMS100 '20*	*NPC 544 MW CC '18*
2019	$527,824	$2,461,144	*NPC 544 MW CC '22*	*SPPC 541 MW CC '19*
2020	$495,608	$2,342,793	*SPPC 541 MW CC '23*	*NPC 6x75 MW LMS100 '20*
2021	$605,917	$2,264,948		
2022	$558,573	$2,306,167	*NPC 6x75 MW LMS100 '24*	*NPC 544 MW CC '22*
2023	$643,214	$2,495,545	*NPC 544 MW CC '26, SPPC 541 MW CC '26*	*SPPC 541 MW CC '23*
2024	$832,068	$2,643,717	*NPC 544 MW CC '27*	*NPC 6x75 MW LMS100 '24*
2025	$875,374	$2,908,808		
2026	$296,578	$3,087,673		*NPC 544 MW CC '26, SPPC 541 MW CC '26*
2027	$128,952	$3,287,744	*NPC 544 MW CC '30*	*NPC 544 MW CC '27*
2028	$336,461	$3,512,053		
2029	$545,013	$3,734,430	*NPC 6x75 MW LMS100 '31*	
2030	$412,433	$3,897,732		*NPC 544 MW CC '30*
2031	$159,147	$4,104,872	*NPC 544 MW CC '34*	*NPC 6x75 MW LMS100 '31*
2032	$336,461	$4,353,166		
2033	$384,848	$4,558,582	*NPC 544 MW CC '36*	
2034	$350,021	$4,726,675		*NPC 544 MW CC '34*
2035	$269,457	$4,961,914		
2036	$13,561	$5,148,728		*NPC 544 MW CC '36*
2037	$0	$5,375,765		
2038	$0	$5,627,354		
2039	$0	$5,860,800		
Sum	$12,315,208	$97,558,870		
PV	$5,963,116	$34,291,703		

3. Plan 3

Table G-4. Annual Expenditures (thousands of 2008 dollars) under Plan 3

Year	Industry Output Increase for "Other New Construction" Sector	Industry Output Increase for "Power Generation and Supply" Sector	Units/Lines Starting Construction	Units/Lines Starting Operation
2010	$305,853	$1,659,603		*E Nevada Microwave '10*
2011	$286,825	$1,759,399		*HACC 484 MW CC '11*
2012	$239,763	$1,848,623	*NPC 544 MW CC '15*	*RS to HA 500 kV Line WO PS '12*
2013	$336,461	$1,844,418		
2014	$624,719	$1,898,573	*NPC 3x75 MW LMS100 '16, SPPC 2x75 MW LMS100 '16, NPC 544 MW CC '17*	
2015	$812,630	$2,018,727	*NPC 544 MW CC '18*	*NPC 544 MW CC '15*
2016	$759,398	$2,157,193	*SPPC 541 MW CC '19*	*NPC 3x75 MW LMS100 '16, SPPC 2x75 MW LMS100 '16*
2017	$619,478	$2,344,464		*NPC 544 MW CC '17*
2018	$558,573	$2,361,258	*NPC 6x75 MW LMS100 '20*	*NPC 544 MW CC '18*
2019	$527,824	$2,459,848	*NPC 544 MW CC '22*	*SPPC 541 MW CC '19*
2020	$495,608	$2,341,952	*SPPC 541 MW CC '23*	*NPC 6x75 MW LMS100 '20*
2021	$605,917	$2,263,161		
2022	$558,573	$2,304,263	*NPC 6x75 MW LMS100 '24*	*NPC 544 MW CC '22*
2023	$643,214	$2,491,213	*NPC 544 MW CC '26, SPPC 541 MW CC '26*	*SPPC 541 MW CC '23*
2024	$832,068	$2,640,436	*NPC 544 MW CC '27*	*NPC 6x75 MW LMS100 '24*
2025	$875,374	$2,904,598		
2026	$296,578	$3,082,484		*NPC 544 MW CC '26, SPPC 541 MW CC '26*
2027	$128,952	$3,283,166	*NPC 544 MW CC '30*	*NPC 544 MW CC '27*
2028	$336,461	$3,507,607		
2029	$545,013	$3,728,488	*NPC 6x75 MW LMS100 '31*	
2030	$412,433	$3,893,635		*NPC 544 MW CC '30*
2031	$159,147	$4,097,270	*NPC 544 MW CC '34*	*NPC 6x75 MW LMS100 '31*
2032	$336,461	$4,347,963		
2033	$384,848	$4,552,804	*NPC 544 MW CC '36*	
2034	$350,021	$4,721,617		*NPC 544 MW CC '34*
2035	$269,457	$4,956,219		
2036	$13,561	$5,144,604		*NPC 544 MW CC '36*
2037	$0	$5,370,742		
2038	$0	$5,619,706		
2039	$0	$5,854,178		
Sum	$12,315,208	$97,458,209		
NPV	$5,963,116	$34,262,770		

4. Plan 4

Table G-5. Annual Expenditures (thousands of 2008 dollars) under Plan 4

Year	Industry Output Increase for "Other New Construction" Sector	Industry Output Increase for "Power Generation and Supply" Sector	Units/Lines Starting Construction	Units/Lines Starting Operation
2010	$287,956	$1,659,603		E Nevada Microwave '10
2011	$223,870	$1,759,399		HACC 484 MW CC '11
2012	$406,185	$1,848,371	NPC 544 MW CC '15	RS to HA 500 kV Line W PS '12
2013	$340,836	$1,844,467		
2014	$824,719	$1,898,371	NPC 3x75 MW LMS100 '16, SPPC 2x75 MW LMS100 '16, NPC 544 MW CC '17	
2015	$812,630	$2,018,567	NPC 544 MW CC '18	NPC 544 MW CC '15
2016	$759,398	$2,157,387	SPPC 541 MW CC '19	NPC 3x75 MW LMS100 '16, SPPC 2x75 MW LMS100 '16
2017	$619,478	$2,344,308		NPC 544 MW CC '17
2018	$558,573	$2,361,028	NPC 6x75 MW LMS100 '20	NPC 544 MW CC '18
2019	$527,824	$2,459,013	NPC 544 MW CC '22	SPPC 541 MW CC '19
2020	$495,608	$2,341,191	SPPC 541 MW CC '23	NPC 6x75 MW LMS100 '20
2021	$605,917	$2,262,049		
2022	$558,573	$2,303,197	NPC 6x75 MW LMS100 '24	NPC 544 MW CC '22
2023	$643,214	$2,488,962	NPC 544 MW CC '26, SPPC 541 MW CC '26	SPPC 541 MW CC '23
2024	$832,068	$2,637,963	NPC 544 MW CC '27	NPC 6x75 MW LMS100 '24
2025	$875,374	$2,901,977		
2026	$296,578	$3,079,268		NPC 544 MW CC '26, SPPC 541 MW CC '26
2027	$128,952	$3,279,792	NPC 544 MW CC '30	NPC 544 MW CC '27
2028	$336,461	$3,504,240		
2029	$545,013	$3,725,624	NPC 6x75 MW LMS100 '31	
2030	$412,433	$3,889,954		NPC 544 MW CC '30
2031	$159,147	$4,091,547	NPC 544 MW CC '34	NPC 6x75 MW LMS100 '31
2032	$336,461	$4,343,351		
2033	$384,848	$4,547,096	NPC 544 MW CC '36	
2034	$350,021	$4,717,590		NPC 544 MW CC '34
2035	$269,457	$4,952,956		
2036	$13,561	$5,139,794		NPC 544 MW CC '36
2037	$0	$5,368,078		
2038	$0	$5,618,279		
2039	$0	$5,849,727		
Sum	$12,405,155	$97,393,147		
NPV	$6,031,785	$34,245,321		

C. Effects of Construction Expenditures

1. Effects of Construction Expenditures on Industry Value Added

Table G-6. Construction Effects on Industry Value Added (millions of 2008 dollars)

Expansion Plan	Direct Effect	Indirect Effect	Induced Effect	Total Effect
Plan 1	$2,775	$848	$993	$4,615
Plan 2	$2,973	$908	$1,063	$4,944
Plan 3	$2,973	$908	$1,063	$4,944
Plan 4	$3,007	$918	$1,076	$5,001

Note: All entries are present values for the period 2010-2039 (discounted at 8.67 percent nominal) as of January 1, 2009, in millions of 2008 dollars.

2. Effects of Construction Expenditures on Employment

Table G-7. Construction Effects on Employment (employee-years)

Expansion Plan	Direct Effect	Indirect Effect	Induced Effect	Total Effect
Plan 1	88,673	24,631	29,063	142,366
Plan 2	92,070	25,574	30,176	147,821
Plan 3	92,070	25,574	30,176	147,821
Plan 4	92,743	25,761	30,396	148,900

3. Effects of Construction Expenditures on Personal Labor Income

Table G-8. Construction Effects on Personal Labor Income (millions of 2008 dollars)

Expansion Plan	Direct Effect	Indirect Effect	Induced Effect	Total Effect
Plan 1	$2,572	$624	$555	$3,751
Plan 2	$2,755	$669	$594	$4,018
Plan 3	$2,755	$669	$594	$4,018
Plan 4	$2,787	$676	$601	$4,064

Note: All entries are present values for the period 2010-2039 (discounted at 8.67 percent nominal) as of January 1, 2009, in millions of 2008 dollars.

4. Effects of Construction Expenditures on State/Local Tax Revenues

Table G-9. Construction Effects on State/Local non-Education Tax Revenues (millions of 2008 dollars)

Expansion Plan	Labor Income and Enterprise Taxes	Household Taxes	Indirect Business Taxes	All Taxes
Plan 1	$27	$24	$185	$236
Plan 2	$29	$25	$198	$253
Plan 3	$29	$25	$198	$253
Plan 4	$29	$26	$200	$255

Note: All entries are present values for the period 2010-2039 (discounted at 8.67 percent nominal) as of January 1, 2009, in millions of 2008 dollars.

D. Effects of Operation Expenditures

1. Effects of Operation Expenditures on Industry Value Added

Table G-10. Operation Effects on Industry Value Added (millions of 2008 dollars)

Expansion Plan	Direct Effect	Indirect Effect	Induced Effect	Total Effect
Plan 1	$13,864	$1,337	$1,479	$16,680
Plan 2	$13,786	$1,329	$1,471	$16,585
Plan 3	$13,774	$1,328	$1,469	$16,571
Plan 4	$13,767	$1,327	$1,469	$16,563

Note: All entries are present values for the period 2010-2039 (discounted at 8.67 percent nominal) as of January 1, 2009, in millions of 2008 dollars.

2. Effects of Operation Expenditures on Employment

Table G-11. Operation Effects on Employment (employee-years)

Expansion Plan	Direct Effect	Indirect Effect	Induced Effect	Total Effect
Plan 1	86,383	49,056	57,846	193,285
Plan 2	85,856	48,757	57,494	192,107
Plan 3	85,768	48,707	57,434	191,909
Plan 4	85,711	48,675	57,396	191,781

Note: All entries are present values for the period 2010-2039 (discounted at 8.67 percent nominal) as of January 1, 2009, in millions of 2008 dollars.

3. Effects of Operation Expenditures on Personal Labor Income

Table G-12. Operation Effects on Personal Labor Income (millions of 2008 dollars)

Expansion Plan	Direct Effect	Indirect Effect	Induced Effect	Total Effect
Plan 1	$3,868	$910	$826	$5,605
Plan 2	$3,846	$905	$822	$5,573
Plan 3	$3,843	$904	$821	$5,568
Plan 4	$3,841	$904	$821	$5,565

Note: All entries are present values for the period 2010-2039 (discounted at 8.67 percent nominal) as of January 1, 2009, in millions of 2008 dollars.

4. Effects of Operation Expenditures on State/Local Tax Revenues

Table G-13. Operation Effects on State/Local non-Education Tax Revenues (millions of 2008 dollars)

Expansion Plan	Labor Income and Enterprise Taxes	Household Taxes	Indirect Business Taxes	All Taxes
Plan 1	$222	$35	$2,285	$2,542
Plan 2	$221	$35	$2,272	$2,528
Plan 3	$221	$35	$2,270	$2,526
Plan 4	$221	$35	$2,269	$2,524

Note: All entries are present values for the period 2010-2039 (discounted at 8.67 percent nominal) as of January 1, 2009, in millions of 2008 dollars.

E. Effects of Combined Expenditures

1. Effects of Combined Expenditures on Industry Value Added

Table G-14. Combined Effects on Industry Value Added (millions of 2008 dollars)

Expansion Plan	Direct Effect	Indirect Effect	Induced Effect	Total Effect
Plan 1	$16,639	$2,184	$2,472	$21,295
Plan 2	$16,759	$2,237	$2,534	$21,529
Plan 3	$16,747	$2,236	$2,533	$21,516
Plan 4	$16,774	$2,246	$2,544	$21,564

Note: All entries are present values for the period 2010-2039 (discounted at 8.67 percent nominal) as of January 1, 2009, in millions of 2008 dollars.

2. Effects of Combined Expenditures on Employment

Table G-15. Combined Effects on Employment (employee-years)

Expansion Plan	Direct Effect	Indirect Effect	Induced Effect	Total Effect
Plan 1	175,056	73,687	86,909	335,651
Plan 2	177,927	74,332	87,670	339,928
Plan 3	177,838	74,281	87,610	339,730
Plan 4	178,453	74,436	87,792	340,682

3. Effects of Combined Expenditures on Personal Labor Income

Table G-16. Combined Effects on Personal Labor Income (millions of 2008 dollars)

Expansion Plan	Direct Effect	Indirect Effect	Induced Effect	Total Effect
Plan 1	$6,440	$1,534	$1,381	$9,356
Plan 2	$6,601	$1,574	$1,416	$9,591
Plan 3	$6,598	$1,573	$1,415	$9,586
Plan 4	$6,628	$1,580	$1,422	$9,630

Note: All entries are present values for the period 2010-2039 (discounted at 8.67 percent nominal) as of January 1, 2009, in millions of 2008 dollars.

4. Effects of Combined Expenditures on State/Local Tax Revenues

Table G-17. Combined Effects on State/Local non-Education Tax Revenues (millions of 2008 dollars)

Expansion Plan	Labor Income and Enterprise Taxes	Household Taxes	Indirect Business Taxes	All Taxes
Plan 1	$250	$59	$2,469	$2,778
Plan 2	$250	$60	$2,470	$2,780
Plan 3	$250	$60	$2,468	$2,778
Plan 4	$250	$61	$2,469	$2,780

Note: All entries are present values for the period 2010-2039 (discounted at 8.67 percent nominal) as of January 1, 2009, in millions of 2008 dollars.

NERA
Economic Consulting

NERA Economic Consulting
200 Clarendon St, 11th Floor
Boston, Massachusetts 02116
Tel: +1 617 927 4500
Fax: +1 617 927 4501
www.nera.com