FIGURES OF MERIT FOR EVALUATING CONSERVATION STRATEGIES: FINDINGS FROM RECENT STUDIES WITH BPA's CONSERVATION POLICY ANALYSIS MODELS

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ABSTRACT

This paper summarizes key findings from recent model assisted studies of conservation strategy for the Pacific Northwest. The models, known as CPAM or Conservation Policy Analysis Models, were developed for the Office of Conservation of the Bonneville Power Administration (BPA). A description of BPA's need for CPAM and their recent experiences in using CPAM to assist in conservation studies are described in a separate paper to be presented at the Santa Cruz meetings.

This paper presents results from a recently completed sub-regional analyses along with regional results from studies conducted during 1984-1985. The goal of the paper is to show the likely changes in strategy evaluation due to changes in "figures of merit" used in the evaluation. We also show the likely changes due to explicit consideration of the main sources of uncertainty in electric resource planning.

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I. BACKGROUND

Work on the conservation models began in 1983 by adapting relevant structure from a simulation model which had proven useful in studies for a major California utility (Ford and Harris 1984). The first step was to design a regional model in which conservation programs, system operation, capacity expansion, and electricity pricing are conducted by a single entity. The regional model has been used in an extensive analysis of the effects of alternative conservation strategies on the Pacific Northwest as a whole (Ford and Naill 1985; Naill, Ford and Hickock 1986). The next step was to construct a sub-regional model which would distinguish between the loads and resources of the investor-owned utilities (IOUs), the publicly-owned utilities, and the BPA. The two models are known collectively as CPAM or the Conservation Policy Analysis Models. A short description of CPAM is given in a separate Santa Cruz paper by Bull and Barton (1986); a more detailed description is given in a BPA report by Ford and Geinzer (1986).

CPAM was designed to give the conservation planner great flexibility in assembling a package of conservation policies. A package might include utility subsidies for increased efficiency of electric space heating in older homes and performance standards for improved space heating in new homes. For other end uses (such as water heating, lighting, or appliances), the planner might wish to consider direct utility subsidies, performance standards, or even a combination of subsidies and standards. CPAM gives the conservation planner the freedom to specify a wide variety of subsidies for different end uses or for different economic sectors. Programs aimed at the residential and commercial sectors, for example, may strive to acquire low cost conservation savings that will substitute for high cost thermal plants in the utilities' capacity expansion plans. Programs aimed at the aluminum industry, on the other hand, may strive to improve the industry's profitability and to prevent loss of revenues to the BPA. The conservation planner is also free to select different subsidies for different income groups or to simulate the effect of a programs on the low, medium and high income groups represented in the model.

Once the planner singles out a particular end use-customer group for a utility financial incentive, great flexibility is permitted in the design of that incentive. The utility might choose, for example, to pay a fixed percentage of the cost of all measures up to some maximum cost, or it might choose to pay only for higher cost measures on the condition that the customer pay for the measures with lower cost. The planner may also choose when the incentive is to begin, how long it will last, and whether the incentive design should be changed during the course of the planning period. Different conservation strategies may be specified for the IOUs and for the publicly-owned utilities, and one may specify whether the utilities will implement separate conservation programs or whether they will participate in BPA programs and cost sharing. And finally, the planner may choose from a variety of methods to recover conservation expenditures. These include cost sharing with BPA, immediate recovery through expensing, and delayed recovery through capitalization.

In addition to tracking direct costs borne by the utility and the customers over the planning interval, CPAM accounts for a variety of factors that can change the cost per "net kw saved" by a program. (Here, "net savings" referrs to the difference in demand from a simulation with a conservation program and a simulation without the program.) "Net savings" may be much smaller than gross savings, for example, if customers are prone to install many of the subsidized measures due to price effects alone. When this happens, utility costs per "net kw" saved can be quite high due to the redundancy between programmatic conservation and price induced conservation (European Commission 1984). "Net savings" may also be lower than expected if the analyst specifies a "take-back" or "rebound" effect whereby consumers increase their electricity useage when conservation measure savings lead to large reductions in the monthly electric bill. In some cases, utility incentives to cut electric conservation costs may cause consumers to switch from other fuels to electricity. Net conservation savings can also turn out to be less then expected when measures wear out or when the buildings they are installed in are torn down. None of these cases affect the cost of installing individual conservation measures, but they all affect the cost to the utility per "net kw saved," and are a potentially important part of CPAM simulations of conservation strategies.

II. FIGURES OF MERIT

CPAM was designed with sufficient detail to represent the many conservation policy options of interest to BPA, to generate an internally consistent set of projections, and to provide "figures of merit" or yardsticks to gauge the success or failure of conservation strategies. The three "figures of merit" of most interest in the Pacific Northwest are electric rates, utility revenues and energy service cost.

A. Electric Rates

Changes in electric rates (ie, mills/kwh) are one of the most closely studied yardsticks in policy studies completed to date. CPAM simulations tend to show adverse rate impacts during the first few years after the initiation of a incentive program. Depending on the timing of the program and the utility costs per "net kw" saved, the rate penalties may be quite small (under 1% in the worst year) and may only last for 3 or 4 years. Subsidies that prove quite costly per "net kw" saved or which generate large savings during periods of surplus generating capacity show larger and more persistent rate penalties. (The question of how to time the implementation of utility conservation programs in the face of a large but uncertain surplus of generating capacity is addressed in a separate BPA paper (Naill, Ford and Hickock 1986).) The short-term adverse rate impacts are primarily attributed to the financing costs of the incentive program and the lower sales of electricity to customers participating in the program.

For almost all programs tested to date, the short term rate penalties are followed by a period of rate benefits. The benefits usually appear about the time in the simulation when the conservation savings lead to postponements or reductions in power plant construction. The transition from penalties to benefits is affected by a wide variety of factors including the cost of the incentive per "net kw" saved, how rapidly customers participate in the program, whether the subsidies are capitalized or expensed, the likely duration of any generation surplus, the cost and lead time of the generating resources being displaced, and whether the utilities are allowed to count construction work in progress (CWIP) in their rate base. A typical "figure of merit" used to combine the effects of the short-term rate penalties and the long-term rate benefits is a simple average rate impact observed over the entire planning period. (We have also calculated a discounted cost of service to a typical residential non-participant, and we have calculated discounted, average rate impacts. These measures may be more appealing to analysts who feel that rate impacts in the distant future should not be weighted as heavily as near term rate impacts.)

B. Utility Revenues

Total utility revenues is another widely used "figure of merit," and CPAM prepares a discounted sum of annual utility revenues for use in evaluating conservation strategies. This yardstick includes the utilities' traditional costs (such as fuel, maintenance, construction, and interest) as well as the utilities' costs for the conservation incentive program. In policy studies completed to date, we have only found one or two instances when a utility incentive program did not reduce the utilities' total, discounted revenues. One reason for this finding is that BPA planners typically limit incentive programs or performance standards to conservation measures whose total cost does not exceed the levelized cost of electricity generation from new power plants. Another reason, however, is that the utility revenues yardstick misses an important part of the picture, the costs incurred by consumers in participating in the incentive program or in complying with performance standards.

C. Energy Service Costs

The energy service cost yardstick takes the consumers' expenditures into account by combining the customers' conservation spending with the utilities' revenues to obtain the total costs in each year of the planning period to provide electric energy services. The present value of these annual costs is the most comprehensive "figure of merit" for evaluating conservation policies. This yardstick combines both the consumers' electric bill payments to the utility with the customers' own investments in conservation measures. Energy service cost is a key yardstick in the Pacific Northwest because of the Pacific Northwest Electric Power Planning and Conservation Act's definitions of "conservation," "system cost," and resource "cost-effectiveness" (BPA 1981). Across the rest of the country, utilities and state agencies are also becoming more familiar with "least cost" energy plans that aim to reduce total costs (Wellinghoff and Mitchell 1985; Sant, Bakke and Nail 1984). Their view is that planners should strive to minimize the cost of electric energy services, not just the cost of electricity.

In policy studies completed to date, conservation programs are usually less attractive when judged by improvement in energy service cost than by improvement in total utility revenues. In a recent test, for example, a package of subsidies for all economic sectors was projected to reduce total, discounted utility revenues by $1,830 million. The projected reduction in energy service cost, however, was only $880 million. The $950 million difference was the model's projection of the extra conservation spending by the region's customers due to the incentive program. This general pattern occurs in simulations with incentive programs that encourage customers to buy more measures and to buy them sooner. The pattern also occurs in simulations with performance standards where the utility pays none of the cost of the conservation measures. In a few policy tests, however, we project that incentive programs lead customers to spend less on conservation than if there were no program. This can occur when the utility pays for the vast majority of the conservation costs, and these costs then become part of the utility's revenue requirements.

In a typical policy evaluation, the energy service cost yardstick is used to judge the overall attractiveness of the conservation strategy, and electric rate impacts are used to gauge the impact on those customers who do not participate in the programs. The impact on utility revenue requirements is also calculated for possible comparison with revenue requirements projected with other models. A typical evaluation may also include an examination of key financial ratios (such as interest coverage) and budget projections.

III. SELECTED RESULTS

CPAM has been used in a general analysis in "Conservation Policy in the Pacific Northwest" (Ford and Naill 1985) and in a specific analysis of conservation policies of interest in BPA's 1986 resource strategy. Selected results from these recent applications are presented below.

A. Conservation Benefits Despite the Surplus

Electric planners expect that the current surplus of generating capacity in the Pacific Northwest will last for around 10 years. With surplus conditions, additional conservation savings do not lead immediately to a reduction in utility spending on new generating capacity. Rather, the immediate effect is to reduce net operating costs due to extra secondary sales to California. This benefit is usually smaller than the costs of financing the conservation program, so planners should expect that conservation programs will lead to rate penalties during the surplus period. Depending on the duration of the surplus, the main benefit of programs may not materialize for 5-10 years, or until the utilities would be able to cut construction spending because of the programs. These circumstances have prompted many utilities to cancel conservation subsidies and shift the focus of their "demand side planning" efforts to energy marketing programs that would increase electric sales during the surplus period. Many planners argue that conservation programs should be pre-tested and then "put on the shelf" while the region waits for the surplus to diminish.

CPAM keeps track of both the short-term and long-term effects of conservation programs and allows the planner to judge the merits of initiating (or continuing) conservation incentive programs in the face of a large and prolonged surplus. The many simulations completed to date show that well-designed conservation programs could be implemented despite the surplus. A variety of conservation programs have been identified that, when implemented in the next budget interval, yield positive benefits regardless of which "figure of merit" is used in program evaluation. All programs lead to lower utility revenue requirements; almost all programs lead to lower energy service cost; and all except the more aggressive programs lead to rate benefits to the non-participants (when rate impacts are averaged over the entire 20 year planning period).

Why such positive results? The main reason is that the incentive policies have been appropriately designed before the simulation analyses began. More specifically, most incentive programs tested to date are:

- targeted at measures whose total cost is lower than the levelized cost of new coal plants;
- projected to show a relatively small "loss of savings" due to the "rebound effect;"
- projected to show relatively low "redundancy" (European Commission 1984);
- capitalized to allow utility costs to be recovered over the life of the conservation measure (rather than in the year of the investment); and

- paced to deliver their savings spread out over the course of the planning period (rather than concentrated during the period prior to the need to start construction on new power plants).

With these assumptions, the CPAM simulations show that many ongoing programs could be continued and new programs could be initiated as early as 1988. A more detailed discussion of the benefits of early implementation despite the generating surplus appears in a separate BPA paper (Naill, Ford and Hickock 1986).

B. The Tradeoff From More Aggressive Programs

All utility financial incentive programs tested to date generate rate penalties for several years after program startup, but almost all incentive programs generate rate benefits later in the planning period. As noted above, all but the more aggressive incentive programs yield rate benefits that outweigh the rate penalties when rate effects are averaged over the entire 20 year planning period. With the more aggressive programs, the utilities pay more per kw saved, and a larger portion of the net savings occur early in the simulation period. Under these circumstances, CPAM simulations have shown that the near term rate penalties outweigh the longer term rate benefits. Although adverse results are found on one "figure of merit," the simulations show that the more aggressive incentive policies do deliver larger benefits to the region in terms of energy service cost. Thus, conservation planning is made difficult by a value tradeoff involving the two worthy goals of minimizing the cost of electric energy services and minimizing the price of electricity.

The value tradeoff is illustrated in Figure 1A by showing the range of possible results from projected changes in these two "figures of merit." The upper right quadrant shows the most desirable result, conservation programs reduce electric rates as well as energy service cost. The least desirable combination is represented by the lower left quadrant where programs are expected to cause higher energy service costs as well as higher electric rates. The lower right quadrant represents the highly unlikely outcome that utility subsidies would lower electric rates without lowering energy service cost. And in the upper left quadrant, we represent the possibility that subsidies reduce energy service costs but increase the price of electricity.

Figure 1B retains the upper half of Figure 1A showing the two quadrants where simulated impacts are most likely to occur. Figure 1B also shows results from recently completed regional model projections for two packages of conservation subsidies. The so-called "balanced program" is a package of subsidies for residential, commercial, and industrial customers that was projected to deliver positive results on both "figures of merit": an energy service cost reduction of about $1 billion and an average rate benefit of about 0.1 mills/kwhr. The "blitz" program is comprised of a package of subsidies for the same customers, but the utility pays for the total cost of conservation measures. We assume that this more generous policy will lead to more rapid customer participation, and the simulations show that the utility cost per "net kw" saved is considerably higher. Thus, the "blitz" policy permits the region's utilities to acquire conservation savings much more rapidly but at greater cost per "net kw" acquired. The simulated effect of the "blitz" was a $1.4 billion reduction in energy service costs and a rate penalty of 0.75 mills/kwhr averaged over the 20 year planning period. Choosing between the "balanced programs" and "blitz" policies shown in Figure 1B requires the conservation policy maker to weigh the importance of the two key goals of electric resource policy. If reducing total sytem cost is given utmost importance, the "blitz" program would be adopted despite the adverse rate impacts. If minimizing electric rates is given equal billing, policy makers would shift toward the less aggressive policies like the "balanced programs."

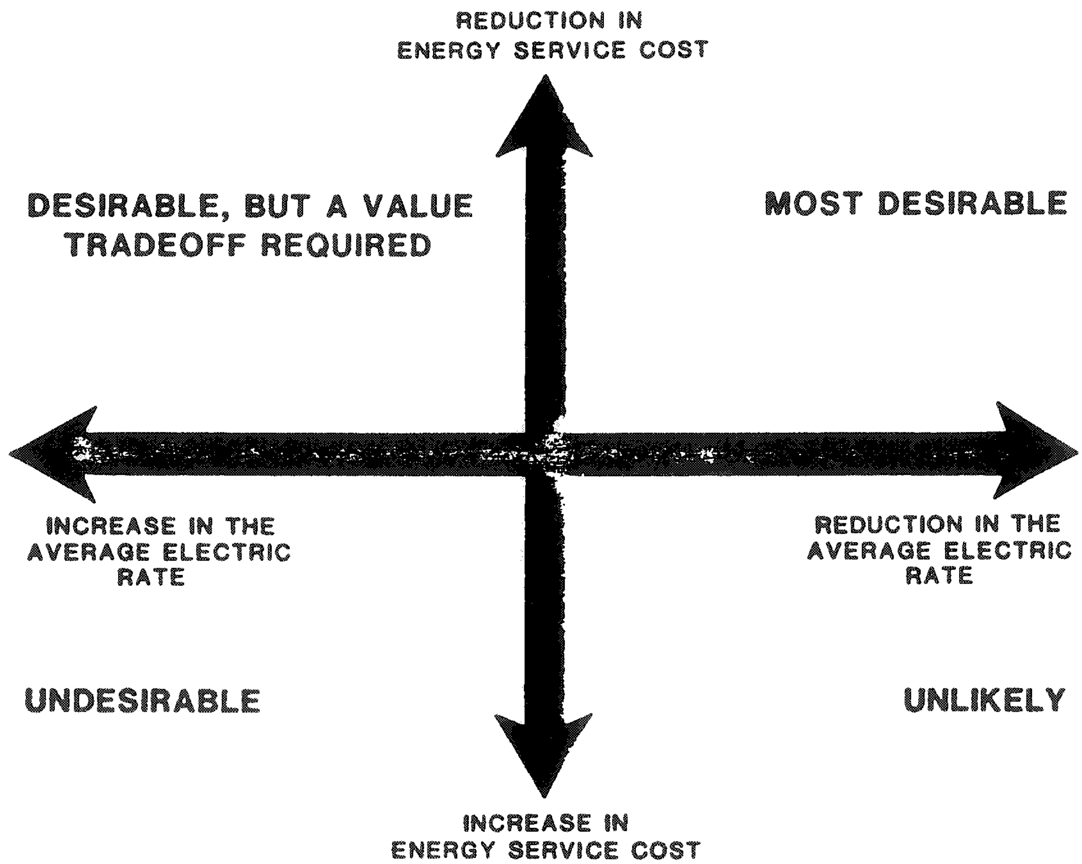

Fig. 1A. Four possible outcomes when studying simulated impacts of the two principal "figures of merit."

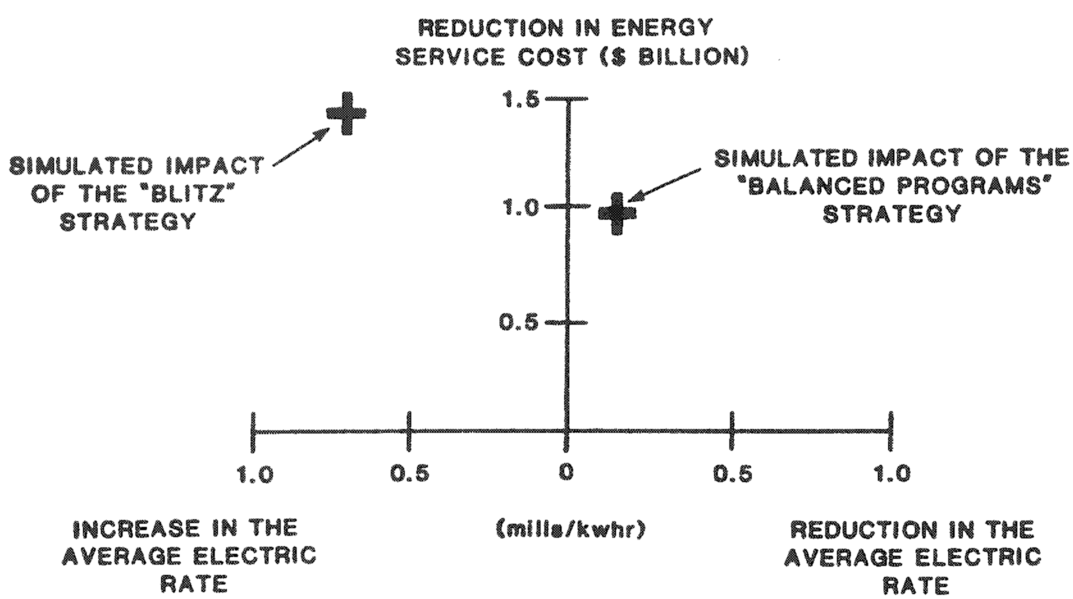

Fig. 1B. Simulated impacts for the "balanced programs" and the "blitz" strategies.

C. Minimizing the Risk of Conservation Programs

The Figure 1B results show the simulated impacts for two conservation policies under base case assumptions adopted in the Spring of 1985. These assumptions include medium growth in the region's economy, no cancellations of the two remaining Washington Public Power Supply System (WPPSS) nuclear units, no significant small hydro resource, 42 mills/kwhr levelized cost for new coal plants, no firm sale to California, regular conditions in the aluminum marketplace and a larger intertie capacity for transmission to California. Since these and other aspects of the base case scenario are highly uncertain, hundreds of sensitivity tests have been completed to learn which of the many uncertainties lead to greatest changes in the simulated impact of conservation policies. Two of the more extreme scenarios are portrayed along side of the base case in Figure 2. This diagram shows a simple decision tree with one decision node and four uncertainty nodes. An unconditional decision to implement the "blitz" policy or to offer no further incentives is to be analysed with independent uncertainties in (1) the rate of growth of the regional economy, (2) the number of WPPSS units cancelled, (3) the market place for aluminum, and (4) the market for secondary power. The darkened legs through the top version of the decision tree show the assumptions adopted for the base case comparison. In the middle version, we show an extreme

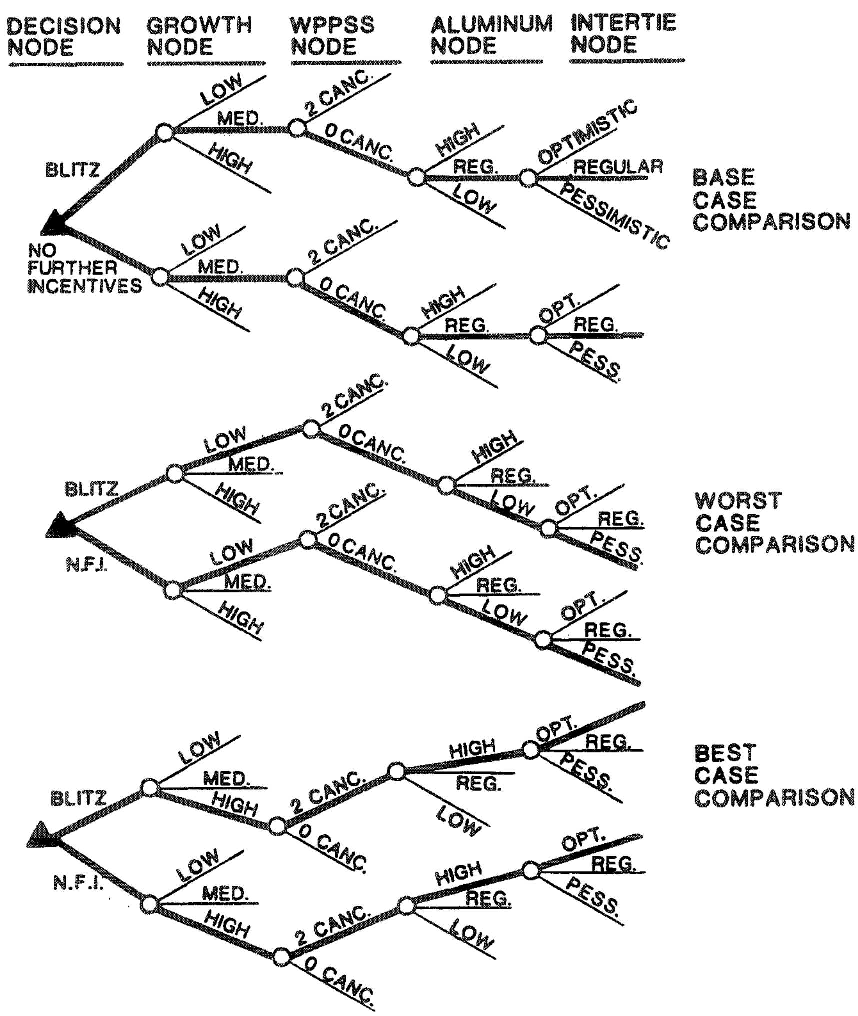

Fig. 2. Example of a simple decision analysis.

set of assumptions which would make the "blitz" policy highly unattractive: slower growth in the regional economy, no WPPSS cancellations, a low price of aluminum (leading to major closures in smelting capacity, loss of DSI load, and more congestion on the intertie) and pessimistic assumptions about the size of the intertie and the California utilities' appetite for secondary power. The opposite extreme provides the best possible conditions for implementing the "blitz," rapid growth in the economy, two WPPSS cancellations, high aluminum prices, and optimistic assumptions on secondary sales.

Simulations for the "blitz" policy show greater variability in simulated impacts than the "balanced program." Under the best case conditions (where conservation savings are needed as quickly as possible), the blitz delivers positive impacts on both "figures of merit," a $2.5 billion reduction in energy service costs and a 0.3 mills/kwhr average rate benefit. With worst case conditions (where the surplus is prolonged and the intertie is saturated), the "blitz" delivers negative impacts: a $1.2 billion increase in energy service cost and a 2.9 mills/kwhr average rate penalty. These extreme results may be combined with the base case impacts to give expected values with differing assessments of the relative likelihood of the three cases. The "symmetric" result in Figure 3, for example, gives the expected impact of the "blitz" policy with a 60% probability for the base case and 20% for the two extreme cases. The "best" and "worst" case results in Figure 3 show the expected impacts when the extreme cases are considered highly probable. Figure 3 shows a similar set of expected impacts for the "balanced programs." With a symmetric set of probabilities that assign greatest likelihood to the base case, the expected impact falls in the upper right quadrant. Figure 3 shows that one might expect average rate penalties from the "balanced programs" only if one thought the probabilities should be heavily slanted toward the worst case assumptions. But even under these unusual conditions, the expected rate penalty is only 0.18 mills/kwhr when averaged over the planning period.

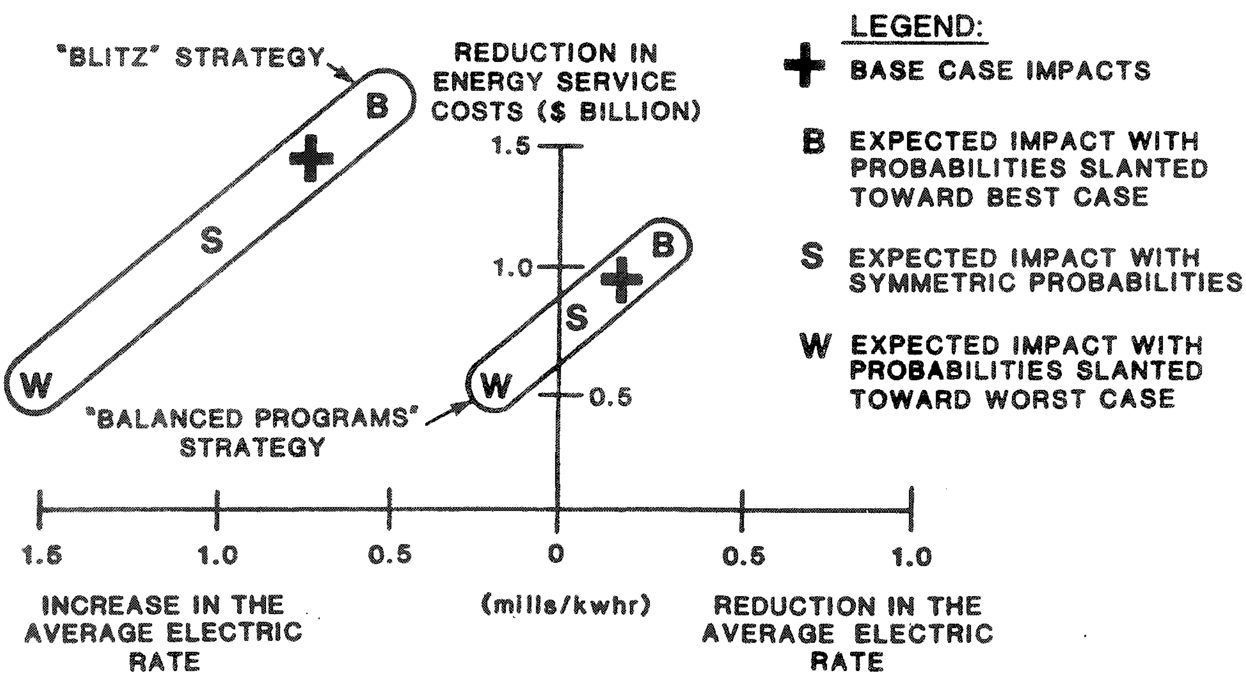

Fig. 3. Summary of expected impacts from two conservation strategies.

Although the preceding decision analysis is quite simple, the Figure 3 results point toward two important conclusions that should turn up in more complicated considerations of conservation planning under uncertainty. First, we conclude that the variation in expected performance of the "balanced programs" is much less than the variation for the "blitz." Since high variability of performance is associated with high risk, one would conclude that the "balanced programs" is a safer strategy. The lower risk of the "balanced programs" arises from the fact that a smaller proportion of net savings appears during the first ten years of the simulation and the utility pays far less per "net kw" saved. As a general rule, therefore, we conclude that aggressive strategies like the "blitz" can deliver greater benefits (measured in terms of energy service cost), but one must expect adverse rate impacts and greater risk.

A second conclusion from Figure 3 is that the expected performance with symmetric probabilities is less attractive than the performance found in the base case simulation. We attribute this shift to asymmetries in simulated performance between the three cases of Figure 2. Specifically, we find that conservation policies look somewhat better when changing from base case to best case conditions, but they look far worse when shifting to worst case conditions. The main cause of this asymmetric behavior is the asymmetry in the duration of the capacity surplus. That is, worst case conditions can result in a seemingly permanent surplus whereas best case conditions merely advance the transition to deficit by a few years.

IV. SUMMARY

This paper summarizes key findings from model assisted studies of conservation strategies for the Pacific Northwest. We focus on the main figures of merit used in evaluating alternative strategies whose impacts are simulated with BPA's CPAM models. We demonstrate a simple way to represent the tradeoffs that may be necessary when conservation incentive programs lower energy service costs but increase electric rates. We also demonstrate a simple method of incorporating uncertainty in loads and resources into the tradeoff analysis.

NOTES AND REFERENCES

Unless otherwise stated, all $ and mills in this paper are constant, 1980 U.S. dollars where 1000 mills equal a dollar. Also, all GW (gigawatt), MW (megawattt), and kw (kilowatt) are measures of average electric power, where 1000 kw equal a MW, and 1000 MW equal a GW. The usual measure of electric energy is a kilowatt-hour (kwh). BPA references may be ordered by writing to the appropriate department at the Bonneville Power Administration, P.O. Box 3621, Portland, Oregon 97208.

BPA report "Pacific Northwest Electric Power Planning and Conservation Act With Index," report DOE/BP-67, August 1981.

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This report refers to redundancy as the "free-rider effect." The Commission noted scattered estimates of the "free rider effect" as follows: (1) unnamed U.S. study 43%, (2) German loan programme 80%, (3) unrepresentative Swedish study 20-25%, and (4) a Germany government study 30-75%. To reduce redundancy, the Commission suggested that the utilities offer larger incentives. The Commission reasons that utilities should increase the level of incentive to gain a greater fraction of customer spending on expensive conservation measures that customers would not have purchased on their own. Sensitivity analysis of a California utility incentive program support the Commision's view that larger incentives have proportionately less redundancy (Ford and Harris 1984). A recently completed CPAM analysis of possible redundancy of a variety of incentive policies showed savings redundancy ranging from around 3% to 18%. The amount of redundancy appears to be more sensitive to external uncertainties (such as the rate of economic growth) than to differences in incentive design.

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