Least Cost Planning at the Margin: Externalities vs. Rate Impacts

Daniel Bloyer and Michael Bull, Bonneville Power Administration

Scenario analysis was performed as part of Bonneville Power Administration's (BPA) bi-annual electric resource planning process. The analysis was conducted to explore how effective different actions (strategies) would be in different operating environments (scenarios). The process began by using the EPRI CATALYST procedure to develop widely varied scenarios and resource strategies in an internal group process. Quantitative analysis using an integrated resource planning model was then used to test various levels of demand-side management and generation options (strategies) to arrive at estimates of short and long-term impacts on regional system cost and average electric rates across various scenarios. The results of the Scenario Analysis were compiled and evaluated based on the impacts on "societal cost" and electric rates. The results were used in Bonneville Power Administration's Draft 1992 Resource Program: Technical Report. This paper presents the findings of the Scenario Analysis, revealing, among other results, that conservation is a consistently attractive resource based on societal costs when environmental costs and policy credits are included. While average rates in the region are increased by more aggressive conservation acquisitions, the effects are offset by the externality benefits of cost-effective conservation acquisitions versus thermal resource acquisitions.

Introduction

Scenario planning has been used extensively to help utilities develop resource plans with sufficient flexibility to deal with an uncertain future. This method acknowledges the unpredictability of the future, then develops and rehearses various responses to change.

The possible approaches for conducting a scenario analysis differ greatly. Previous studies have varied in the number of scenarios examined, their reliance on planning models, and their measures of performance used to summarize each scenario.[1] The literature suggests that there is no single best way to conduct a scenario analysis.

Early in 1991 a group of managers from BPA discussed issues relating to the development of the 1992 Resource Program using scenario planning techniques. To assist the group in analyzing possible futures and strategies for BPA, the Planning staff used the CATALYST process from the Electric Power Research Institute (EPRI) as the framework for the discussions.[2] CATALYST is a structured method for a group process of creating and evaluating scenarios and strategies. Scenarios represent "external" factors which are beyond BPA's control that influence the success of possible resource acquisition strategies. Strategies represent different acquisition targets or methods of acquiring those resources. To explore the implications of these scenarios for BPA's 1992 Resource Program, analysis was subsequently conducted using the Resource Policy Screening Model hereafter called "The Screening Model."

The "Catalyst" Process

The BPA CATALYST group process involved four steps (1) discuss and select candidate strategies, (2) generate a limited set of challenging scenarios based on major uncertainties in the planning environment, (3) walk though each scenario for each strategy to identify impacts and likely reactions, and (4) reflect on what was learned when looking at all the results together.

Three "general" strategies were used to represent a range of resource preferences. They were (1) continuation of BPA's 1990 Resource Program with some updating for the Council's 1991 Northwest Power Plan, (2) a strategy with greater emphasis on conservation, and (3) a strategy with greater emphasis on new fossil fueled generating units. These strategies are called the High, Blitz and Moderate Conservation Strategies, respectively. The first strategy is labeled the "High Conservation Strategy" because conservation is the main resource to be acquired during the planning period. The second strategy is labeled the "Blitz Conservation Strategy" because the acquisition of conservation resources is accelerated beyond the already high levels planned in the first strategy. The third strategy is labeled the "Moderate Conservation Strategy" because it places less emphasis on conservation and a corresponding greater emphasis on thermal generating units fired by fossil fuels.

The group brainstormed a long list of uncertainties that BPA may confront over the next decade, including fuel prices and resource costs, viability of nuclear power plants, Investor Owned Utility (IOU) and Direct Service Industry (DSI) issues, California and Canadian issues, environmental constraints, resource performance, and legislative and regulatory changes. Key uncertainties including Economic Growth, Natural Gas Prices, Conservation Program Performance, Environmental Constraints on Hydro and New Renewable Technologies were selected as building blocks for scenarios. The scenarios were subsequently labeled (1) Base Case, (2) Base Case/Resource Change, (3) Demand Boom/ Resource Bust, (4) Demand Boom/Resource Change, (5) Demand Low/Resource Stable, and will be discussed in further detail later.

The next step was to follow up by analyzing the CATALYST scenarios and strategies using The Screening Model. Computer simulation models have been used in a variety of ways to aid previous scenario studies, and a review of the literature indicates that there is no standard approach. The spirit of our approach is to use computer simulation as an aid for planners who wish to "rehearse" their response under each scenario. We were particularly interested in how each rehearsed (or simulated) response would impact electric rates as well as total regional cost.

Model Description

The Screening Model (adapted from BPA's Conservation Policy Analysis Model with non-utility generation added) was used for the quantitative analysis of scenarios and strategies.[3] The Screening Model simulates the Pacific Northwest electric power system, including electric consumption, system expansion, system operation and ratemaking for the BPA with its public utility and DSI customers over a 20-year period. The model permits integrated analysis of energy supply and demand policy options with an especially detailed treatment of conservation and cogeneration.

Particular strengths of the Screening Model for scenario analysis include (1) it is an integrated model which tracks outcomes for decision variables constantly and consistently throughout the simulation period, (2) it simulates conservation and non-utility generation (e.g., private cogeneration) as responses to both market conditions (price induced) and utility incentive programs, (3) it allows scenarios to play out over time in order to rehearse how particular events unfold, and (4) it accounts for the particular customer groups (IOU's, DSI's and Public Utilities) so that individual impacts can be isolated. The model's weaknesses for performing scenario analysis are that it has only annual energy accounting, so it cannot monitor seasonal hydro-system operations, power marketing conditions or capacity limitations; and, it is not set up to automatically perform risk analysis or decision analysis over hundreds of scenarios.

The model requires explicit specification of each scenario and strategy, including, a forecast of economic activity, natural gas prices, regional power resource characteristics, forecasts of the worldwide price of aluminum, conservation supply curves, generating resource costs, and other data. Inclusion of end use detail and the explicit modeling of consumer behavior enable a wide range of demand side policy analyses. Conservation acquisitions and resources are treated as market responses rather than resources whose delivery a utility can guarantee precisely. While conservation programs offer incentives and specify which efficiency measures are eligible, it is the endogenous response to programs being offered that results in reduced loads. The Screening Model does not anticipate conservation savings when scheduling acquisition of new generating resources. Rather, it adjusts the forecast of resource needs only after the savings occur on the system. If resource requirements exceed what programs can deliver, the model automatically acquires generating resources, either by bidding or by building utility-owned generation. The response to utility requests for generating resources under bidding depends on the utility's avoided cost for generation and the quantity needed.

Scenario Analysis Methodology

The Screening Model was used to examine specific, fixed scenarios originating in the CATALYST process. For the purpose of this paper, only three of the five scenarios identified previously are presented. They include (1) the Base Case Scenario, (2) the Demand Boom/Resource Bust Scenario, and (3) the Demand Boom/Resource Change Scenario. The high economic growth scenarios were selected due to great interest in "rehearsing" a response to higher resource requirements. The scenarios were generated by specifying key drivers in the model provided in Table 1.

Scenarios. The <u>Base Case scenario</u> reflects widely held assumptions concerning trends in the region. The level of economic growth that drives the medium load forecast takes place, and regional conservation programs perform as anticipated. However, the hydro system's operation is

Table 1. Scenario Input Assumptions for the Screening Model

Assumptions	Base Case	Demand Boom/ Resource Bust	Demand Boom/ Resource Change
Economic Growth (real)	1.28% per year	2.47% per year	2.47% per year
Conservation Supply	Current Estimate	77% of Current est.	136% of current est.
Gas Price Escalation (real)	+3.1% per year	+5.3% per year	+0.0% per year
Gas Supply Limit	3 GW	1.5 GW	4.5 GW
Hydro Constraints			
- Dry	-1.0 aGW	-2.0 aGW	-2.0 aGW
- Average	-0.2 aGW	-0.4 aGW	-0.4 aGW
- Wet	0 aGW	0 aGW	0 aGW
New Technology	+400 aMW	0 aMW	+400 aMW

reduced somewhat due to environmental constraints. New technologies, represented by renewables in the model, expand the portfolio of resources available at less than 35 mills/kWh.

Both BPA and the Council expect natural gas supplies for the region to be limited. Consequently an overall limit on new gas availability is imposed. When the gas limit for the region is reached, the avoided cost (based on a coal-fired plant) for utility generation rises, increasing the available supply of cogeneration (non-gas fueled) that bidders can provide. The price of natural gas used by generating resources is set at $2.09/MMBtu in 1991 and escalates 3.1% above inflation.

Under the Demand Boom/Resource Bust scenario, the price of natural gas rises at 5.3% above inflation, and supply is limited. Conservation programs do not perform as well as anticipated, suffering a 23% decrease in savings acquired for a given level of expenditures. Lastly, new technologies fail to provide low cost resources. This scenario tests the limits of the region's ability to cope with acquisition challenges.

Under the Demand Boom/Resource Change Scenario, assumptions concerning conservation program performance, gas supplies, and the development of new technologies are much more favorable than in the preceding cases. This scenario explores the extent to which attractive resource options can offset prolonged, high regional demand.

Strategies. The principal controls in the model to plan conservation acquisitions are incentive levels and budget limits. The response of end users to programs being offered influences what, if any, generation acquisitions the model must make to meet projected load growth. Only if the bidding process (acquisitions primarily from Non-Utility Generation) falls short of need, do utilities acquire their own generation. The model assumes both BPA and IOU planners adopt similar strategies for each scenario.

The results of each test strategy are compared to a Reference Strategy *for each scenario.* The Reference Strategy acquires utility generation resources only, with no non-utility generation or conservation, but is subject to the same economic growth, resource availability and resource cost assumptions.

The conservation goal in the High Conservation Strategy is about 1200 aMW of regional net savings by the year 2000 under the Base Case scenario. Incentives are set at 90% of measure cost in the residential and commercial sectors, and somewhat less (63%-82%) in the industrial and agricultural sectors. The annual spending limit for utility programs in existing residential and commercial buildings is $450 million. All conservation measures up to

56 mills/kWh (in 1990 dollars) are eligible for programs. The 56 mill cap applies to all strategies tested, and was based on the 1991 Council Plan limits.[4]

The conservation goal in the Blitz Conservation Strategy is about 1550 aMW of regional net savings by the year 2000 under Base Case assumptions. The objective is to acquire as much savings as possible, and the spending limit is effectively removed. Residential and commercial incentives remain at 90%, while the range of industrial and agricultural incentives is raised to 70-90%.

The Moderate Conservation Strategy targets more cost-effective measures by scaling back from the High Conservation Strategy. The conservation goal is about 600 aMW of regional net savings by the year 2000 under Base Case assumptions. The Screening Model will automatically represent the utilities effort to require more generating resources. This matches the CATALYST definition of a strategy that emphasizes more thermal resources at the onset. Lower incentives mean the end user bears a greater share of costs, so the market response will shrink the most where end-user payback periods are greatest (close to the 56 mill/kWh cap). Lower incentives also result in lower program participation rates. Incentives were reduced to 60% in the residential sector, 45%-60% in commercial, and 50%-65% in industrial and agriculture sectors. The spending limit that applies to existing residential and commercial buildings is set at $75 million. All the same measures are eligible, so programs operate across virtually all end-uses.

Finally a generation bidding strategy, labelled "NUG-Only" (Non-Utility Generation), was added for comparison purposes to focus in on this non-traditional resource. For this strategy no new conservation programs are launched beyond 1990, and all new resources are acquired through bidding. Non-Utility generation includes coal, gas-fired, renewable, and small generating power producers.

Adjustments to Resource Costs

A Northwest Power Act Credit for conservation and BPA estimated environmental costs were included in the total regional cost result for each strategy. The Northwest Power Act credit, as mandated by the Northwest Power Act of 1980, gives a ten percent credit to all regional conservation costs.[5] For the purpose of this analysis, the ten percent credit was applied to the sum total of utility and consumer expenditures on all purchased conservation measures. It is important to note that these expenditure totals include all financing costs for both the utilities and the program participants.

Environmental externalities are the economic costs and benefits not directly borne by the entity causing the environmental effect. BPA is required by the Northwest Power Act to include quantifiable environmental costs and benefits in determining a resources total system cost for BPA's planning and acquisition activities.[6] Draft environmental costs applied to regional costs for each strategy are provided in Table 2.

Results

The analytic results for the three scenarios are presented below. The scenarios are evaluated based on the impacts on total regional cost versus average electric rates. The Demand Boom/Resource Bust scenario represents a world of limited resources with higher prices, while the Demand Boom/Resource Change scenario represents a world of abundant resources at lower prices. The high demand scenarios are most interesting since planners face the greatest challenges in maintaining load/resource balance.

The two primary figures of merit used here to rehearse the different strategies are the discounted present value of total regional cost (societal cost) and regional average electric rates over the years 1990 - 2010. "Regional Costs" include all monetary costs incurred by utilities and consumers in the region. Regional costs are calculated by adding total utility revenues to the customers' annual spending on conservation. "Total Regional Costs" also include the Regional Power Act 10% conservation cost credit and the monitized effect of external impacts on the environment. Environmental costs (Table 2) are assigned to generation technologies in mills/kWh escalated at 1% real, accumulated over the course of the run and added to regional cost.[7]

The electric rate results represent the combined effect of regional rules on recovering a flow of nominal dollar expenditures by the utilities in the region. The rate impacts provided in Figures 1-3 are illustrative, and should be interpreted in relative terms rather than in absolute terms. The results in this study use existing methods (primarily capitalization of the costs) for recovering conservation costs, e.g., the costs for BPA's share are allocated across all of its electricity sales. Conservation acquisitions tend to increase electric rates since comparable costs are spread over smaller loads. However, another cost recovery method, such as an energy service charge on the savings, could yield different regional cost and electric rate results.

Base Case Scenario. Table 3 shows the total regional cost and rate impacts relative to the Reference Strategy

Table 2. Derived Environmental Cost Adjustments

Resource Type	(1990 mills/kWh)
Main Hydro	1.00
Small Hydro	2.00
Integrated Gasification Combined Cycle Coal	2.32
Natural Gas-fired Combined Cycle Turbine	1.60
Natural Gas-fired Simple Cycle Turbine	1.91
Natural Gas-fired Cogeneration	1.40
Biomass	4.69
Solid Waste	9.19
Renewables	0.50

These adjustments are subject to change based on an on-going review. The adjustments are BPA's Environmental Cost Adjustments for planning purposes released on June 25, 1991.

BPA's draft estimates of the quantifiable environmental externality costs focus on plant operations. The estimates include three airborne pollutants: (1) nitrogen oxides (NOx), (2) sulfur oxides (SOx), and (3) total suspended particulates (TSP).

for the Base Case scenario. Total Regional Costs, including the conservation credit and environmental costs, are lowest under the Moderate and High Conservation strategies. The Moderate and High Conservation strategies acquire resources at cost-effective levels, with moderate hydro system losses. The Blitz strategy is the least attractive, both in terms of the amount acquired and the level of utility and consumer payments; it is just too expensive for the circumstances.

The four test strategies in Figure 1 generate electricity rate trends that are similar in shape, and they contrast

Table 3. Regional Cost and Rate Impacts - Base Case Scenario (Billion 1990 $)

	Reference Strategy	NUG-Only Strategy	Moderate Conservation (High Gas) Strategy	High Conservation Strategy	Blitz Conservation Strategy
Regional Cost (monetary)	120.6	118.6	117.6	119.2	121.6
Regional Cost (% Benefit)		**1.7%**	**2.5%**	1.2%	-0.8%
Northwest Power Act Credit	-0.4	-0.4	-0.9	-2.5	-3.6
Environmental Cost	6.7	7.1	6.9	6.7	6.6
Total Regional Cost	126.9	125.3	123.6	123.4	124.6
Total Regional Cost (% Benefit)		1.3%	**2.6**	**2.8%**	1.8%
Regional Rates (% Benefit)		**2.2%**	**1.6%**	-2.7%	-6.2%

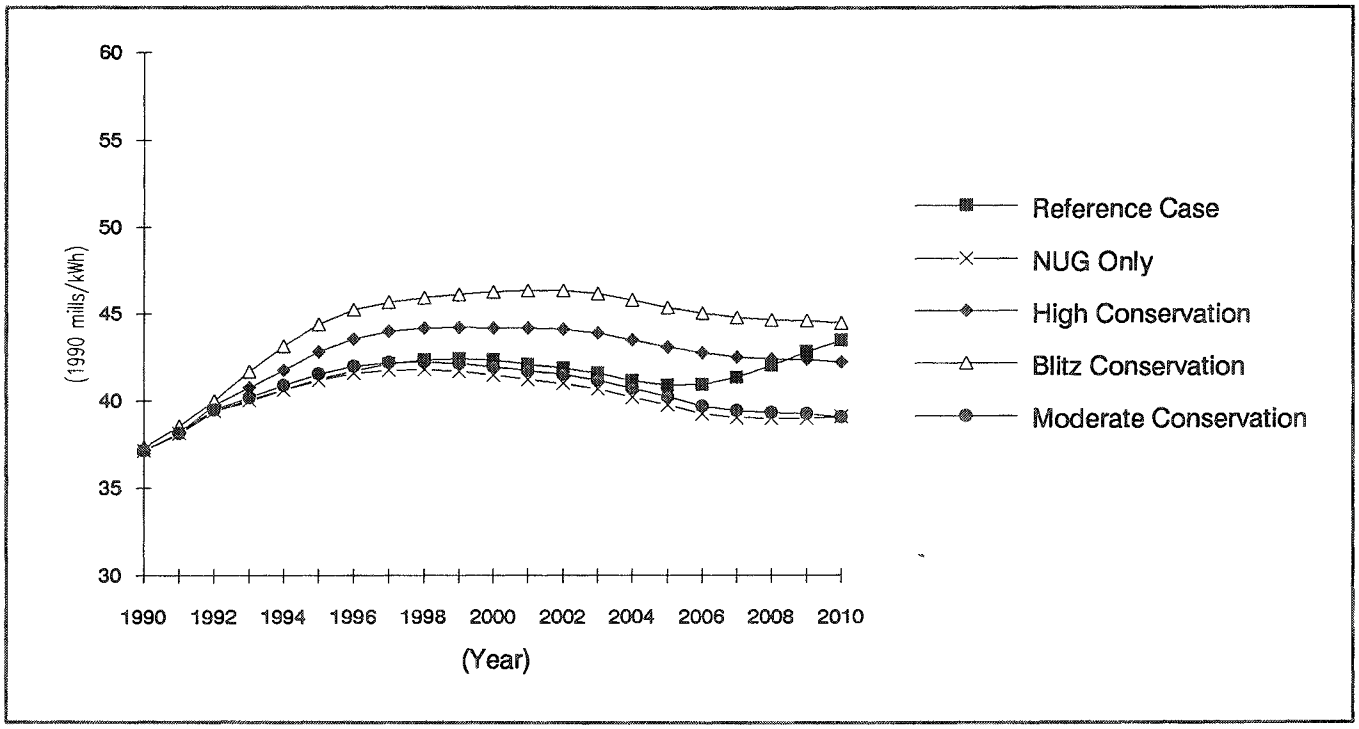

Figure 1. Average Regional Rates -- Base Case Scenario

with the Reference Strategy. The test strategies primarily acquire conservation and non-utility generation. The Reference Strategy primarily acquires utility generation. The Reference Strategy average electric rate starts increasing after 2005 due to increased construction of utility generation. The NUG-Only and Moderate Conservation strategies generate the lowest, and nearly identical rates through most of the period; the impact of conservation on rates is moderated due to its smaller size and modest incentive levels. The High Conservation and Blitz Conservation strategies generate higher rates throughout the period due to successively higher levels of spending on conservation and reduced rate base.

Demand Boom/Resource Bust Scenario. The Demand Boom/Resource Bust scenario was designed to place maximum stress on the electric supply system by combining high growth, low resource availability and high resource prices. Total Regional Cost impacts relative to the Reference strategy for the Demand Boom/Resource Bust scenario are provided in Table 4. Total Regional Costs are lowest under all three Conservation strategies due to the desperate need for resources. Environmental costs are high because of the resource constraints on both conservation and gas supply; the model must ultimately turn to coal. The Reference Strategy is severely constrained due to gas shortages and high gas prices.

Average regional rate results for the four test strategies the Reference strategy are shown in Figure 2. The rates for the NUG-Only and the Moderate Conservation strategies are virtually identical and again are the lowest. The rapid increase in rates under all strategies in the early part of the period is due in large part to the necessity of recovering from the severe hydro system loss and keeping up with the higher economic growth rate. The Reference strategy increases the most rapidly because gas supplies expire by about 1994 in this scenario, and the utilities proceed to acquire coal resources with relatively higher capital costs. In the four test strategies it is more common for NUG coal plants to be constructed and expensed, which has a more advantageous long-term impact on rates in this scenario. Rates in the Blitz and High Conservation strategies are higher due to the acquisition of large amounts of conservation at higher prices throughout the period.

Demand Boom/Resource Change Scenario. This scenario couples high growth, abundant resources and low resource prices. This tends to have the opposite effect in a high growth situation as the Demand Boom/Resource Bust scenario. Total Regional Cost results relative to the Reference strategy for the Demand Boom/Resource Changed scenario are provided in Table 5. More natural gas is available for non-utility generators in this scenario than in the Demand Boom/Resource Bust scenario. As a

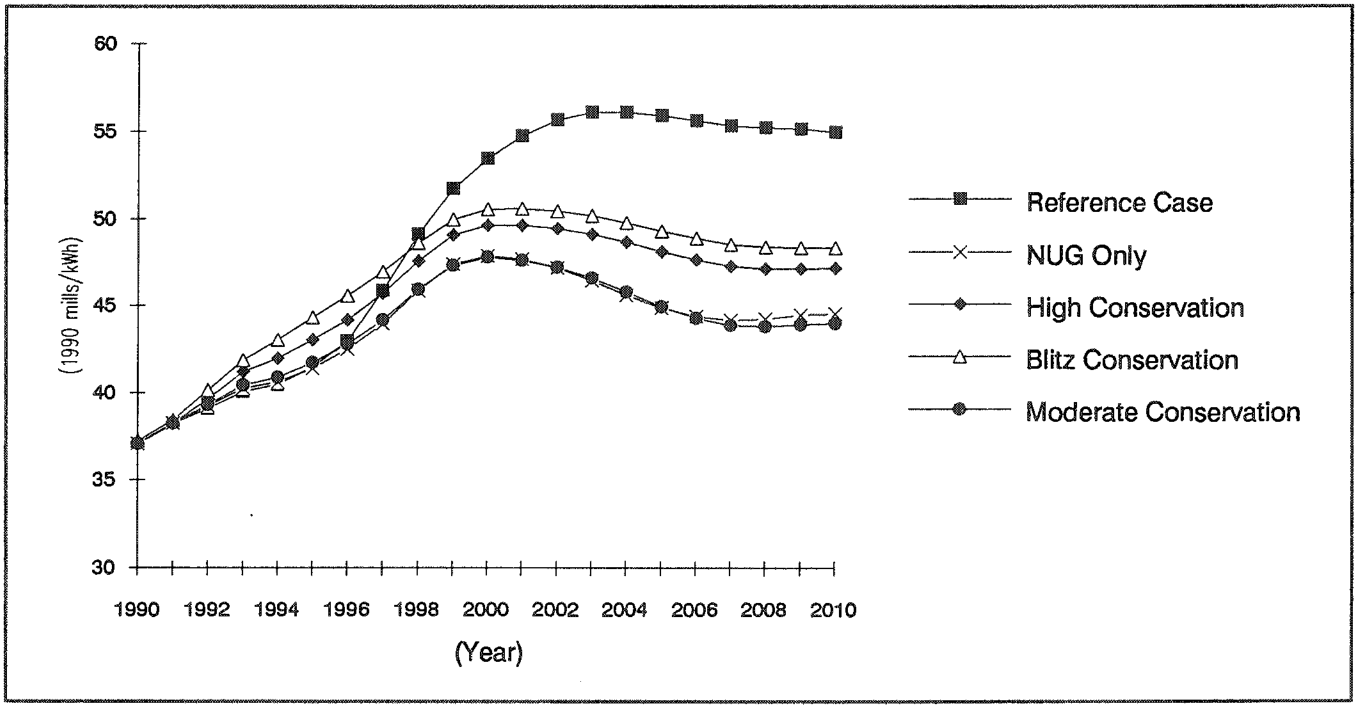

Figure 2. Average Regional Rates -- Demand Boom/Resource Bust Scenario

result environmental costs are lower for all conservation strategies than for the reference case. In addition, the environmental costs for the High and Blitz Conservation strategies are sufficiently low that these two plans result in the lowest total regional cost. The least desirable plan in terms of total regional cost reduction is the NUG-Only strategy. This is in part due to a windfall the region receives from the added availability of conservation and new technologies.

Average regional rate results for the four test strategies including the reference strategy are shown in Figure 3. The Reference strategy rates rise continually throughout the period. The NUG-Only and Moderate Conservation strategies both generate similar rate impacts and again are the lowest.

Table 4. Regional Cost and Rate Impacts - Demand Boom/Resource Bust Scenario (Billion 1990 $)

	Reference Strategy	NUG-Only Strategy	Moderate Conservation (High Gas) Strategy	High Conservation Strategy	Blitz Conservation Strategy
Regional Cost (monetary)	161.9	147.8	145.8	148.2	149.3
Regional Cost (% Benefit)		8.7%	9.9%	8.5%	7.8%
Northwest Power Act Credit	-0.7	-0.6	-1.3	-3.4	-4.4
Environmental Cost	9.3	9.8	9.5	9.1	8.9
Total Regional Cost	170.5	157.0	154.0	153.9	153.8
Total Regional Cost (% Benefit)		7.9%	9.7%	9.7%	9.8%
Regional Rates (% Benefit)		9.6%	9.6%	6.1%	4.4%

Table 5. Regional Cost and Rate Impacts - Demand Boom/Resource Change Scenario (Billion 1990 $)

	Reference Strategy	NUG-Only Strategy	Moderate Conservation (High Gas) Strategy	High Conservation Strategy	Blitz Conservation Strategy
Regional Cost (monetary)	147.0	138.5	135.2	135.9	137.5
Regional Cost (% Benefit)		5.8%	**8.0%**	**7.6%**	6.5%
Northwest Power Act Credit	-0.5	-0.5	-1.3	-3.5	-4.6
Environmental Cost	7.5	7.5	7.1	6.7	6.6
Total Regional Cost	153.9	145.4	141.0	139.1	139.5
Total Regional Cost (% Benefit)		5.5%	8.4%	**9.6%**	**9.4%**
Regional Rates (% Benefit)		**6.9%**	**6.5%**	2.5%	-0.4%

These results are applicable to the single, fixed Base Case scenario. There is no accounting for how uncertainty in resource requirements and/or resource performance would affect the choice of a final strategy. For example, if one embarked on the Moderate Conservation strategy, it could look timid or extravagant later depending on which scenario unfolded. This is one of the limitations of scenario analysis which seeks to explore and rehearse a limited set of scenarios as contrasted with decision analysis which applies probabilities and tests fixed short term resource decisions. The key in doing scenario analysis is to discern common themes or lessons across a wide variety of futures.

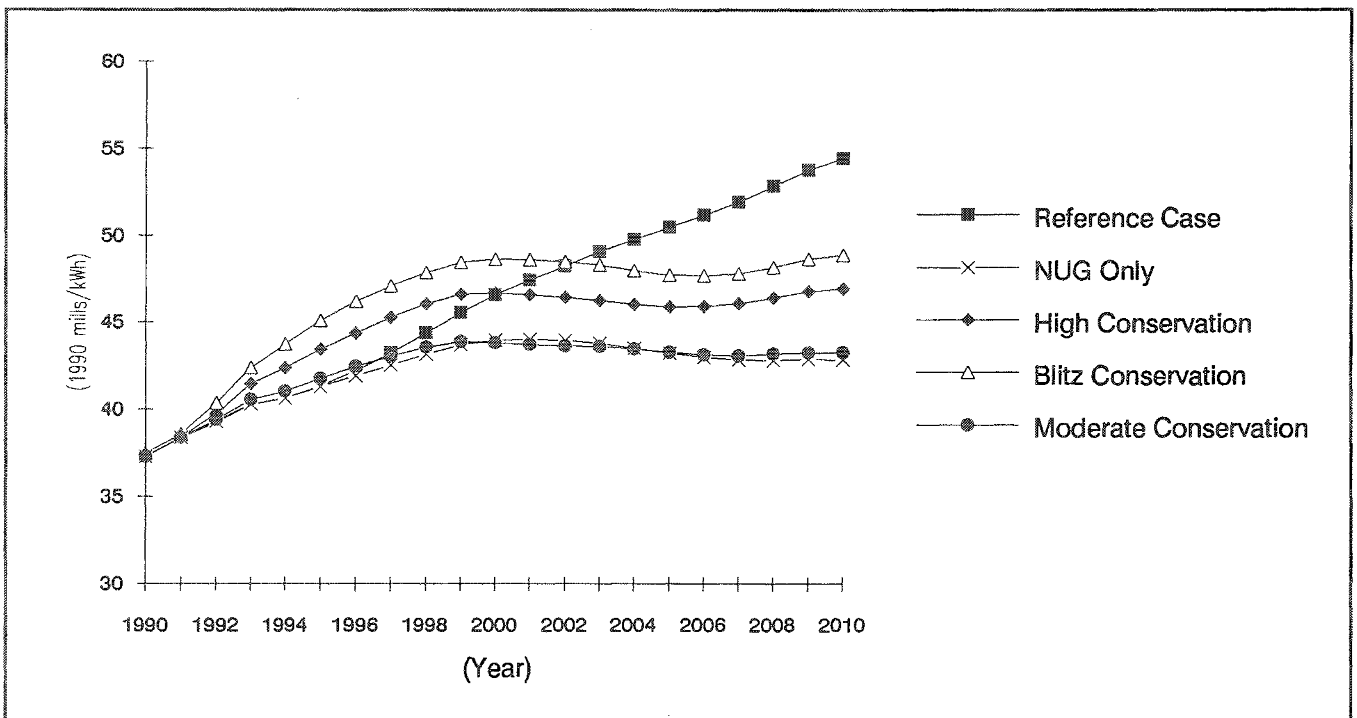

Figure 3. Average Regional Rates -- Demand Boom/Resource Change Scenario

Conclusion

The results of the quantitative analysis using The Screening Model illustrates the increasing electric rate impacts of more aggressive conservation. However, when environmental costs and policy credits are included in a total regional cost figure of merit, a clear shift in attractiveness from thermal to conservation resources appears. Total regional cost results from the Base Case Scenario reflect a shift in attractiveness from the NUG-Only and Moderate Conservation Strategies to the Moderate and High Conservation Strategies. The Demand Boom/Resource Bust Scenario reflects similar results. The Demand Boom/Resource Change Scenario reflects a shift in attractiveness from the Moderate and High Conservation Strategies to the High, and very aggressive, Blitz Conservation Strategies based on total regional costs.

This study shows that while average rates in the region are increased by more aggressive conservation acquisitions, the effects are offset by the externality benefits of cost-effective conservation acquisitions versus thermal resource acquisitions.

The adverse rate impacts do not reflect the reduced electricity bill for conservation program participants. While consideration of this bill reduction would serve to offset the rate impacts of aggressive conservation, aggregating the bill reductions across the end use consumer base does not address the challenging reconciliation of the equity issue. However, the more comprehensive the conservation strategy is, the more the equity issue is mitigated by reducing everybody's bill. Also, only conventional (status quo) cost recovery methods are deployed in this analysis. Other recovery methods or rate rules could be tested using The Screening Model to rehearse similar impacts over various scenarios.

Acknowledgments

This project was conducted by the Policy Analysis Section, Resource Planning Division of the Bonneville Power Administration. We gratefully acknowledge Andrew Ford (University of Southern California) and Jay Geinzer (Applied Energy Services) for providing their modeling expertise and extensive labor spent on the Scenario Analysis project. We also wish to acknowledge Franklin Neubauer (Advanced Data Concepts) and Mike Cranna (Applied Energy Services) for their technical support involving The Screening Model. Also, thanks are extended to Wally Gibson and Pete Swartz (Northwest Power Planning Council) for their insights provided during the project.

Endnotes

1. A sample of previous scenario studies by author include (1) Northwest Power Planning Council, (2) Puget Sound Power and Light Company, (3) Peter Hadfield, (4) John Morecroft and Kees van der Heijden, (5) Southern California Edison Company, System Planning and Research, and (5) Peter Wack.

2. See "CATALYST: A Group Process For Strategic Decision Making, "Electric Power Research Institute, Draft: February 1992.

3. See Andrew Ford and Jay Geinzer, "The BPA Conservation Policy Analysis Models," U.S. DOE document no. BP-24760-1, Bonneville Power Administration, April 1986.

4. See the Northwest Power Planning Council's "1991 Northwest Conservation and Electric Power Plan," Volume II - Part II, April 1991, pp. 930-931.

5. See Section 3.(4)(D), "Pacific Northwest Electric Power Planning and Conservation Act with Index." U.S. DOE document no. BP-67, Bonneville Power Administration, December 1991.

6. See Section 3.(4)(B) of the Northwest Power Act.

7. The 1% real escalation is based on the forecast rate of population growth and serves as a reasonable proxy for the real damage expected to occur over time. See Shepard Buchanan and Elizabeth Bowers "Taking The Next Step: Integrating Environmental Costs Into Utility Resource Planning," paper presented at National Association of Regulatory Commissioners Conference on Integrated Resource Planning, Santa Fe, New Mexico, April 8-10, 1991, p. 6.

References

Bonneville Power Administration. December 1991. *Draft 1992 Resource Program: Technical Report*. DOE/BP-1727.

Bonneville Power Administration. December 1991. Pacific Northwest Electric Power Planning and Conservation Act with Index. DOE/BP-67, Eighth Printing.

Hadfield, Peter. October 1991. "Corporate Strategies for a Changing Environment." *Utilities Policy*.

Northwest Power Planning Council. April 1991. *1991 Northwest Conservation and Electric Power Plan.*

Puget Sound Power and Light Company. December 1989. *Demand and Resource Evaluation Project - Securing Future Opportunities 1990-1991.*

Morecroft, John and Heijden, Kees van der. October 1990. *Modeling the Oil Producers: Capturing Oil Industry Knowledge in a Behavioral Simulation Model.* Available from John Morecroft, London Business School, Regent's Park, London NW1 4SA, United Kingdom.

Southern California Edison Company. March 1988. *System Planning and Research - Strategies for an Uncertain Future.*

Wack, Peter. September-October 1985. "Scenarios: Uncharted Waters Ahead" *Harvard Business Review.*