BONNEVILLE'S CONSERVATION POLICY ANALYSIS MODEL

Mike Bull and Patrick Barton
Bonneville Power Administration

ABSTRACT

In 1980 the U.S. Congress mandated that the Bonneville Power Administration use conservation as the first priority resource to meet its load obligations. As Bonneville began to address this challenge, it lacked the tools to easily and accurately analyze the system-wide impacts of the many conservation policy options available to it. In 1983 Bonneville began the development of the Conservation Policy Analysis Model (CPAM). The model features full representation of the major components of the electric power system of the Pacific Northwest and treats conservation programs and policies as simulated market responses by using simplified end use modeling. This paper discusses the important attributes of strategic policy analysis tools for conservation in general along with Bonneville's experience with the CPAM effort. Selected policy analysis results and observations and conclusions on future directions for strategic conservation modeling follow the general discussion.

BONNEVILLE'S CONSERVATION POLICY ANALYSIS MODEL

Mike Bull and Patrick Barton
Bonneville Power Administration

INTRODUCTION

The 1980's have been a time of substantial change in resource planning for the electric utility sector. Construction of conventional large generating power plants has often outpaced the need for them as higher electricity prices have caused diminishing load growth rates. Also, the advent of special considerations for energy conservation and decentralized power plants has created new viable options for long range resource planning.

The passage of the Pacific Northwest Electric Conservation and Power Planning Act of 1980 (Regional Power Act) made the Bonneville Power Administration (Bonneville) responsible for serving the electric power needs of the Pacific Northwest.[1] It granted conservation and renewable resources preferred status for resource planning and acquisition. As a result, Bonneville's strategic planners needed to understand conservation and its contribution to the future resource development for the region earlier than much of the nation. We had to learn how to plan for conservation as a competitor to generating resources and to consider it as a resource to be purchased from the consuming public or as a mandated efficiency standard.[2]

Conservation is a unique resource, particularly in a utility planning framework. Part of the analytical challenge lies in understanding the many ways generating and conservation resources differ. First, conservation is relatively new as a resource for utility planning, and data on its availability and reliability as a resource is needed for it to be a credible resource. Historically, the only information about its availability was embedded in the utility load forecasting estimates of price elasticity effects. Second, conservation produces savings on a "pay as you go" basis, while generating resources are rolled into the system as a lump upon completion. If the decision is made to cancel a program before it is finished, benefits may still accrue from the conservation which has already been completed. Third, conservation is relatively divisible, and implementation can begin to produce savings quickly. Conventional large generating resources can cost billions of dollars and can take more than a decade to come on line. Fourth, conservation produces different fiscal and rate impacts. Large generating plant costs are often accumulated over many years until the plant is on-line, and hit the rate base with a shock. Conservation starts coming "on-line" immediately, and costs show up through gradual rate increases.

Utility conservation programs can also differ substantially from one another. Differences arise in timing, cost, targeted consumer groups, levels of financial incentives, use of mandatory efficiency standards, program financing, magnitude of consumer participation, distribution of benefits, etc. These differences can be key when considering what role conservation plays in the utility's strategic planning. From a resource planning perspective, conservation programs need to be conceived, implemented and realized in a manner consistent with existing trends in load growth, existing and planned generating resources, and the fiscal goals of the utility.[3]

The complexity of the utility system, along with conservation options, can overwhelm the capability of planners to effectively evaluate resource options. The balance of this paper discusses (1) the difficult conservation policy questions which confront utility resource planners, (2) what the important attributes of conservation policy analysis tools are, (3) how these planning complexities were addressed at Bonneville through development of a strategic conservation planning model, and (4) how our model has proven useful in evaluating the conservation agenda for the Pacific Northwest.

QUESTIONS YOU WERE AFRAID TO BE ASKED

Conservation policy analysis is complex partially because it is not a conventional resource for traditional utility planning. Matters related to conservation programs must be judged against conventional generating resources, established system operations and given ratemaking practices. Conservation itself may be seen as a loss of load or revenues, completely counter to traditional utility goals. Three of the most interesting and challenging questions facing utility conservation planners are:

1. How much conservation is there, and what will it cost?

Conservation is a multi-faceted and complex resource. It permeates the market place, and takes on a variety of forms in each economic sector. How much is there? How can it be measured? How does one know how much it will cost, and how quickly it can be available?

2. How much conservation do you buy and when?

Like many utilities in the United States, those in the Pacific Northwest currently face a surplus of generating capacity. The region does not need additional capacity on-line until some time in the mid-1990's. Why should a utility make the capital outlays, operate the programs and support the staff necessary to develop conservation at this time? But, on the other hand, if you don't start now, when should you start and how fast should you go?

3. Who pays for conservation?

Conservation programs affect many parties in many different ways. The potential winners and losers include the utility, the program participants, the non-participants, and the taxpayers. The benefits and costs fall differently on these groups depending on the particular program adopted.[4] How does one separate the effects on these groups and test equity considerations?

There are also corollary issues beyond these three, such as lost revenue effects, resource reliability, equity issues, effectiveness of program incentives, and program selection. However, these three are the principal ones that all conservation planners face within a utility planning environment.

DESIRABLE ATTRIBUTES FOR A STRATEGIC CONSERVATION PLANNING MODEL

Bonneville decided early on that it needed a mathematical model to help answer these questions. In order to be useful, the model would have features often lacking in conventional corporate utility models, e.g., capacity expansion planning models or load forecasting models. Some of the most important attributes for a strategic conservation planning model would be:

1. Reflect "real-world" conservation potential.

There should be a physical accounting for the conservation available during the planning period and how its development can be influenced by utility programs or policies. It is important that conservation resource assessments be concrete and well-documented and that policy models reflect these "real world" assessments.

2. Reflect financial impact on the utility through time.

Utilities, whether public or private, must concentrate on the bottom line financial impact of any resource decision. The financial condition of the utility affects the competitiveness of its product, the public perception of the quality of service received and the competitiveness of its service territory. Also, since conservation resources impact rates and revenue requirements uniquely, it is important to have a complete representation of its financial effects vis-a-vis generating resources.

3. Reflect the economic impact on all of society.

Utility policy should support resource decisions which are economically efficient for the service area as a whole. One of the principal bases for viewing conservation as a resource is that it produces benefits for both consumers and the system. The model should be able to demonstrate how the utility's action helps to promote economic efficiency in the marketplace by minimizing total energy service costs.[5]

4. Facilitate the analysis of alternative conservation policies and programs.

Instead of treating conservation as a lump, it is important to disaggregate down to major program elements. These elements may include targetted sectors, e.g., old versus new buildings or residential versus commercial sector, etc. With this disaggregation, alternative programs can be compared objectively.

5. Reflect consumer energy decisions with and without conservation programs.

Engineering and programmatic estimates of conservation potential or program savings can easily ignore the effect of program incentives in the marketplace. By modeling consumer energy usage and conservation investment decisions with and without utility programs, both the gross and net effects of a utility's program efforts can be projected.

6. Reflect alternative generation resource availability.

In order to establish conservation as a competitive resource for utility planning, its performance should be judged by the same criteria as alternative generation resources. Also an adequate representation is needed of the diversity in the availability and cost of all major competing generating resources.

7. Mimic conventional load growth scenarios, system operation characteristics and capacity expansion planning logic.

All utilities have conventional system planning tools. Typically, these tools were created before conservation came to be seen as a resource, and they represent the utility's view of the planning environment. A credible conservation planning model must reflect the conventional logic embodied in load forecasting, dispatching, capacity expansion and other utility models.

8. Simplicity, without being trivial.

There are three important reasons for model simplicity. First, a simple conceptual design will help in convincing conservation decision makers, as well as non-conservation modeling experts, that the model logic and results are plausible and prudent. Second, most utility conservation staff members do not have the time to work as full-time modelers, and ease of model use and maintenance is critical to the model being both useful and current with changing planning assumptions and data inputs. Finally, fast turnaround is a key to access to decision makers and decision making.

Bonneville's model also needed the ability to support enough region-specific content to accurately reflect the impact of conservation projects on the rest of system. For instance, the model had to represent individual customer groups, load uncertainty, and dispatching problems unique to large hydro systems. Also Regional Power Act considerations needed to be reflected. Finally, there had to be enough "switches" to enable model support staff to change assumptions about exogenous policy inputs, e.g., completion dates of partially completed generation plants, quickly and accurately.

THE BONNEVILLE CONSERVATION POLICY ANALYSIS MODEL (CPAM)

The Conservation Policy Analysis Model is a computer simulation model used by the Office of Conservation to evaluate the effects of conservation policies and programs on the operation of the regional electrical system and system expansion decisions.[6,7] The model gives the Bonneville a policy screening tool for testing many conservation policy scenarios. These scenarios include changes in conservation program incentive levels, incentive designs, program timing, and sectoral strategies. It also has the ability to represent mandatory efficiency standards for new construction and electric equipment. All of these need to be tested for their effects on conservation savings, utility and consumer budgets, regional resource requirements, rate impacts, and system operations.

Structurally the model is straightforward. It has a complete, though greatly simplified, representation of the regional electrical supply system and sufficient logic to reflect electrical load growth. It includes the power planning modules (in Figure I, the Capacity Expansion Planning, Capacity and Asset Accumulation, Price Regulation and Construction Financing, and Hydro-Thermal System Operation), so it can mimic the purchase of generating resources to meet loads, operate the system, keep track of the assets the region acquires and the liabilities incurred, set the rates and collect the revenues to pay the bills. Because it is an integrated model, these rates also affect the level of loads for the next period.[8]

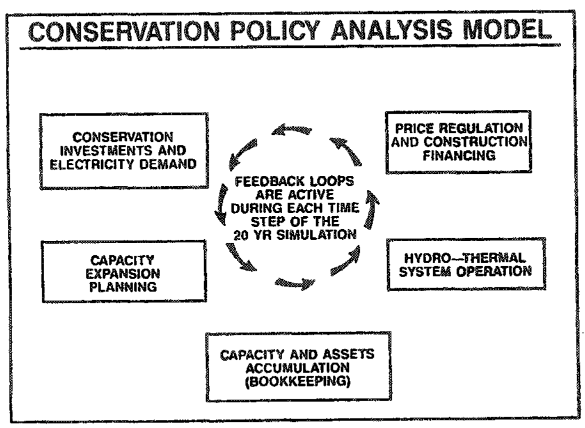

Figure I. CPAM Components.

CPAM's structure simplifies user inputs and provides a choice of outputs. Data regarding the costs and availability of conservation savings is provided with supply curves, which are discussed in the next section. Output is available to analysts with simple, interactive commands which allow construction of formatted, run-specific data tables in real time. CPAM monitors key policy variables throughout the simulation, thus analysts have access to their behavior over time. The following sections discuss the underlying structure of CPAM and policy analysis results from the Regional CPAM (single utility version) and the Subregional CPAM (where Bonneville's customer groups are broken out).

QUANTIFICATION OF CONSERVATION - SUPPLY CURVES

Supply curves embody engineering and empirical data relating energy savings to the costs of various conservation measures.[9] This information is gathered through end use surveys, billing information, program evaluation, engineering calculations and actual metering of energy uses. The information is used to determine building prototypes, feasible measures and measure saturations, physical barriers to measure installation, measure lives, market penetration rates and maximum saturation levels. With projections of building stocks from the Bonneville load forecast, cost and savings estimates are aggregated into technical potential supply curves by sector and end use.

The incremental costs and savings from each measure are ordered from the least expensive to the most expensive. Within CPAM consumers make economically rational decisions, and they purchase conservation measures until the cost of the next incremental measure equals the value they place on the savings associated with that measure. Since CPAM is an integrated, dynamic model, the optimum level of conservation savings changes as conditions change, e.g., electricity prices, financial incentives, or mandatory efficiency standards. CPAM uses supply curves in its inner working to determine loads, conservation investments, conservation savings and costs, fuel switching and behavioral savings. The curves are used as table look-up functions. At any level of conservation investment, one can determine from the supply curve the amount of savings available in each sector, or at any retail rate one can look up the level of conservation which the consuming group would like to achieve.

HOW MUCH TO BUY AND WHEN - REGIONAL MODEL RESULTS

In 1985 Bonneville used CPAM to analyze a variety of conservation strategies in order to select a diverse set of strategies for use in its annual resource planning process.[10] When used in this way, the CPAM becomes a screening tool to select the most promising conservation strategies for analysis in the larger corporate models. In 1985 CPAM was used to generate savings targets by sector, given different combinations of conservation policies for different time periods through the 20 year planning period.

In considering alternative strategies for resource acquisition planning Bonneville uses multiple criteria to judge which is best.[11,12] The first criteria, Minimizing Energy Service Cost, evaluates whether the region is investing its money in those resources that will provide energy services, e.g., heat, light, and machine operation, for the least economic cost. The second goal, Minimizing Cost to the Utility, examines the financial burden on the utility given different programs. Finally, the goal of Minimizing Bonneville Rates addresses the concern of assuring Bonneville customers the best value for their energy dollar and providing equitable treatment for those not participating in conservation programs.

Sometimes desirable goals come into conflict. For example, we found that when conservation is acquired, progress is made toward the goal of minimizing utility costs. However, conservation may work simultaneously against the goal of rate minimization in the short term. At current rates a decrease in utility revenues may result in a rate increase to cover expenses. The magnitude of the rate increase will be a function of the value of displaced generating resources or increased sales. Because the Pacific Northwest is currently in surplus, conservation programs tend to raise rates modestly in the near term. These goals also can come into conflict on ratepayer equity issues. For instance, many programs prove beneficial to the region as a whole since relatively expensive generation is displaced. However, some individual ratepayers can be worse off if they cannot or do not participate in utility programs.

Table I shows representative model results from the CPAM screening process. Results are based on Bonneville's medium load forecast. The strategies included span the range of activity from minimum (strategy "G") and conservation in new structures only (strategy "F") to cost sharing incentive levels of 90% in all sectors (strategy "A"). Strategy (A) has the worst one-year rate penalty, but it provides the largest benefits to the region and to the utility over the forecast period. Strategy (F) generates a higher rate impact than either of strategies (C) or (E) while providing less benefits. This phenomena occurs because conservation resources are available at lower unit cost than generating resources. Higher strategies tap relatively more of this potential during the planning period.

Table I. Impacts of Alternative Conservation Strategies

Strategies	(A)	(B)	(C)	(D)	(E)	(F)	(G)
Utility Incentives							
Residential							
New	90%	75%	75%	75%	75%	75%	-
Existing	90%	75%	75%	75%	50%	-	-
Commercial							
New	90%	75%	75%	75%	75%	75%	-
Existing	90%	75%	50%	-	50%	-	-
Industrial							
New	90%	75%	50%	-	50%	-	-
Existing	90%	75%	50%	-	50%	-	-
Results							
Utility Conservation Spending over 20 Years (85 \$, 10^9)	\$4.2	\$2.7	\$2.0	\$1.8	\$1.6	\$1.3	\$0.8
Utility Spending per Net Ave. KW Saved (85 \$, 10^3)	\$3.3	\$2.7	\$2.5	\$3.1	\$2.3	\$3.6	-
Average Rate Penalty (mills/kwh, 85\$)	0.2	0.0	0.0	0.1	0.0	0.0	-
Worst Year Rate Penalty (mills/kwh, 85\$)	0.9	0.5	0.3	0.2	0.2	0.1	-
Regional Benefit (NPV) (85 \$, 10^9)	\$1.2	\$0.8	\$0.6	\$0.3	\$0.4	\$0.1	-

One of the issues raised for the analysis is whether to do conservation in a surplus. Our analysis indicated that Bonneville may do well to begin programs in a surplus. Conservation in a surplus period makes sense because it allows the region to accumulate enough savings to defer construction of the more expensive generating plants (required when the system goes deficit), and reduce current operating costs or increase power exports in the near term. Some benefits accrue from starting any of the strategies immediately. Other model runs indicate that if program implementation were delayed for 5 years, followed by the most aggressive strategy, additional benefits would be minimal and utility cost would be high. Further, the prospect of shutting off programs and then turning them back on aggressively 5 years later was deemed unrealistic from a program delivery standpoint. The ultimate policy decision was to proceed to implement conservation programs at the Medium to Medium-High levels, trading off the regional benefits against the rate penalties.

WHO SHOULD PAY - SUBREGIONAL MODEL RESULTS

CPAM can also be used to examine program design issues as they relate to broad impacts on the system. Late in 1985 a question came up about how much of a program financial incentive Bonneville should pay in utility service territories who do not place load requirements on Bonneville. Due to the unique ratemaking structure for Bonneville wholesale power, we needed to determine the financial benefit received by current Bonneville customers from conservation resources acquired by potential Bonneville customers. During 1985, CPAM was disaggregated to portray the three major customer groups individually, i.e., the public utilities, the private, investor-owned utilities (IOUs) and the direct service customers (mainly aluminum smelters) which purchase their power directly from Bonneville.

Bonneville has a different relationship with each of these customer groups, both historically and due to changes embodied in the Regional Power Act. Three factors are important: (1) all Northwest utilities can rely on Bonneville for their load growth requirements by giving 7 years notice before placing a load on the system; (2) all the residential and rural customers of every Northwest utility have rights to the cheapest firm power pool rate through the residential and rural exchange provisions of the Regional Power Act (Bonneville exchanges power at the utility's average system cost); and (3) IOU's must pay a melded new resources rate for non-residential loads put on Bonneville. The situation is further complicated by the fact that Bonneville does not know how much load will be placed on the system beyond 7 years, or whether or not utilities will exchange loads. This complex ratemaking situation makes it difficult to assess the relative benefit to the Bonneville system for conservation on IOU loads.

Therefore, a disaggregated system-level model was needed. An analysis conducted in the Spring of 1986 using the Subregional Model considered the financial impacts on Bonneville relative to those on the investor owned utilities of early conservation savings on IOU loads. We used CPAM to simulate the financial impacts of an advancement of new home efficiency improvements to 1986 rather than 1989. The 1985 Bonneville medium load forecast was used as the basis for the analysis. The period of study was set to 1986-2005. The savings achieved were modeled as a 100% effective code within the IOU service territory. No utility cost was associated with the savings since the goal was to calculate only the relative financial benefit to Bonneville and the IOUs. The IOUs were represented as a single entity, and no geographical or climate area breakdowns are represented. Sensitivity analysis was performed on the assumption of IOU load placement on Bonneville in the long term: (1) no load placement (0%); (2) Bonneville provides 50% of the new resources to serve IOU deficits; and (3) 100% reliance on Bonneville to meet IOU new resource requirements.

The model was run twice for each load placement assumption. The base case run assumed the code for the IOU service territory began in 1989. The test case then assumed the code began in 1986. The difference in IOU loads and the net present value of future Bonneville and IOU revenue requirements were used as the primary indicators of impacts. Table II presents the results.

Table II. Benefits of Conservation on IOU Exchange Loads

IOU Deficits Placement	0%	50%	100%
Reduction of PV of Bonneville Rev. Req.	$43 M	$83 M	$135 M
Reduction of PV of IOU Rev. Req.	$154 M	$136 M	$121 M
Bonneville % of Total	22%	38%	53%

As the IOUs place load on Bonneville, Bonneville benefits from the early conservation in two ways. First, less residential load is exchanged, so Bonneville saves the difference between the average system cost of the IOUs and its priority firm power rate on each kilowatt-hour saved. Second, since the IOUs are not building their own new, expensive resources, their average system cost and the cost of each unit exchanged is lower over the long term. The IOUs benefit because they build less capacity and avoid the costs and risks of large, capital-intensive construction ventures.

The magnitude of the benefits of advancing construction standards varies with the extent to which IOUs place load on BPA. The shift in relative benefits toward Bonneville from higher IOU load placement is due to (1) the reduced cost of the exchange due to lower average system costs for the IOUs, and (2) higher avoided costs for Bonneville from the additional generating resources needed to serve the larger system load. The opposite is true for the IOU customer group. The ultimate policy decision was to make the conservative judgment that 25% of the benefits would accrue to the Bonneville system, and a program cost sharing offer was extended to the IOUs on that basis.

WHAT CPAM DOESN'T DO/IMPROVEMENTS

There are several areas of potential and planned improvements for CPAM. Improvements which will command the most immediate attention include:

1. System Uncertainty - We have used "best case-worst case" analysis to portray the range of possible impacts of alternative conservation policies in face of the region's system uncertainties. The computational requirements for simulating various system uncertainties stochastically is burdensome, but we plan to experiment with ways to automate such a process. While CPAM is capable of stochastic analysis, its limited representation of the system makes the benefits uncertain.

2. Vintaging - CPAM performs its calculations with a average consumer calculation by sector and end use. We now intend to separate program participant and non-participant behavior to facilitate improved monitoring of program budgets and penetration. We will also experiment with the representation of different penetration behavior through time for each group. The prospect for accurately tracking buildings and energy-using equipment by the year in which it was built will probably have to wait until we have a computer language capable of handling extensive data base processing.

3. Micro-computer Implementation - Conversion to a micro-computer would make the model much more accessible to interested technical parties and demystify it for planners within Bonneville. People could learn how to use the model to explore their own assumptions on individual basis. We hope to use a new personal computer based DYNAMO compiler with CPAM this fall.

Although the ideal model would reflect the improvements listed below, we currently have no plans to implement them in CPAM. These include:

1. Representing Each Individual Utility - There is a great deal of diversity among the individual utilities comprising Bonneville's major customer groups. Although it is desirable to be able to portray the role that individual customers play in system planning, it would be a tremendous analytical and calculation burden to expand the model to include individual utilities. CPAM would lose much of its speed, simplicity, and ease of use and maintenance. Further, it would also detract from the strategic planning focus of CPAM's design.

2. Representing Seasonality and Capacity Benefits of Conservation - There is a great deal of diversity among the individual conservation measures and their effects on the Bonneville system capacity requirements. Although it is desirable to be able to portray the role that individual measures play in system planning, the sacrifices necessary to incorporate this detail are prohibitive. So far, experience indicates that when Bonneville acquires resources to meet its energy needs, sufficient additional capacity is simultaneously added to forestall any foreseeable

shortages. Ideally, Bonneville would utilize conservation in its overall demand side management strategies, but so far efforts have been limited to evaluating individual projects independently.

3. Integrated Economic Forecasting - CPAM does not provide an economic forecast for the region; it merely takes the load forecast activity levels and demonstrates the cumulative effects of conservation policies on them. Although the model can be manipulated to show the impacts of fast or slow growth on the system and on conservation decision-making, it does not have the capability for any internal integrated modeling of various economic growth scenarios, i.e., there is no endogenous economic base model.

4. Marketing Effects - A lot of work could be done to more accurately represent the effects of marketing (non-financial incentives) on consumer adoption rates. However, available research runs from the esoteric to the implausible. Best judgment is used in combination with survey and evaluation results as they become available. In the meantime, it is very difficult to quantify the incremental impact of effective (or ineffective) marketing.

CONCLUSIONS

Some of the main advantages to Bonneville of using this type of model are:

1. It is a simulation ("what-if") model, not an optimization model. Instead of giving a single best answer, it simulates the performance of the system and the behavior of decision-makers under different circumstances. This enables us to provide Bonneville policy makers results for several figures of merit for each of the conservation options. Model behavior can be monitored and tested under severe assumptions to check on the plausibility of the results.

2. It is a "simple" model. It does not attempt to capture all of the details and subtleties of Bonneville acquisition planning. This attribute makes it relatively quick to run and easy to use. Also, it is generally simple in its representation of each part of the model, making the logic easy to explain to those responsible for existing, separate corporate models.

3. The model is integrated, i.e., it includes representations of the major components of the regional electrical system operation, ratemaking, forecasting, resource availability and financial indicators. Issues related to price induced conservation, lost revenues, impacts on loads and rates and financial impacts can be treated in a consistent analytical framework.

4. Various policy perspectives can be monitored simultaneously within a consistent modeling framework. The major effort in the model construction has been focused on flexibility and detail in specifying alternate conservation policies for analysis. Program options across sectors within various corporate policy scenarios can be studied and will yield consistent, comparable results. The model can project both gross and net energy savings, total economic cost and cost to the utility, impacts on program participants and non-participants. It can also address financial impacts for Bonneville, net load reductions for load forecasting, and "price-induced" conservation for comparison with program evaluation results. Hence, in the public policy debate, alternative figures of merit can be referenced within a consistent analytic framework to identify and evaluate the trade-offs among various desirable objectives.

The Conservation Policy Analysis Model provides Bonneville policy makers with a powerful and flexible tool for analyzing different conservation programs. Planners have applied the model to specific regional policy issues with some measure of success. Although the model does not have all the features we would like, it has sufficient detail to provide significant insight to operation of Bonneville's system under a wide variety of conservation policies and planning scenarios.

ENDNOTES

1. Pacific Northwest Electric Power Planning and Conservation Act with Index," DOE/BP-7, August 1981.

2. M. Bull, "Testing Conservation Incentive Levels Through System Simulation," Proceedings of the ACEEE Summer Study on Energy Efficiency in Buildings, Volume I, August 1984.

3. The fiscal goals of regional utilities vary widely. Bonneville seeks regional rate stability and prompt payments on its Treasury indebtedness. Investor owned utilities may attempt to maximize the quality of their earnings, their times interest ratio, or pursue other objectives.

4. In general this is the division between program participants and non-participants. Also for Bonneville as a wholesale power (and conservation program) supplier, there are several different institutional relationships possible between Bonneville and the utility. Utilities may or may not generate their own power, they may or may not exchange residential and rural loads with Bonneville per the Regional Power Act, and they may or may not rely on Bonneville for meeting future resource requirements. Therefore costs and benefits can fall on utility groups differently. Also rate groups within a utility's service area may be affected differently since program costs may be passed on differently across rate groups.

5. "Total energy service costs" are used here to represent the present value of the total costs of energy services, e.g., heat, light, machine drive, etc. The total costs incorporate capital costs for the measures (both utility and consumer portions of the cost), as well as the energy bills.

6. A. Ford and R. Naill, "Technical Report: Conservation Policy in the Pacific Northwest," DOE/BP-2761-1, May 1985. This provides a detailed description of the model.

7. A. Ford and J. Geinzer, "The BPA Conservation Policy Analysis Models," April 1986. Available from the Office of Conservation, Bonneville Power Administration.

8. CPAM is a system dynamics model, written in a continuous simulation computer language (DYNAMO), and it runs on a mainframe computer. The system dynamics paradigm was chosen as an appropriate means to facilitate representation of the intricate way in which conservation affects the power system. The DYNAMO language allows the output of any variable to be easily monitered, changed or graphed through simple rerun instructions after the model has initially compiled. The closure of feedback loops within the model is facilitated through the language structure.

9. "1985 Conservation Supply Document," March 1986. Available from the Bonneville Power Administration Office of Conservation. This document provides an in-depth view of the calculation and use of supply curve data.

10. "1986 Resource Strategy," Volumes 1 and 2, Bonneville Power Administration, March 1986.

11. "Scoping Document for the 1986 Long Range Conservation Projection," DOE/BP-04, April 1985.

12. A. Ford and J. Geinzer, "Findings from Recent Studies with BPA's Conservation Policy Analysis Models," to be presented at the ACEEE Summer Study on Energy Efficiency in Buildings, Santa Cruz, California August 1986.