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Assessing Integrated Resource Plans Prepared by Electric Utilities

Eric Hirst
Martin Schweitzer
Evelin Yourstone
Joseph Eto

OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
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ASSESSING INTEGRATED RESOURCE PLANS PREPARED BY ELECTRIC UTILITIES

ERIC HIRST, MARTIN SCHWEITZER,
EVELIN YOURSTONE,* AND JOSEPH ETO**

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*Consultant, Albuquerque, New Mexico.
**Lawrence Berkeley Laboratory, Berkeley, California

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operated by
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SUMMARY

During the past several years, more and more electric utilities have prepared long-term resource plans that integrate demand-side programs into the utility's mix of energy and capacity resources. Several organizations have enumerated the states with laws or regulations requiring utilities to prepare such plans. But no one has yet reviewed enough plans to assess utility progress in integrated-resource planning and to develop criteria for a good plan. This report suggests guidelines for the preparation and review of utility reports on their resource plans.

We reviewed more than 30 resource plans and related documents from electric utilities and government agencies. Guidelines in the form of a checklist were developed on the basis of these reviews. This checklist (summarized in Table S-1) should help staff in public utility commissions who review the utility reports and utility staff who prepare such planning reports.

Four broad topics are covered in the checklist (and in the body of this report):

- The clarity with which the contents of the plan, the procedures used to produce it, and the expected outcomes are presented;
- The technical competence (including the computer models and supporting data and analysis) with which the plan was produced;
- The adequacy and detail of the short-term action plan; and
- The extent to which the interests of various stakeholders are addressed.

Utilities should carefully prepare and present their resource plans because the plans are so important, both to the utility and to the public. The plan encourages interdepartmental cooperation and understanding within the utility. It develops a shared view of the utility's vision of the future and how the utility plans to meet the energy needs of that future. The plan also explains the rationale for the utility's proposed actions. The plan is useful to regulatory commissions and the public because it presents the utility's short- and long-term plans to provide electric-energy-services.

Some of the utility reports do not present the company's resource plan, a clear statement of what resources will be acquired to meet future energy-service needs. Although these reports contain much useful information, the failure to consolidate this information and commit the utility to a course of action renders these reports incomplete.

Because integrated resource planning is a new process, the suggestions offered here will evolve. Also, most of the plans we reviewed did not meet all the criteria on our checklist. To some extent, the checklist presents objectives that utilities should strive to meet in preparing future resource plans.

Table S-1. Checklist for a good integrated resource plan

Clarity of plan - adequately inform various groups about future electricity resource needs, resource alternatives, and the utility's preferred strategy

- Clear writing style
- Comprehensible to different groups
- Presentation of critical issues facing utility, its preferred plan, the basis for its selection, and key decisions to be made
- Logical report structure

Technical competence of plan - positively affect utility decisions on resource acquisitions and regulatory approval thereof

- Comprehensive and multiple load forecasts
- Thorough consideration of demand-side options and programs
- Thorough consideration of supply options
- Consistent integration of demand and supply options
- Thoughtful uncertainty analyses
- Full explanation of preferred plan and its close competitors
- Use of appropriate time horizons

Adequacy of short-term action plan - provide enough information to document utility's commitment to acquire resources in long-term plan, and to collect and analyze additional data to improve planning process

Fairness of plan - provide information so that different interests can assess the plan from their own perspectives

- Adequate participation in plan development and review by various stakeholders
- Sufficient detail in report on effects of different plans

INTRODUCTION

BACKGROUND

Many electric utilities throughout the U.S. periodically prepare long-term resource plans, often in response to requirements from state public utility commissions (PUCs). These plans inform regulators and customers about the utility's analyses of future demands for electricity, alternative ways to meet customer energy-service needs, and the utility's preferred mix of energy and capacity resources to meet those needs. The plan is an opportunity for the utility to share its vision of the future with the public and to explain its plan to implement this vision.

The integrated resource plan also serves important functions within a utility. Preparation of the plan encourages cooperation and communication among several departments within the utility. The resource-planning process helps the utility to develop and communicate internally its plan to provide electric-energy resources for the future.

PUC requirements provide one yardstick with which to judge these plans. However, the "data list or cookbook approach" (Schweitzer 1981) sometimes prescribed by PUCs is not sufficient to assess whether these plans enhance utility decisions on resource acquisitions or whether they adequately inform the public. A more analytical approach is needed to help utility planners and PUC staff.

Ideally, utility plans should be assessed on the basis of the utility's resource-acquisition activities. But integrated resource planning (IRP) is so new that insufficient implementation has as yet resulted from these plans. Currently, utility plans can be assessed only on the basis of their planning reports.

PURPOSE OF THIS REPORT

This report discusses guidelines for long-term resource plans, based on the written reports only. The word *plan* refers to both the program worked out beforehand to accomplish a goal and the report that describes the plan. The particular meaning should be clear from the context.

The purpose of these guidelines is to assist PUC staff who review utility plans and utility staff who prepare such plans. These guidelines were developed at Oak Ridge National Laboratory with contributions from Lawrence Berkeley Laboratory. They are based on discussions with staff in utilities and PUCs and on reviews of formal plans and related planning documents prepared by more than 30 utilities and government agencies

(Fig. 1 and Table 1). They reflect our judgments on what is important to include in an IRP report, primarily because no one else has yet suggested criteria for the preparation and review of utility resource plans.

Table 1. **Utilities and government agencies whose planning reports were reviewed**

Utilities	
Bonneville Power Administration	Pacific Gas and Electric Company
Boston Edison Company	Pacific Power & Light Company
Carolina Power & Light Company	Potomac Electric Power Company
Central Maine Power Company	Puget Sound Power & Light Company
Commonwealth Edison Company	Seattle City Light
Consolidated Edison	Sierra Pacific Power Company
Duke Power Company	Southern California Edison Company
Florida Power and Light Company	Southern Company
Green Mountain Power Corporation	Tennessee Valley Authority
Georgia Power Company	Union Electric Company
Idaho Power Company	Virginia Electric and Power Company
Montana Power Company	Washington Water Power Company
Nevada Power Company	Wisconsin Electric Power Company
New England Electric	Wisconsin Power and Light Company
Northeast Utilities	
Government Agencies	
Illinois Department of Energy and Natural Resources	Northwest Power Planning Council
Michigan Public Service Commission	Public Utility Commission of Texas
	Vermont Department of Public Services

The utilities and state agencies from which these plans were obtained are, in our view, the nation's leaders in IRP. Mitchell and Wellinghoff (1989) ranked each of the 50 states in least-cost planning.* Ten states have what they consider "a full featured LCUP [Least-Cost Utility Planning] regulatory framework ... adopted and implemented." Nine of these ten states are in our sample of utility and PUC reports; only Delaware is missing from our group. (Four of the seven states ranked by Mitchell and Wellinghoff as having

*The Electric Power Research Institute (Chamberlin, Fry, and Braithwait 1988) also ranked the states in IRP. Of the 18 states that EPRI determined have fully functioning IRP processes, 12 are in our sample.

adopted an LCUP regulatory framework but not yet having implemented the framework are represented within the plans we have; Iowa, Maryland, and New Hampshire are missing from our plans.) Donovan and Germer (1989) reviewed the "latest practical planning methodologies." Eight of the ten utilities included in their review are in our sample also.

A companion document (Schweitzer et al. 1990) focuses on the processes utilities use to prepare useful integrated resource plans. Schweitzer et al. discuss key factors, such as consideration of inputs from a variety of sources and balance between short- and long-term interests, that affect a utility's ability to prepare a valuable resource plan. Although the two reports cover similar material, Schweitzer et al. focus primarily on *how* to prepare a resource plan and this report focuses on *what* such a plan should include.

The "goodness" of a plan can be judged by at least four criteria:

- The clarity with which the resource plan, the procedures used to produce it, and the expected outcomes are presented;
- The technical competence (including the computer models and supporting data and analysis) with which the plan was produced;
- The adequacy and detail of the short-term action plan; and
- The extent to which the interests of various stakeholders are addressed.

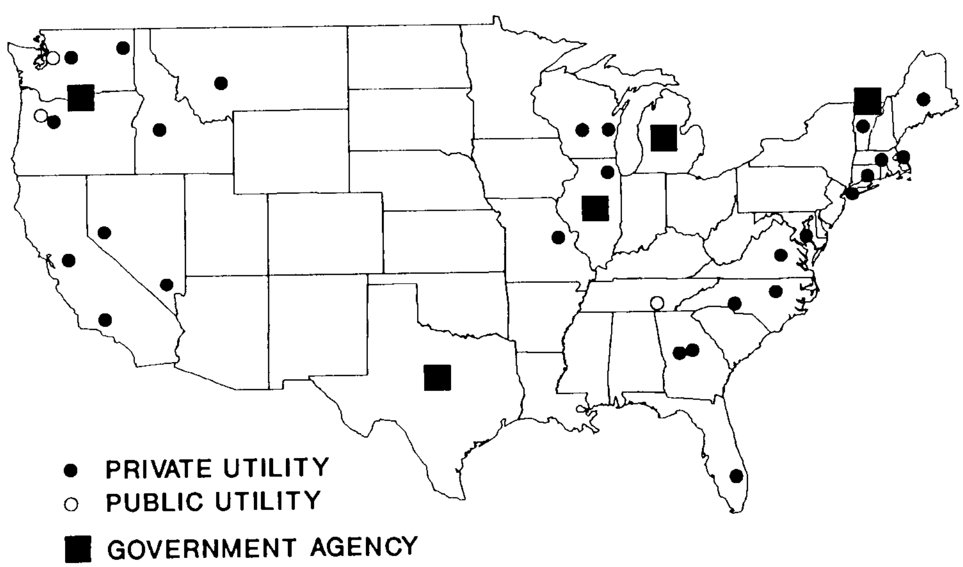

Fig. 1. States from which resource plans and planning documents were obtained.

These criteria (shown in Table 2) go far beyond what is included in most utility plans. It might be more accurate to view Table 2 as a wish list rather than a checklist. Many of the plans recently completed by utilities do not meet fully the guidelines suggested here. This is not surprising because most utilities are preparing such plans for the first time; later plans are likely to be much improved.

The criteria listed in Table 2 (discussed in the following chapters) apply more to large utilities than to small utilities, and more to utilities facing immediate decisions concerning future resource acquisition than to those with no immediate decisions. Because the criteria are detailed and comprehensive, utilities should not be asked to produce planning reports more than once every two or three years. However, plans should be revised when key assumptions change that affect future decisions.

How well a plan does on each of these criteria depends on the audience. At least three broad groups can be considered as legitimate stakeholders: utility shareholders and bondholders; customers and public interest groups; and regulators (representing societal interests).

For several reasons, this report focuses more on demand-side management (DSM) resources than on supply resources. First, many utilities remain uninterested in, and skeptical about, DSM programs. For example, the latest forecast from the North American Electric Reliability Council (1989) essentially ignored utility energy-efficiency programs and makes the following comments about utility load-management programs:

> There is substantial uncertainty as to how much peak demand reduction will be realized at the particular time when load management is needed and implemented. Another major concern is that customers, who initially participate in load management programs because of the financial incentives, may decide, once the electric supply to their equipment has actually been interrupted a number of times, that the inconvenience of the interruption outweighs the cost savings and withdraw from the programs.
>
> ... there are also certain drawbacks and uncertainties associated with dependence upon load management ... There is also substantial uncertainty as to how much actual demand reduction will be realized at the particular time it is needed.

Second, utilities have decades of experience with the construction and operation of power plants but only a few years of experience with DSM programs. Therefore, more attention is needed on the demand side to improve our understanding of how these programs work and their benefits for utilities and customers. Second, the U.S. Department of Energy Least-Cost Utility Planning program (the sponsor of this research) focuses on the demand-side aspects of IRP because of the need for additional data on the cost and performance of DSM technologies and programs (Temple, Barker and Sloane 1986).

Table 2. Checklist for a good integrated resource plan

Clarity of plan - adequately inform various groups about future electricity resource needs, resource alternatives, and the utility's preferred strategy

- Clear writing style and use of graphs and tables
- Comprehensible to different groups, including utility staff, investors, PUC, public interest groups, and customers
- Clear presentation of critical issues facing utility, its preferred plan, the basis for its selection, and key resource-acquisition decisions to be made
- Logical report structure: Executive Summary, Report, Glossary, Technical Appendices, and References

Technical competence of plan - positively affect utility decisions on resource acquisitions and regulatory approval thereof, ensure that decisions are based on thorough analysis of present and future conditions and of alternative resources

- Comprehensive and multiple load forecasts
  - Energy and peak loads
  - Clear relationships between forecasts and utility DSM programs, both new and existing
- Thorough consideration of DSM options and programs
  - Examine existing DSM programs
  - Screen various DSM options
  - Combine promising options into a few programs; estimate utility program costs, participation rates, and effects on annual energy use and peak loads
- Thorough consideration of supply options, including transmission and distribution options as well as life extension of existing plants, purchased power, alternative energy sources, and utility construction of power plants
- Consistent integration of demand and supply options
  - Consistent economic tests used to select resources
  - Similar screening methods to yield broad and comprehensive lists of options
  - Head-to-head competition in integration and in uncertainty analysis; planning models must be capable of using different combinations of both supply and demand options
  - Feedback between electricity prices and load forecast
  - Show results for different integrated resource plans
- Thoughtful uncertainty analyses
  - Consider uncertainties about external factors and about resources
  - Develop alternative plans for different futures
  - Assess performance of preferred plan under different assumptions, show how uncertainty affects choice of preferred plan
- Full explanation of preferred plan and its close competitors
  - Explain resource-selection criteria
  - List key assumptions (e.g., inflation rate, debt/equity ratio, rate regulation, and reserve margin)
  - Show how plan addresses critical issues facing company
  - Present results for utility revenues, total costs, electricity prices, reliability, fuel and technology diversity, utility financial indicators, and environmental effects
- Use of appropriate time horizons: two to three years for action plan, ten to 15 years for planning, and 20 to 40 years for analysis (to account for end effects)

Adequacy of short-term action plan - provide enough information to document utility's commitment to acquire resources in long-term plan and to collect and analyze additional data to improve planning process

- Show budgets, departments, and milestones for key actions
- Include future data collection and analysis activities as well as resource acquisition
- Report progress since preparation of last resource plan

Fairness of plan - provide information so that different interests can assess the plan from their own perspectives

- Adequate participation in plan development and review by customers, local energy experts, representatives of different groups of customers (e.g., low-income and large industrial), environmental groups, etc.
- Sufficient detail in report on effects of different plans, such as utility revenue requirements, total costs, electricity prices, environmental emissions, earnings, and interest coverage

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ELEMENTS OF INTEGRATED RESOURCE PLANNING

Although this report focuses on the utility's formal plan, recognize that the written plan is a snapshot of an ongoing, dynamic planning process. Indeed, the ensuing discussions deal with the process of plan preparation as well as the final product itself. IRP includes the utility's departments and people, analytical methods, and data as well as inputs from customers, nonutility energy experts, and the PUC (Fig. 2). The process is a blend of quantitative data and analysis, qualitative assessments, and judgments reflecting alternative points of view. The key elements of IRP are shown in Table 3 (Goldman, Krause, and Hirst 1989). IRP differs from traditional utility planning in that it (1) explicitly includes energy-efficiency and load-management programs as energy and capacity resources, (2) considers environmental and social factors as well as direct economic costs, (3) involves public participation, and (4) carefully analyzes the uncertainties and risks posed by different resource portfolios and by external factors.

Cavanagh (1986), Hirst (1988), and the National Association of Regulatory Utility Commissioners (1988) describe various aspects of IRP. None of these authors, however, discusses standards against which to assess these long-term resource plans.

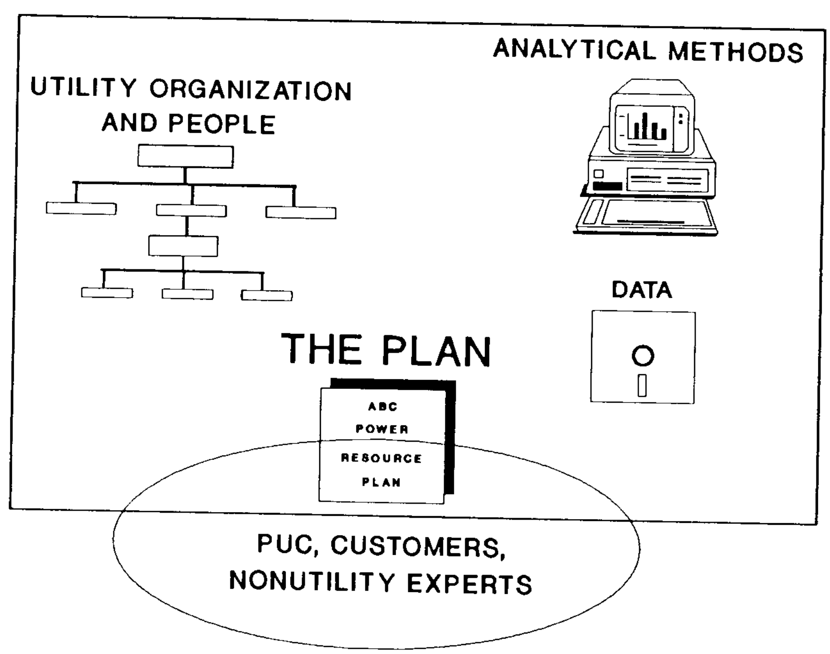

Fig. 2. **The utility's plan is a key output from the integrated-resource planning process.**

Table 3. **Key elements of integrated resource planning**

Integrate resources
- Supply, demand, transmission, distribution, and pricing

Integrate people and departments
- Cooperation, coordination, and communication

Treat uncertainty explicitly
- Alternative resource portfolios
- Factors external to the utility

Involve the public in the planning process
- Customers, nonutility experts, independent power producers, and PUC

Consider environmental factors

Implement plan
- Acquire demand and supply resources
- Collect and analyze additional data

Continue planning process
- Feedback from implementation to planning
- Develop new plans

Source: Hirst (1988).

CLARITY

The primary purpose of an IRP plan is to help utility executives decide which resources to acquire, what amounts to acquire, and when to acquire those resources. The planning report documents the utility's decisions, and helps the PUC and public to review and understand the basis for the utility's decisions. Thus, the report must be useful both within and outside the utility. The report provides a forum for the utility to present its vision of the future and how it plans to meet that future. The report provides utility data, assumptions, analyses, results, and plans to the public (including customers and regulators). For this information to be useful, the report should be easily understood by different groups and should point the reader to further information as needed.

The utility's plan should be well-written and appropriately illustrated (with tables and figures) and roughly 100 pages long (Table 4). The writing style should be aimed at an audience of intelligent and interested people with modest technical backgrounds.

Preparing a document that serves the needs of different readers is difficult. Some utility plans are so detailed and complicated (e.g., filled with equations) that only the most technically sophisticated readers can understand what the plan contains. At the other end of the scale, some utilities publish short, glossy documents that present only limited information on the resource plan. The lack of detail frustrates readers interested in how the utility developed its preferred plan. One utility, while genuinely interested in resource planning, produced only a short summary report; ample documentation existed within the utility, but only in the form of loose-leaf binders in the offices of planners and analysts.

Boston Edison (1988) and Seattle City Light (1987) dealt with these issues by preparing multi-volume plans. Boston Edison published a separate 12-page summary, which covered only the highlights of the plan. The company also issued three volumes: *Integrated Planning Process*, *Energy and Peak Load Forecast*, and *Resource Plan*. Together, these three volumes, which totalled several hundred pages, provide ample details on the data, assumptions, methods, and analyses that support the results presented in the summary. Similarly, Seattle's plan included separate *Executive Summary*, *Overview*, and *Analysis* volumes plus technical documentation reports.

Customers, public interest groups, the media, and shareholders will probably require a simpler presentation with less technical language than will utility staff and regulators. The former groups may also want more emphasis on the overall plan than will the latter groups, who are likely to be more concerned with the individual options selected. Different groups also may want different information on the expected outcomes. Customers, for instance, might be most interested in short-term rates, utility shareholders

Table 4. **Suggested outline for utility report on its integrated resource plan[a]**

Executive Summary (25 to 40 pages)	
	Energy and peak-load forecasts, demand and supply resources considered, resource integration, assessment of alternative resource mixes (including uncertainty analyses), selection of preferred resource portfolio, and short-term action plan
The Plan (75 to 150 pages)	
	Overview and objectives of the plan
	Progress since completion of last plan
	Long-term load forecasts
	Comparison of load growth with existing resources
	Demand-side resources
	Past and current programs and their effects
	Future potential and programs
	Supply resources
	Existing resources
	Potential new resources
	Resource integration
	Methods used to screen resources
	Criteria for resource selection
	Assessment of alternative resource portfolios
	Uncertainty analysis
	Preferred resource mix
	Short-term action plan
	Glossary
	References
Technical Appendix (no page limit)	
	Bound separately from plan

[a]A formal report of this type probably would be published every two or three years. Shorter updates might be prepared annually.

in return on investment, independent power producers in avoided energy and capacity costs, and regulators in the resources planned to meet customer needs during the next 20 years.

The report should discuss the objectives of the utility's planning process, explain the process used to produce the plan, present load forecasts (both peak and annual energy), compare existing resources with future loads to identify the need for additional resources, document the demand and supply resources considered, describe alternative resource portfolios, show the preferred long-term resource plan, and present the short-term actions to be taken in line with the long-term plan. The report should also explain the technical aspects of the planning process as described in Chapter 3.

While each utility will choose a format for its plan suitable to its needs, the structure shown in Table 4 might generally apply. Puget Sound Power & Light (1989) used a structure similar to this, producing a 70-page report plus six appendices. The appendices covered: (1) progress on the action plan developed in 1987, (2) detailed descriptions of planning scenarios, (3) demand-side alternatives, (4) supply alternatives, (5) recommendations from the company's consumer panels, and (6) membership in the company's technical advisory committee.

The report should include references to other company publications, to reports from other utilities, and to the relevant literature on forecasts, supply resources, and demand resources. This list will help interested readers examine certain issues in greater detail and will also demonstrate the utility's knowledge of what is happening at other utilities, commissions, the Electric Power Research Institute, national laboratories, universities, and consulting firms.

Because the information to be presented is detailed and complicated, utilities should find effective and visual ways to show results. New England Electric (1989), for example, presented the key results of their long-term plan in a compact fashion (Fig. 3).

Important future decision points should be identified, and the use of monitoring procedures to provide input for those decisions should be explained. The most significant effects of choosing among the available options (in terms of capital and operating costs, resource availability, environmental effects, etc.) should be discussed. The report should also briefly describe the methods used to develop the plan, including uncertainty-analysis techniques. Finally, the plan should point the reader to more detailed documentation on each of the above topics. For example, Seattle City Light (1988) published a separate report that explains the structure of the computer models used to develop its resource plan. This report describes the utility's economic and demographic model, demand model, model of electricity prices from the Bonneville Power Administration, supply model, revenue requirements model, and cost allocation and rate design model. Placing this documentation in a separate report makes this information available to technical specialists without cluttering the utility's resource plan.

Finally, some planning documents do not present the company's resource plan, although they contain much interesting and useful information. These reports, therefore cannot be considered integrated-resource plans. For example, one utility report includes forecasts of future peak demands and annual electricity use and a resource plan showing additions and retirements. However, the report notes:

The reference case electric resource plan summarized below represents one of many possible scenarios which may develop in the future. It is not a commitment to a particular course of action.

Unfortunately, nowhere in the report does the utility indicate what actions it will take to meet future loads.

Another utility filed a four-volume report with its PUC in 1989. The report included many of the elements of an integrated resource plan: load forecasts for each customer class, existing and planned capacity additions, existing and proposed transmission facilities, and details on the company's DSM programs. This report is not a true integrated resource plan because it did not assess alternative mixes of supply and demand resources, did not subject these resource portfolios to uncertainty analysis, and included no public involvement. Thus, this four-volume report did not show *how* the company arrived at its preferred resource plan and how this plan compares to alternative plans.

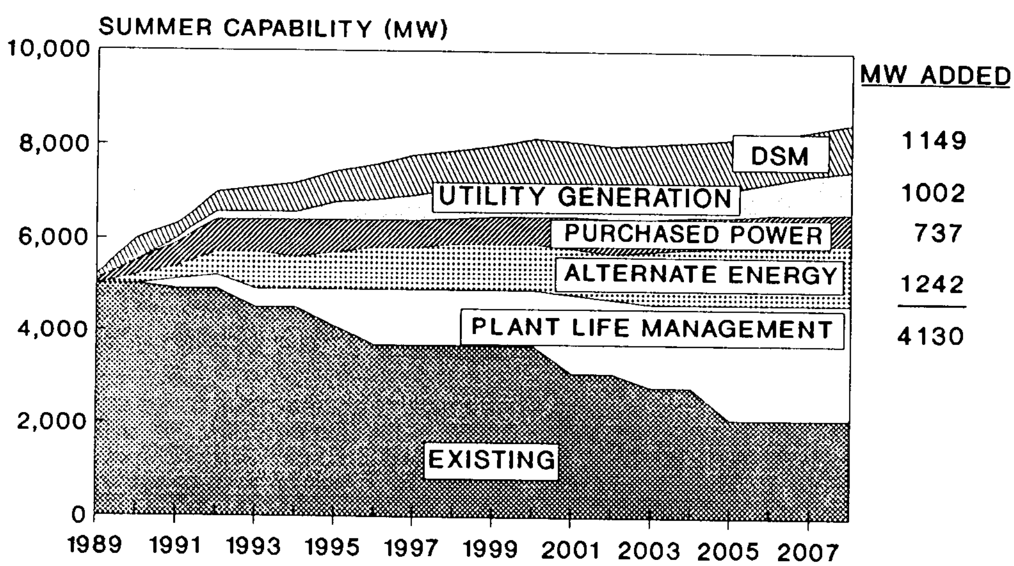

Fig. 3. **The demand and supply resources that New England Electric (1989) plans to use in meeting peak demand between 1989 and 2008.**

TECHNICAL COMPETENCE

The amount of information that must be processed to prepare integrated resource plans is daunting. Computer models are routinely used to manage these data for load forecasting; screening of demand and supply resources; and analysis of production costs, revenue requirements, electricity rates, and other financial parameters. These models are used to analyze a wide range of plausible futures (scenarios) and resource mixes (strategies) in developing the utility's preferred resource portfolio.

The models used to develop a plan should accurately simulate the processes under study and should use realistic assumptions to derive their results. The basic structure of the models, the data and assumptions on which they are based, how data passes from one model to another, and the inputs used in each model should be clearly explained in an appendix.

In the following sections, technical competence is discussed for load forecasts, demand-side resource screening and assessment, supply resource screening and assessment, integration of demand and supply resources into a comprehensive resource plan, and uncertainty analysis.

LOAD FORECASTS

Forecasts of annual electricity use and of peak demand (e.g., in GWh and MW) for each customer class should be presented, and the basis for each forecast should be clearly explained. A reference document (e.g., an appendix) should explain the forecasting methodology, input data sources, and historical performance of the forecasting models. Because future conditions are inherently uncertain, a range of load forecasts is desirable.

Meaningful links between the annual energy and peak-load forecasts are needed. Some utilities develop detailed energy forecasts, while the peak-load forecast is based on a simple model that is not coupled to annual energy use. This approach is not tenable unless the consistency of the two sets of models can be demonstrated. Serious consideration of DSM resources requires detailed analysis of both the energy and load-shape effects of these resources and of the consequences of these effects on the power-supply system. End-use forecasting approaches for both energy use and load shapes are needed to provide these details.

The utility should explain how the effects of projected changes in electricity price (outputs from resource integration) are fed back into the load-forecasting models. This feedback loop is especially important if the prices initially used as inputs to the load forecasts were quite different from those resulting from the resource-integration process.

The relationship between the forecasting process and forecasts on the one hand and the utility's DSM programs on the other hand needs to be clearly explained. In particular, it is essential to know whether (as well as how) the forecasts include the effects of demand-side activities. Such activities include the company's energy-efficiency and load-management programs, government appliance-efficiency standards and building codes, other DSM programs, as well as changing fuel and electricity prices. Without quantification of existing DSM activities, it is impossible to establish a baseline for the acquisition of additional DSM resources.

End-use forecasts are desirable because they provide much more detailed estimates of future electricity use than do traditional econometric models. This detail is needed to assess the effects of past and current DSM programs and the likely effects of future programs. For example, new federal standards for refrigerators and freezers, issued in November 1989, will cut their average electricity use by more than 25%. Forecasting models that lack end-use details cannot account for such changes in future electricity use.

Also, the link between DSM potentials and load growth needs to be made explicit. In particular, the size of the conservation potential in new buildings increases with increasing economic and load growth (Ford and Geinzer 1988; Hirst 1988; Northwest Power Planning Council 1989a).

Dworkin (1989) discusses the role of end-use models in load forecasting:

> ... historical demand forecasts, which directly influence the timing and composition of supply requirements, are methodologically independent of the underlying structure of energy end-uses. Consequently, existing forecasting methods prevent utilities from explicitly linking the baseline consumption of buildings targeted for efficiency programs with future consumption projections.
>
> The resulting gap between program planning and demand forecasting introduces considerable uncertainty in the integration of demand-side and supply-side resources. This risks double-counting savings from demand-side programs that are already included in demand forecasts; it also invites utilities to dismiss certain efficiency measures or programs on the unsubstantiated presumption that their forecasts incorporate savings from such measures.

The Northwest Power Planning Council (1989a) notes that forecasts play three important roles in resource planning, beyond estimation of future electricity demands:

First, forecasts of demand define the extent and nature of uncertainty that planners must face. Second, the level of demand is not independent of resource choices, but responds to the costs of resource choices to meet future demands. Finally, sophisticated demand models are needed to assess the potential impacts of choosing conservation programs as alternatives to building new generating resources.

The Council uses its demand models to produce three types of forecasts. The frozen-efficiency forecast (top curve in Fig. 4) estimates electricity use under the assumption that no further improvements in energy efficiency will be made. The price-effects forecast (middle curve in Fig. 4) shows the effects of increasing electricity prices on electricity use. The difference between the price-effects forecast and the sales forecast (bottom curve in Fig. 4) represents the effects of utility programs.

DEMAND-SIDE RESOURCES

A broad range of demand-side resources (both energy efficiency and load management) should be considered to balance the traditional emphasis on utility-owned power plants. These programs should include all customer classes, all major end uses, and a variety of current and emerging technologies. (Some utilities also include any resource that reduces the need for company-owned generation in the category of demand-side options. However, we recommend that purchased power and industrial cogeneration

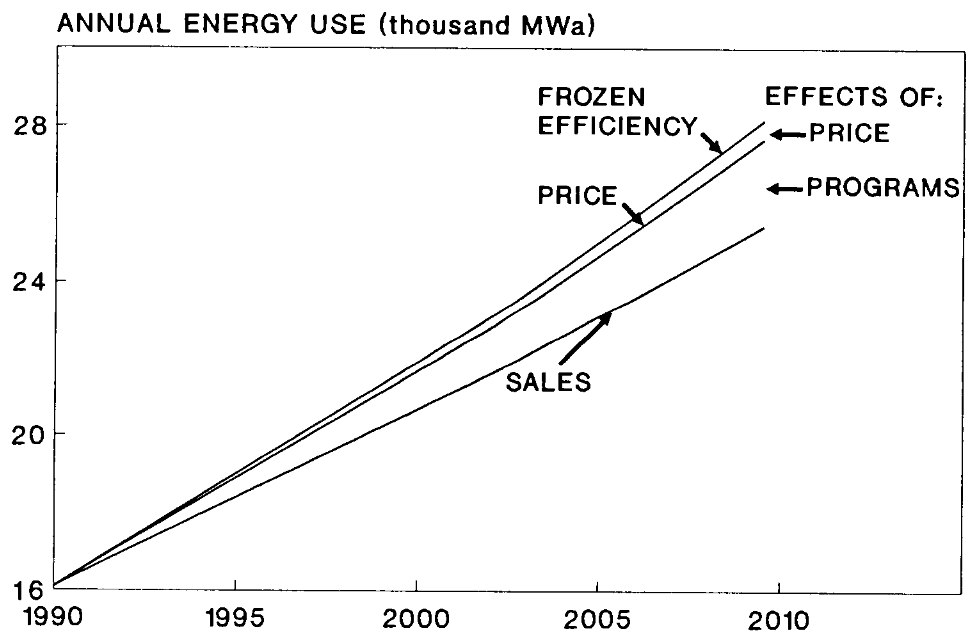

Fig. 4. Electricity-use forecasting concepts used by the Northwest Power Planning Council (1989a). One average MW (MWa) equals 8.76 GWh.

not be included as DSM resources.) DSM resources that are slightly more expensive than supply resources under baseline conditions should not automatically be rejected at this point. These DSM options may later turn out to be attractive as the integration and uncertainty analyses proceed.

This portion of the report should begin with a review of the company's past and ongoing DSM programs. The discussion of each major program should include: program description, annual utility budgets, program participation rates, estimated energy and load effects (and the basis for these estimates), and analysis of program cost-effectiveness. The estimated effects on electricity use should distinguish between net and total savings. (Net savings are those directly attributed to the program, while total savings include market-induced as well as program-induced effects.) The utility should show what evaluations and market research support its knowledge about the process and performance of existing programs.

New York State Electric and Gas, for example, conducted a commercial audit pilot program. The pilot tested two marketing approaches and three audit-pricing approaches (Fig. 5). Different samples of customers were approached either through onsite personal visits from utility staff or by phone and mail. Different samples of these customers were offered free audits, a charge for the audit that was rebated if the customer adopted audit recommendations, or a charge for the audit with no rebate. Results of the pilot showed that participation rates were higher with personal contacts; in spite of the high cost of personal contacts, the cost per audit completed was much lower with personal contact than with the phone/mail approach (Xenergy 1989).

The utility should then discuss new program possibilities, building on its existing programs and a comprehensive assessment of DSM resources in its service area. The results of such an assessment are summarized in conservation and load-management supply curves, which show the amount of resource available at various costs (in ¢/kWh and $/kW). Because much more is known about the residential sector than about the commercial and industrial sectors, special emphasis should be placed on collecting information on the DSM potentials in the latter sectors (Goldman and Kahn 1989).

As part of its plan update, Wisconsin Electric Power (1989) reviewed energy audits of commercial and industrial facilities. These audits had been conducted as part of their DSM program, which began in 1987. These audits identified new conservation and load-management opportunities that were unknown to the company at the time it had prepared its previous resource plan. By the year 2000, new programs intended to capture the additional DSM potential identified in these audits are expected to cut peak demand by 289 MW, in addition to the 167-MW reduction expected from existing programs (Fig. 6).

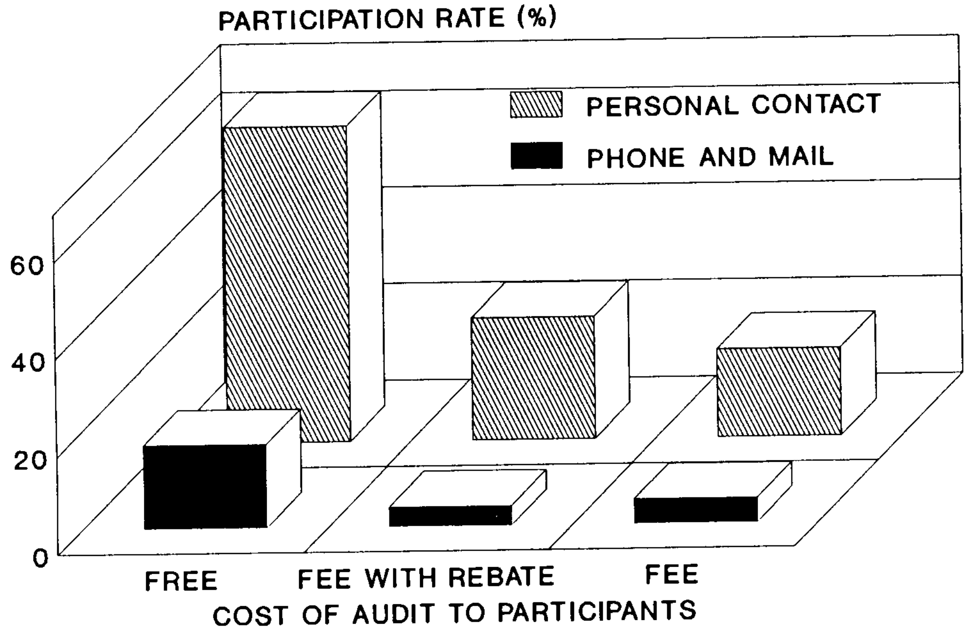

Fig. 5. **Results of a commercial audit pilot program conducted by New York State Electric and Gas. The pilot tested the effects of marketing approach and audit cost on participation rates.**

New programs can include modifications of existing programs (e.g., to gain more participation from existing target markets, to reach new market segments, or to change financial incentives) and initiation of new programs (new end uses, new technologies, or new market segments). DSM options (e.g., electric heat pumps, high-efficiency lighting systems, and industrial cogeneration) should be combined into program designs because that is what the utility delivers to its customers. It is not enough to analyze the costs and electricity savings of high-efficiency lights and motors for commercial buildings. The combination of these measures and the utility's delivery system (e.g., marketing approach and audit cost) is what is relevant. The analysis should build on experience with current programs to develop estimates of administrative costs, program participation rates over time, and energy and load reductions. The utility should also review the experience of other utilities with similar programs.

Each DSM program should then be assessed using the economic tests developed by the California Commissions (1987) or equivalent tests. These tests assess the benefits and costs of DSM programs from the perspectives of participating customers, nonparticipating customers, the utility as whole, and society in general (Table 5). The plan should clearly state which tests are used, how they are used for resource screening and selection, and the sensitivity of the results to the input assumptions. Assumptions concerning program costs, participation rates, and changes in marginal energy and capacity costs are especially important.

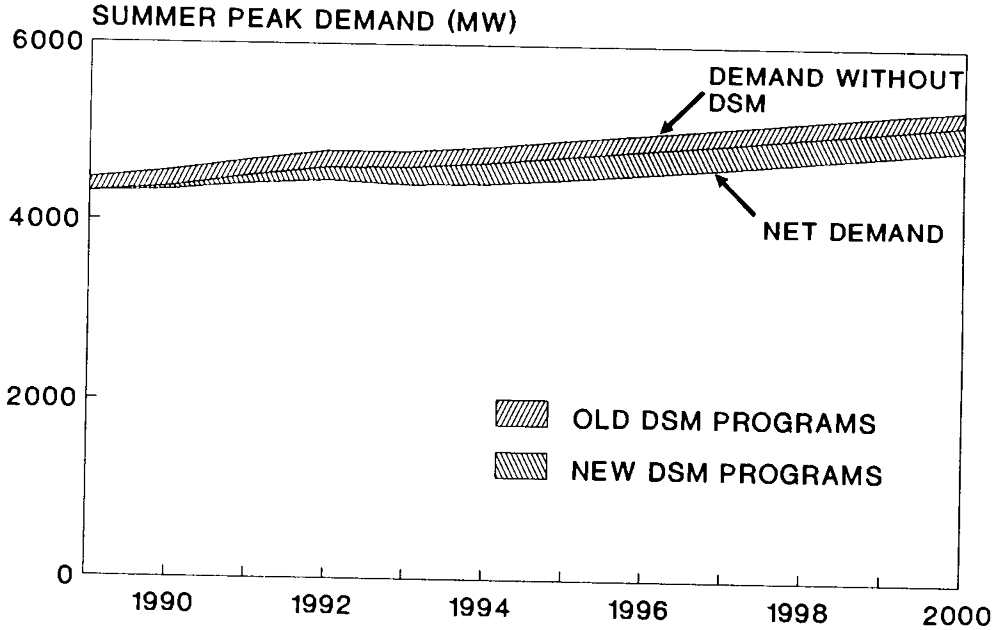

Fig. 6. **Reductions in summer peak demand caused by Wisconsin Electric's demand-side programs. The company's 1989 plan update included additional savings in the commercial and industrial sectors based on energy audits the company had conducted during the previous two years.**

This step should result in the selection of a set of DSM packages (say four to eight). Each package would include several programs aimed at a common objective. The packages could differ by cost-effectiveness and by goal (e.g., cut summer peak vs improve overall energy efficiency). These aggregated program packages would then be used in the resource integration process. More than one implementation rate should be considered for each package to allow program deployment to better match changing system needs.

The documentation for these DSM program packages should include information comparable to that provided for supply resources. Such information includes program participation goals, program budgets, staff requirements, anticipated total and net energy and load-shape effects, and the expected lifetimes of these energy and load reductions. The relationships between new and existing programs and the load forecast should be explained clearly. To the maximum extent possible, the results of program evaluations should be used to develop the estimates of performance for planned programs.

Goldman and Kahn (1989), in their review of DSM plans from New York utilities, developed guidelines to assess the strengths and limitations of these plans. Their guidelines covered the following topics:

Table 5. **Economic tests proposed by the California Public Utilities Commission and the California Energy Commission for use in assessing DSM programs**

Benefit or cost component	Perspective			
	Participant	Rate-payer	Utility	Society
Benefits				
Avoided supply costs (fuel and capital)		X	X	X
Participant incentives	X			
Participant bill reduction	X			
Costs				
Program costs		X	X	X
Participant incentives		X	X	
Lost revenue[a]		X		
Participant costs	X			X

[a]Lost revenue is equal to the participant bill reduction.

Source: Krause and Eto (1988); California Public Utilities Commission and California Energy Commission (1987).

Comprehensiveness of DSM options considered,
Assessment of technical and market potentials for each option,
Inclusion of program administrative and marketing costs,
Program design and implementation,
Economic assessment of DSM programs, and
Commitment of utility staff and funding to assure development of DSM programs.

SUPPLY RESOURCES

The list of supply resources considered should be as complete as possible, including purchased power (from other utilities, facilities that qualify under the federal Public Utility Regulatory Policies Act, and other independent power producers), alternative energy sources (such as photovoltaics, wind, and geothermal), life extension and repowering of existing plants, as well as utility construction of power plants. New or upgraded transmission facilities should be included also.

The data sources used to estimate construction times, construction costs, and operating costs should be listed in an appendix. The relationships between these assumptions about future resources and the costs and performance of existing generating units should be specified. It is especially important to assess the possibility and consequences of higher-than-anticipated construction and operating costs caused by stricter environmental regulations and public opposition to construction of power plants and transmission lines.

The Public Utility Commission of Texas (1989) carefully assessed the potentials for co- and self-generation because this is a large resource in Texas. The total potential for industrial cogeneration in Texas, as of 1986, was 17,000 MW. The commission analyzed the costs of cogeneration as a function of plant size and capacity factor and compared these costs with current and forecast industrial rates for different utilities. These results were summarized in supply curves for individual utilities, an example of which is shown in Fig. 7.

Analysis of customer supply options, such as self-generation, needs to be consistent with the load forecast. The same issues of agreement arise here as do in analysis of DSM resources.

The Northwest Power Planning Council (1989b) discussed ways to improve efficiencies within a utility's transmission and distribution (T&D) system:

> Replacement of transmission and distribution system components, such as transformers and conductors, with components having lower electrical losses.
>
> Modification of system operating conditions, such as lowering nominal voltage levels, to reduce losses. [This option is sometimes called conservation voltage reduction.]
>
> Reconfiguration of the transmission and distribution system. An example is reconfiguring distribution feeders to reduce the average distance, and therefore losses between the substation and its loads.

Unfortunately, most utilities do not consider T&D improvements as a resource. Where the T&D system is discussed at all in an IRP report, it is usually in terms of expanding transmission lines to provide access to other sources of power outside the utility's service area. Of the plans we reviewed, only Green Mountain Power (1989) dealt explicitly with losses in the T&D system.

Green Mountain Power (1989) was unique also in its assessment of resources from independent power producers. The company issued a request for proposals in May 1988 and received 24 proposals in July. The six most promising proposals, primarily for gas-fired combustion turbines, were reviewed in the company's 1989 resource plan.

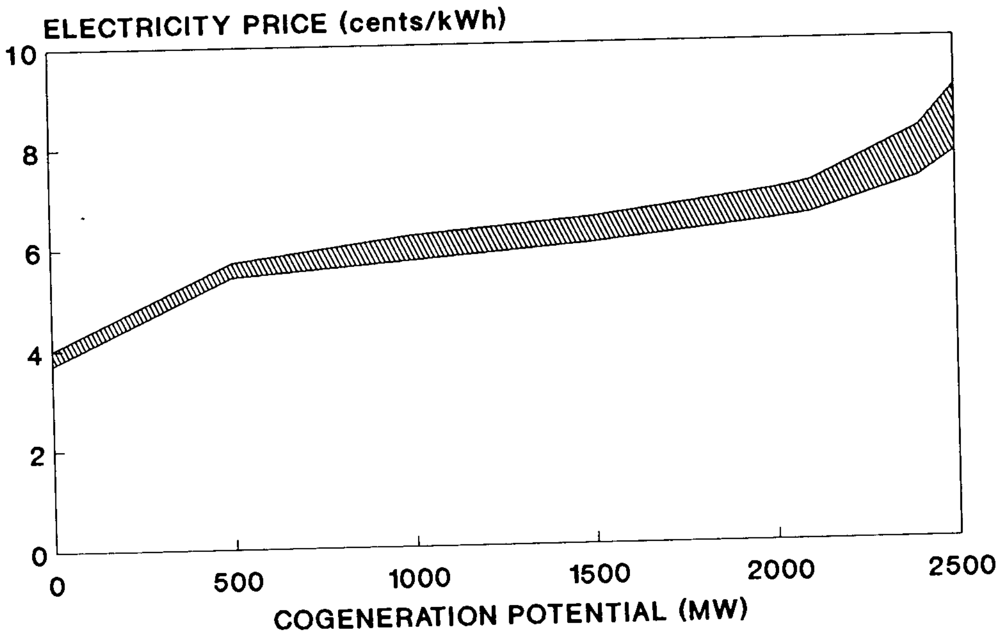

Fig. 7. The relationship between the future amount of cogeneration in the service area of Houston Lighting & Power and the price of electricity as estimated by the Public Utility Commission of Texas (1989). The shaded area reflects uncertainty about the costs of cogeneration and about the response of industrial customers to changes in electricity prices.

The benefits and costs of diversity (in fuel mix, production technology, and power-plant ownership) should be assessed. In addition, the financial and regulatory risks of different resource-acquisition strategies should be considered.

The criteria used to screen supply resources and to select those for further analysis (in the integration phase) should be consistent with the criteria used for demand-side programs. As discussed in the preceding section, these criteria should be defined explicitly and their sensitivity to key assumptions quantified.

INTEGRATION OF DEMAND AND SUPPLY RESOURCES

The selection of resource portfolios can be based on many different criteria (e.g., to minimize revenue requirements, capital costs, or average electricity prices; to ensure adequate reserve margins and the ability to meet high load growth; to maintain certain financial ratios; or to reduce environmental effects of electricity production). The utility should clearly specify what criteria it used in selecting individual resources and choosing among alternative resource mixes. For example, Carolina Power & Light (1989) used several economic, financial, strategic, and reliability factors in assessing resource portfolios (Table 6); each attribute was assigned a numerical weight used to rank alternative plans.

Table 6. **Attributes used by Carolina Power & Light to assess different combinations of demand and supply resources**

Economic attributes	
	Present value of revenue requirements, 1988 to 2016
	Present value of revenue requirements, 1988 to 2005
Financial attributes	
	Times interest coverage
	Percent of construction internally funded
	Present value of dividends, 1988 to 2000
Strategic attributes	
	Resource diversity
	Construction expenditures, 1988 to 1992
	Average electricity price in 1993
	Average annual use of oil for electricity generation
Reliability attributes	
	Reserve margins

Source: Carolina Power & Light Company (1989).

Results for different combinations of supply and demand resources should be shown explicitly. Southern California Edison (1989) began its process with a forecast that assumes no conservation or load management. The company then identified four alternative customer-service strategies; these paths emphasized energy conservation, managed demand, energy productivity, and marketing. The company developed alternative resource plans, including both demand and supply options, to meet each load-growth path and assessed the cost and rate impacts of each path (Table 7). Forecasted sales ranged from 75,000 to 90,000 GWh in 1998 across these four paths. Ultimately, the company selected the energy productivity path as the preferred choice for the next decade.

The methods used to integrate supply and demand resources often involve linkages among several planning models (Eto 1989). In general, screening models are used to develop a short list of resources that are then subjected to more detailed analyses, both individually and in various combinations.

Table 7. Resource additions (1989-1998) and 1998 electricity prices for alternative paths analyzed by Southern California Edison

	Energy Conservation	Managed Demand	Energy Productivity	Energy Marketing
Demand additions (MW)				
Conservation	900	200	300	100
Cool storage	400	200	400	700
Air-conditioner cycling	300	0	300	300
Interruptible rates	400	400	400	400
Subtotal	2000	800	1400	1500
Supply additions (MW)				
Qualifying facilities	1250	1250	1250	1250
Firm purchases	400	750	750	850
Oil/gas units returned to service	0	450	450	700
Other	250	750	850	1400
Subtotal	1900	3200	3300	4200
Total additions, 1989-1998 (MW)	3900	4000	4700	5700
Average price in 1998 (¢/kWh)	13.0	12.3	12.0	12.1

The screening process and criteria have important effects on the final mix of resources chosen for integration. For example, Pacific Power & Light (1989) used an estimate of the cost of a coal plant (5.5 ¢/kWh) to screen DSM programs. After taking all DSM programs with a levelized cost less than this hurdle rate, supply resources were used to meet the remaining gap between projected demands and existing resources. This approach may bias resource selection decisions. In this case, if supply options were available at less than 5.5 ¢/kWh, too much demand resources would have been chosen. On the other hand, if supply resources cost more than 5.5 ¢/kWh, then too few demand resources would have been chosen. The use of a hurdle rate makes practical sense, but uncritical use of such a factor can lead to biased results. A particular subtlety in this example is that the value of DSM resources diminishes as more of these resources are chosen because the reductions in demand reduce short-run marginal costs (i.e., the appropriate hurdle rate).

A related problem in the analysis of DSM programs is that, taken one at a time, they may not warrant adjustments to the utility's capacity-expansion plan. However, in aggregate, their effect may be large enough to defer or cancel some future power plants (Eto et al. 1988; Kahn 1989).

The general issue underlying these observations is that utilities must use a rigorous analytical process that both integrates and incorporates feedbacks among different aspects of the planning problem. In this regard, the planning models used by Seattle City Light (1988) are noteworthy (Fig. 8). The process links several detailed models into an integrated whole, which includes inputs of regional and local economic and demographic determinants of electricity use and wholesale electricity prices from the Bonneville Power Administration. Analyses of electricity demands, production costs, revenue requirements, and electricity prices proceed in an integrated and recursive fashion.

Duke Power (1989) begins its integration process by preparing a reference supply-only resource plan. This plan is developed with a large capacity-expansion model that produces the least-cost mix of supply options to meet future load growth consistent with the existing mix of power plants. Duke then adds each candidate DSM program to the resource mix to assess its cost effectiveness relative to the optimized supply-only plan. Those DSM programs that are cost effective are then combined into various packages, and the packages are tested against the supply-only plan. The final plan includes those DSM programs that are more cost effective than the reference supply plan and those supply resources that were still cost effective after addition of the DSM programs.

Other utilities, including New England Electric, Puget Power, and Pacific Power & Light test various combinations of demand and supply alternatives in the search for a preferred mix of resources. Rather than begin with an optimized supply plan, they combine demand and supply options from the beginning.

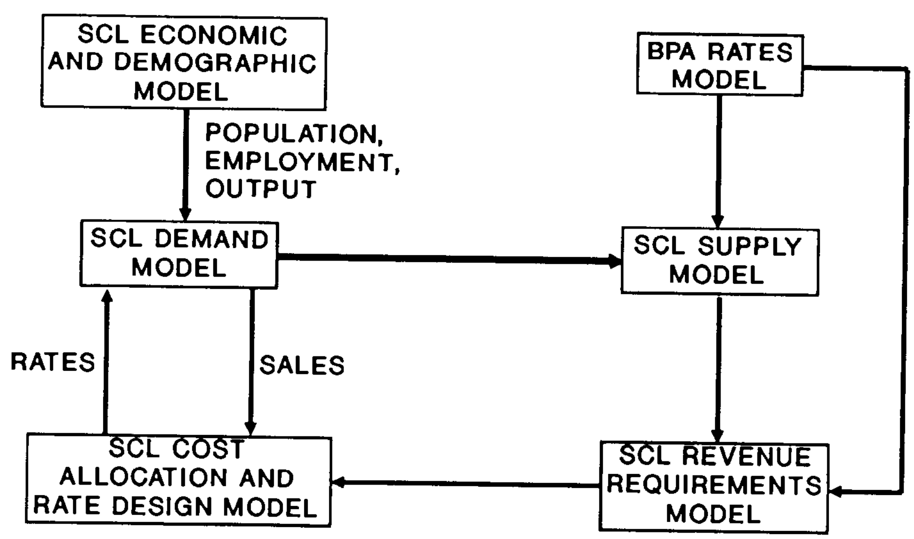

Fig. 8. **Individual models and their integration used by Seattle City Light (1988).**

Regardless of the type of models or particular approach used, it is not sufficient to treat demand as a subtraction from the load forecast and then analyze supply options only, as some utilities do (top part of Fig. 9). Subtracting DSM-program effects from the forecast and using the resultant "net" forecast for resource planning eliminates DSM programs from all integrating analysis. This approach makes it difficult to assess alternative combinations of DSM programs and supply resources and the uncertainties, risks, and risk-reduction benefits of DSM programs (e.g., small unit size and short lead time). Demand-side resources should be treated in a fashion that is both substantively and analytically consistent with the treatment of supply resources so that demand and supply resources compete head to head (bottom part of Fig. 9). The plan must show how the process integrates and coordinates key functions within the utility: load forecasting, DSM resources, supply resources, finances, rates, and the important feedbacks among these components (especially between rates and future loads).

If several models are linked together to integrate resources, data transfers are an important problem. Differences among the models will probably require simplification of data transfers and clear definitions of each data element to ensure consistency across models. Using several models, with sequential model runs and transfers of data among models, is time consuming and will reduce the number of computer runs that can be conducted.

During the past few years, several computer models, some of which run on microcomputers, have been developed that perform the integration shown in the bottom part of Fig. 9. Examples include the Load Management Strategy Testing Model, Multiobjective Integrated Decision Analysis Model, Conservation Policy Analysis Model, and UPLAN; as examples, see Farber, Brusger, and Gerber (1988), Ford and Geinzer (1988), and USAM Center (1988). While these models can facilitate the integration process, potential users should be aware of the limitations of these models. First, these models often do not replace the existing, stand-alone models used by the utility. Consequently, they must be benchmarked to the stand-alone models. Second, the ability of these integrated models to represent load-shapes often outstrips the available data, which creates a reliance on defaults whose relevance to the particular utility must be scrutinized. Third, deferred or cancelled power plants must be input to these models. Fourth, although feedback effects are included in the integrated models, the treatment of electricity-price changes on future demands is often primitive. Typically, load forecasts are input to the integrated model from a stand-alone forecasting model.

Finally, the analysis must be carried out far enough into the future (e.g., at least 20 years) to capture the end effects associated with long-lived resources, such as coal plants and DSM programs aimed at new construction. The plan should explicitly recognize the time horizons required for different aspects of resource planning: 2 to 3 years for the action plan, 10 to 15 years for resource planning, and 20 to 30 years for analysis.

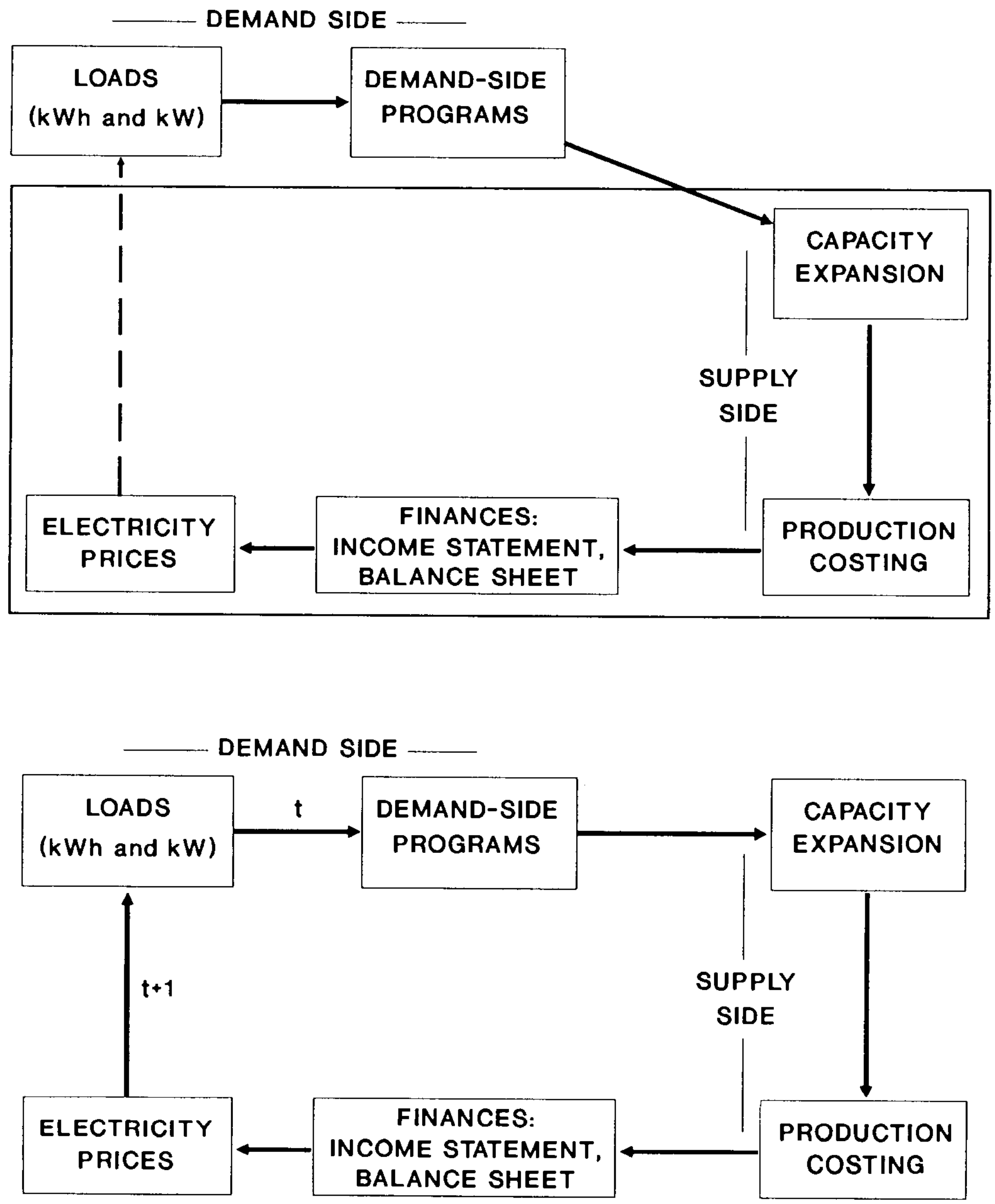

Fig. 9. Different approaches used to assess demand and supply resources. The top part shows the traditional approach, still used by some utilities. The bottom part shows an integrated approach, embodied in several recently developed planning models. In this figure, t refers to the year of analysis.

UNCERTAINTY ANALYSIS

A thorough analysis of a variety of plausible future conditions and the options available to deal with them is essential to a good plan. Such an analysis would use one or more of the following techniques: scenario analysis, sensitivity analysis, portfolio analysis, and probabilistic analysis (Table 8). These techniques should be used to assess uncertainties about both the utility's external environment and factors at least partly under the utility's control.

Uncertainties about the external environment include economic growth, inflation rates, fossil-fuel prices, and regulation. As Shealy's (1989) discussion of oil prices showed, it is very difficult to forecast fuel prices accurately (Fig. 10): "The predicted price [of crude oil] goes through a grand cycle, beginning around $10/barrel in 1977, rising steadily to a peak of $27/barrel in 1981, then declining to a minimum of $6/barrel in 1988." The consistent inability of forecasting organizations to predict accurately the trend of oil prices suggests the need for humility in estimation of future electricity demand, fuel prices, and other factors that affect the costs and amounts of resource acquisition. Therefore, the ranges (or distributions) of future values for these external factors should be quite broad.

Table 8. **Analytical techniques used to treat uncertainty**

Scenario	Alternative, internally consistent, futures are first constructed and then resource options are identified to meet each future. Best options can then be combined into a unified plan.
Sensitivity	Preferred plan (combination of options) is first identified. Key factors are then varied to see how the plan responds to these variations.
Portfolio	Multiple plans are developed, each of which meets different corporate goals. Often, these plans are then subjected to sensitivity analysis.
Probabilistic	Probabilities are assigned to different values of key uncertain variables, and outcomes are identified that are associated with the different values of the key factors in combination. Results include the expected value and cumulative probability distribution for key outcomes, such as electricity price and revenue requirements.

Source: Hirst and Schweitzer (1988).

The uncertainty analysis should also consider uncertainties about the costs and performance of different demand and supply resources (Hirst and Schweitzer 1988). The analysis should show how utility resource-acquisition decisions are affected by these different assumptions and show the effects of these uncertainties and decisions on customer and utility costs. Differences among resources in unit size, construction time, capital cost, and operating performance should be considered for how they affect the uncertainties faced by utilities. The assumptions must be varied in ways that are internally consistent and plausible. Pacific Power & Light (1989) developed different, scenario-specific mixes

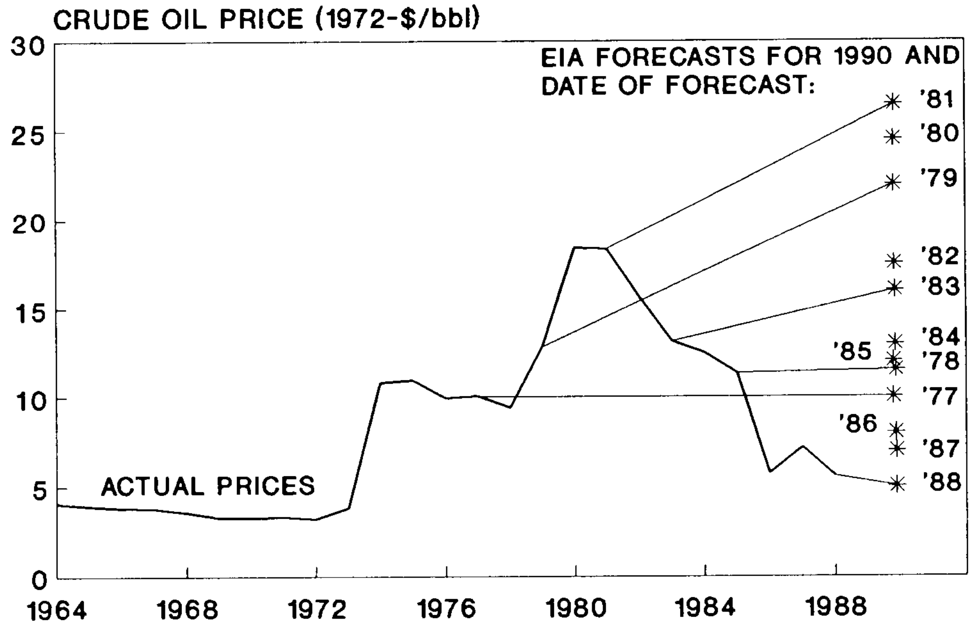

Fig. 10. **Comparison of actual crude oil prices and forecasts made by the Energy Information Administration between 1977 and 1988 (Shealy 1989). The dark line shows actual prices from 1964 through 1988. The light lines show the forecasts of 1990 oil prices made by EIA in different years (shown on the far right).**

of DSM programs, power purchases, cogeneration, alternative schedules for plant maintenance, renewable resources, and improved operation of existing power plants. For each scenario, results were presented on the amounts of each resource acquired; utility operating revenues; average electricity prices; and emissions of sulfur dioxide, nitrogen oxides, and carbon dioxide. The company provided details on the results of its scenario analysis and showed results in a compact form (Fig. 11).

Pacific Gas and Electric (1988) presented results of its sensitivity analysis in a similarly graphic and effective fashion (Fig. 12). The chart shows that the most important uncertainties affecting the price of electricity are load growth and oil prices.

While many utilities consider uncertainties about supply resources, few pay explicit attention to uncertainties about DSM programs (in part, because of the models that utilities use for such analyses; see Fig. 9). New England Electric (1989) conducted probability analyses as part of its IRP. Staff from various departments assessed the probabilities associated with the performance of the different demand and supply resources being considered. The purpose of this analysis was "to provide an estimate of how certain [New England Electric] can be that a given resource plan will meet future needs." The probabilities of meeting target conservation and load management MW reductions are shown in Fig. 13. For example, DSM programs have an 80% chance of reducing peak demands by at least 400 Mw in 1995 and a 50% probability of cutting demands by at least 580 MW that year. The company selected as a planning goal an 80% probability that, in the first five years (i.e., through 1995), planned resources will meet or exceed projected requirements. This analysis was especially appealing because it combined scenario and probability analyses to develop useful results.

That some uncertainties are much more significant than others and that some can be influenced by the utility is often lost in the details of analysis. A reasoned treatment of the most important uncertainties that the utility can influence is far more valuable than an exhaustive treatment of all uncertainties with little regard for their importance.

Finally, the links between the results of these uncertainty analyses and the utility's resource-acquisition decisions must be demonstrated. The uncertainty analysis should demonstrate the robustness of the selected resource plan. The mix of resources selected should be able to withstand the shocks of different futures and should minimize the risks associated with various adverse outcomes (e.g., rapid increases in oil prices or a moratorium on nuclear power).

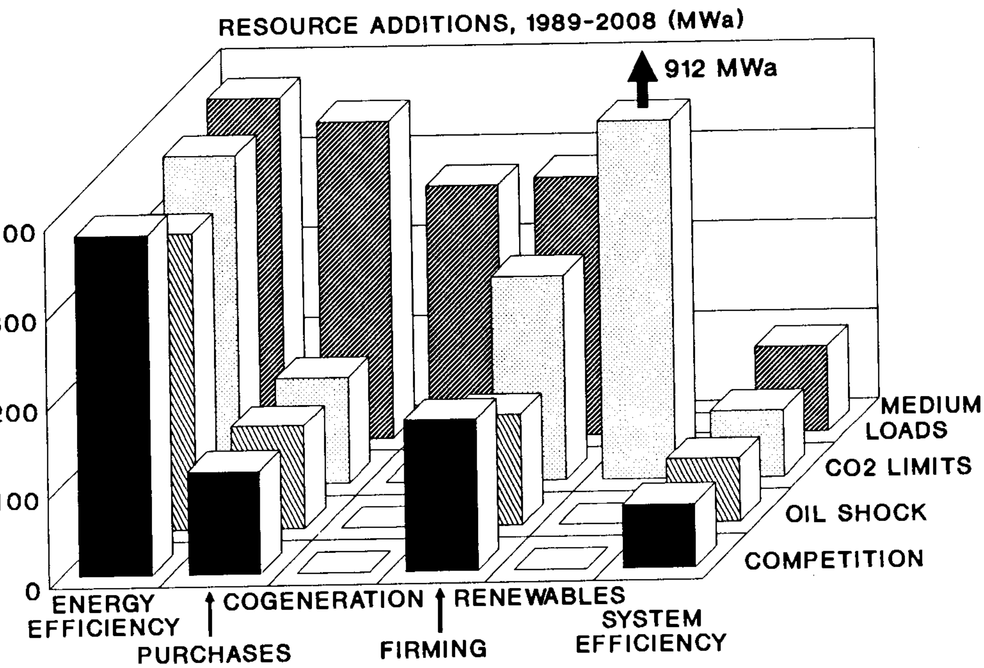

Fig. 11. Results of a scenario analysis conducted by Pacific Power & Light (1989). This diagram displays the amounts and types of resources that the utility would acquire under three scenarios and under baseline conditions (medium load growth).

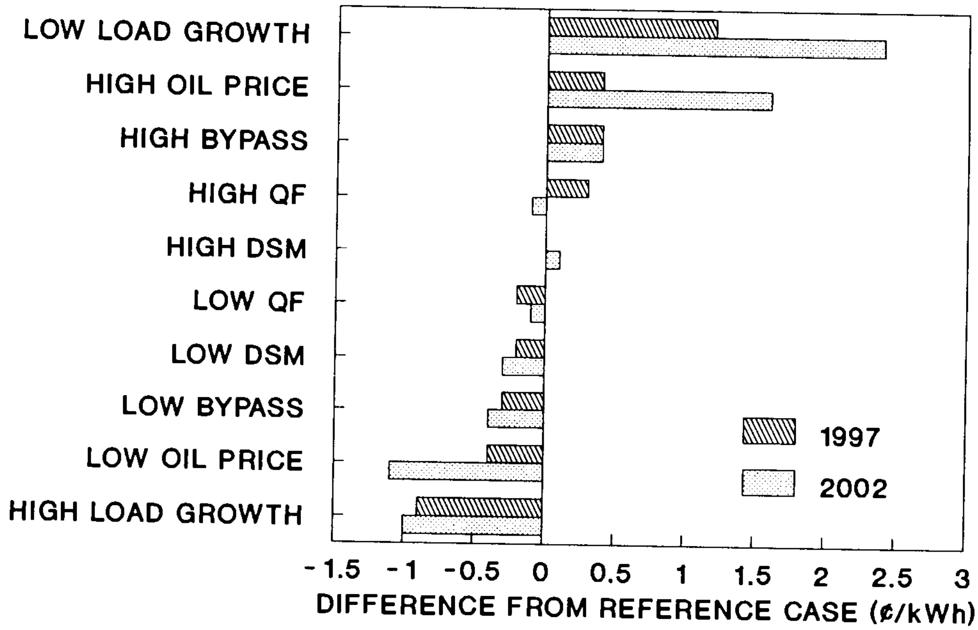

Fig. 12. Results of a sensitivity analysis conducted by Pacific Gas and Electric (1988). This bar chart shows the estimated effects of changes in five factors on electricity prices in 1997 and 2002. Nominal prices in the reference case are 14.2 and 17.7 ¢/kWh in 1997 and 2002, respectively. QF refers to qualifying facilities, under the 1978 federal Public Utility Regulatory Policies Act.

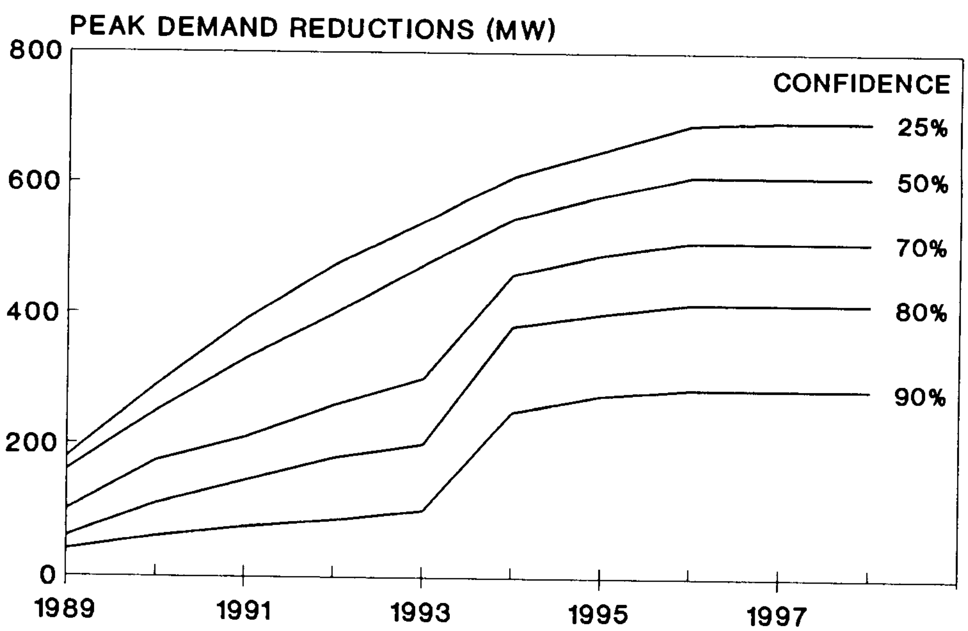

Fig. 13. A probability analysis of the performance of planned DSM programs to be run by New England Electric (1989). Each curve shows the minimum amount of peak demand reduction expected for each year for a given confidence level.

SHORT-TERM ACTION PLAN

The utility's action plan is, in many ways, the "bottom line" of the resource plan. Because it reflects the utility's commitment to specific actions, it may be the most important part of the plan. However, more than half of the plans reviewed did not include a formal action plan. Submitting an action plan with the resource plan is preferable to preparing separate budget documents because the action plan is more accessible to regulators and the public and allows for easier assessment of the consistency between the short- and long-term plans.

The action plan must be consistent with the long-term resource plan to assure that what is presented as appropriate for the long haul is actually implemented, and implemented in an efficient manner. If, for example, the long-term plan calls for acquisition of baseload power in ten years, the short-term plan should call for initial site selection, environmental assessment, and facility design. Alternatively, a short-term plan that included marketing programs to boost off-peak sales might be inconsistent with a long-term need for additional baseload power.

The action plan also should be specific and detailed. The reader should be able to judge the utility's commitment to different actions from this short-term plan. Specific tasks should be identified, along with organizational assignments, milestones, and budgets. The action plan should present the utility's expected accomplishments during the next one to three years, including the number of participants and the reductions in annual energy use, summer peak, and winter peak for each DSM program.

Such detail serves two purposes within the utility. First, preparing the action plan necessarily involves those departments that are responsible for implementation, thus encouraging the planners and operators to work closely. Thus, the action plan is more likely to be implementable than if it is developed by planners alone. Second, the detail provides a useful road map for its implementors.

The action plan can be used by PUCs to ensure that utility budgets and rate-case filings are consistent with the long-term resource plan.

The Bonneville Power Administration (1989) prepared an action plan that shows budgets and resource acquisitions year by year from 1990 through 1993. Estimates for DSM resources are presented separately for the residential, commercial, industrial, and agricultural sectors. For example, Bonneville plans to spend $40 million on residential conservation programs in 1991 with an expected energy savings of 7 MWa.

The action plan should also discuss the data and analysis activities, such as model development, data collection, and updated resource assessments, needed to prepare for the next integrated resource plan. The Bonneville (1989) plan presents its intentions to study alternative acquisition approaches (competitive bidding and utility-designed programs, in particular), preservation of two mothballed nuclear plants, and the need to reduce carbon emissions.

The action plan should include a progress report showing the utility's accomplishments in meeting the goals of its prior action plans. Puget Power (1989) included a table summarizing accomplishments from its 1987 action plan and a 50-page appendix on *Action Plan Status*. For each of the 18 action items, the appendix presented a description of the item from the 1987 plan, a discussion of activities in 1988 and 1989, findings, and conclusions.

Both the utility and readers of the IRP report should recognize that not all the projects presented in the action plan will be completed as specified. As circumstances and opportunities change, the utility should respond accordingly. Thus, the action plan is the utility's plan as of a certain date. Because changes will occur in the utility's environment (e.g., local economic growth, fossil-fuel prices, or environmental regulations), the plan should indicate how, and under what circumstances, the utility will revise its action plan.

OUTCOMES FOR INTERESTED PARTIES

A final criterion by which a plan can be judged is the effect of its recommended actions on various groups. Because the interests of all stakeholders are not identical, the ways in which they will be affected by utility actions differ. Therefore, utilities should seek the advice of and inputs from different groups as they develop long-term resource plans. In addition, utilities should report results for their plans along enough dimensions so that different groups can assess the plan's effects on them.

Different interests implicitly weight different attributes of resource plans in different ways. These attributes include short- and long-term electricity prices and costs, shareholder earnings, power availability, pollution from electricity production, and other results of utility actions. For example, customers will be interested in electricity bills, utility shareholders in earnings, bondholders in interest coverage, and regulators in various outcomes, including emissions of pollutants. Northeast Utilities (1989), as part of its planning process, identified several "themes [that] are intended to reflect NU's interpretation of current public and corporate policy objectives, and are useful in helping decision makers compare alternative resource plans that emphasize different objectives." The company's themes include resource portfolios that emphasize energy efficiency in construction of new buildings, use of small-scale supply resources, and reductions in dependence on oil-fired generation.

Without two-way communication between the utility and its customers and interest groups, a plan is in danger of ignoring community needs (Wolfe 1988). Accordingly, the plan should present evidence that the utility sought ideas and advice from its customers and other interested parties. For example, customers and public interest groups are likely to be interested primarily in DSM programs that emphasize energy efficiency, while utility interests might focus on programs that control peak loads. Energy experts from the state university, the state energy office, the PUC, environmental groups, and organizations representing industrial customers could be consulted as the plan is being developed. Utilities in New England are working closely with the Conservation Law Foundation to design, implement, and evaluate DSM programs (Ellis 1989). Such public involvement might cause short-term delays for the utility, but is likely to serve long-range utility and societal interests.

Utilities in the Pacific Northwest, including Puget Power and Pacific Power & Light, invite customers to participate in plan development and review. The Bonneville Power Administration publishes the *Journal*, "a monthly newsletter for customers and interested publics," subtitled "What's New and How to Get Involved." And the Northwest Power Planning Council has an extensive public-involvement process, including a monthly newsletter *Update*, public comment on issue papers, and public hearings held throughout the four-state region.

Some utilities rely on outside experts to independently assess the utility's planning process and plan. For example, New England Electric has a Demand Side Advisory Board comprised of industrial customers, university professors, environmental groups, and utility management (Destribats 1989).

The interests of the utility, its customers, and its regulators may not all be well met by a single plan. For example, actions taken to reduce utility risks, like purchasing power from other utilities, may assure short-term company profits and stable electricity prices but result in capacity shortages or higher prices in the long run. Thus, construction of some baseload capacity (although such plants have high capital costs and long construction times) may be prudent because of the low long-term operating costs such plants enjoy.

The acceptability to specific groups of impacts resulting from a given plan will be judged by the interested parties themselves. The plan must provide sufficient information so that different groups can assess the costs and benefits to them of the utility's plan. Wisconsin Electric (1989) presented results for three plans that differed in the company's DSM programs. For each plan, estimates were given of annual revenue requirements, total (utility plus customer) costs, electricity prices, sulfur dioxide emissions, nitrogen oxide emissions, particulate emissions, ash production, and capital requirements. These estimates should provide the information different groups need to assess roughly the benefits and costs of different resource-acquisition strategies. Thus, the economic and other criteria used to include specific resources must be clearly specified; the effects of these criteria on selection of individual resource options must also be stated.

It is unlikely that utility attention to the interests and concerns of different groups will eliminate controversy about utility actions. However, such attention will yield some areas of consensus (which should be presented in the planning report) and will more sharply define the areas where disagreements still exist.

CONCLUSIONS

Integrated-resource planning is a new and powerful way for utilities to provide desired energy services to their customers at reasonable cost. IRP includes a broad array of supply and demand resources, explicit treatment of uncertainty, environmental costs as well as direct economic costs, and public involvement. Because of these features, IRP is likely to yield a better mix of resources and fewer protracted controversies among the utility, its regulator, and the public than would traditional planning approaches.

The long-term resource plans filed by utilities with their public utility commissions represent key outputs from this IRP process. It is therefore important to develop criteria to use in preparing and assessing these plans. The guidelines discussed here focus on the analytical rather than prescriptive aspects of these long-term resource plans. These suggestions deal with the readability of the plan, the technical competence demonstrated in developing the plan, the specificity of the short-term action plan, and the extent to which the plan addresses concerns of different stakeholders.

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REFERENCES

Bonneville Power Administration 1989, *Draft 1990 Resource Program*, Portland, OR, December.

Boston Edison Company 1988, *Boston Edison's Integrated Resource Plan 1988-2011: A Flexible, Least Cost Planning Approach*, Boston, MA, February.

California Public Utilities Commission and California Energy Commission 1987, *Standard Practice Manual, Economic Analysis of Demand-Side Management Programs*, P-400-87-006, San Francisco and Sacramento, CA, December.

Carolina Power & Light Company 1989, *CP&L Exhibits 1, 2 and 3, Before the North Carolina Utilities Commission, Docket No. E-100, Sub 58*, Raleigh, NC, April.

R. C. Cavanagh 1986, "Least-Cost Planning Imperatives for Electric Utilities and Their Regulators, *The Harvard Environmental Law Review 10*(2), 299-344.

J. Chamberlin, T. Fry, and C. L. Matheny Braithwait 1988, *Status of Least-Cost Planning in the United States*, EPRI EM-6133, Electric Power Research Institute, Palo Alto, CA, December.

A. F. Destribats 1989, "Implementation, Evaluation and Incentives," presented at the Demand Side Management National Conference, Electric Council of New England, Boston, MA, November.

D. J. Donovan and M. F. Germer 1989, "Integrated Utility Resource Planning in Practice," *Public Utilities Fortnightly 124*(4), 15-21, August 17.

Duke Power Company 1989, *Least-Cost Integrated Resource Planning 1989*, Charlotte, NC, April.

M. H. Dworkin 1989, *Hearing Officer's Report and Proposal for Decision, Investigation into Least-Cost Investments, Energy Efficiency, Conservation, and Management of Demand for Energy*, Docket No. 5270, Vermont Public Service Board, Montpelier, VT, July.

W. B. Ellis 1989, "The Collaborative Process in Utility Resource Planning," *Public Utilities Fortnightly 123*(13), 9-12, June 22.

J. Eto 1989, *An Overview of Integrated Resource Planning Models*, LBL-28842, Lawrence Berkeley Laboratory, Berkeley, CA.

J. Eto et al. 1988, "Integrated Analysis of Demand-Side Programs," *IEEE Transactions on Power Systems 3*(4), 1397.

M. Farber, E. Brusger, and M. Gerber 1988, *Multiobjective Integrated Decision Analysis System (MIDAS), Volume 1: Model Overview*, EPRI P-5402, Temple, Barker and Sloane, Inc. and M. S. Gerber and Associates, prepared for the Electric Power Research Institute, Palo Alto, CA, April.

A. Ford and J. Geinzer 1988, *The Impact of Performance Standards on the Uncertainty of the Pacific Northwest Electric System*, University of Southern California and Applied Energy Services, prepared for the Office of Conservation, Bonneville Power Administration, Portland, OR, February.

C. Goldman and E. Kahn 1989, *Review of the Demand-Side Management Plans of Four New York Utilities*, LBL-26374, Lawrence Berkeley Laboratory, Berkeley, CA, February.

C. Goldman, E. Hirst, and F. Krause 1989, *Least-Cost Planning in the Utility Sector: Progress and Challenges*, LBL-27130 and ORNL/CON-284, Lawrence Berkeley Laboratory, Berkeley, CA, and Oak Ridge National Laboratory, Oak Ridge, TN, May.

Green Mountain Power Corp. 1989, *Integrated Resource Plan*, South Burlington, VT, February.

E. Hirst 1988, "Integrated Resource Planning: The Role of Regulatory Commissions," *Public Utilities Fortnightly 122*(6), 34-42, September 15.

E. Hirst 1988, *Effects of Energy-Efficiency Programs on Load-Growth Uncertainty for Electric Utilities*, ORNL/CON-260, Oak Ridge National Laboratory, Oak Ridge, TN, August.

E. Hirst and M. Schweitzer 1988, *Uncertainty in Long-Term Resource Planning for Electric Utilities*, ORNL/CON-272, Oak Ridge National Laboratory, Oak Ridge, TN, December.

E. Kahn 1989, "Proxy Plant Valuation Methods for Demand-Side Utility Programs," *Energy 14*(1), 9-22, January.

F. Krause and J. Eto 1988, *Least-Cost Utility Planning Handbook for Public Utility Commissioners, Volume 2, The Demand Side: Conceptual and Methodological Issues*, Lawrence Berkeley Laboratory, prepared for the National Association of Regulatory Utility Commissioners, Washington, DC, December.

C. Mitchell and J. Wellinghoff 1989, "Status of Least Cost Utility Planning in the United States," draft, Attorney General's Office of Advocate for Customers of Public Utilities, Carson City, NV, October.

National Association of Regulatory Utility Commissioners 1988, *Least-Cost Utility Planning, A Handbook for Utility Commissioners*, Washington, DC, October.

New England Electric 1989, *Conservation and Load Management Annual Report*, Westborough, MA, May.

North American Electric Reliability Council 1989, *1989 Reliability Assessment, The Future of Bulk Electric System Reliability in North America 1989-1998*, Princeton, NJ, September.

Northeast Utilities 1989, *1989 Forecast of Loads and Resources for 1989-1998*, Hartford, CT, March.

Northwest Power Planning Council 1989a, *1989 Supplement to the 1986 Northwest Conservation and Electric Power Plan, Volume II*, Portland, OR.

Northwest Power Planning Council 1989b, *Transmission and Distribution Loss Reduction*, Staff Issue Paper 89-29, Portland, OR, October.

Pacific Gas and Electric Company 1988, *Long-Term Planning, Application No. 88-12-005, 1990 Test Year*, San Francisco, CA, December.

Pacific Power & Light Company and Utah Power & Light Company 1989, *Planning for Stable Growth*, Portland, OR, November.

Public Utility Commission of Texas 1989, *Long-Term Electric Peak Demand and Capacity Resource Forecast for Texas 1988*, Austin, TX, February.

Puget Sound Power & Light Company 1989, *Demand and Resource Evaluation: Securing Future Opportunities, 1990-1991*, Bellevue, WA, December.

M. Schweitzer 1981, "The Basic-Questions Approach to Social Impact Assessment," *Environmental Impact Assessment Review* 2(3), 294-299.

M. Schweitzer, E. Yourstone, and E. Hirst 1990, *Key Issues in Electric-Utility Integrated Resource Planning: Findings from a Nationwide Study*, ORNL/CON-300, Oak Ridge National Laboratory, Oak Ridge, TN, forthcoming.

Seattle City Light 1987, *Strategic Corporate Plan*, Seattle, WA, June.

Seattle City Light 1988, *Long Range Load Forecast, 1988-2010, Technical Documentation*, Power Supply and Planning Department, Seattle, WA, November.

M. T. Shealy 1989, "A Review of Energy Forecasts: What Have We Learned?," pp. 353-362 in *Energy Markets in the 1990s and Beyond*, Proceedings of the Eleventh Annual North American Conference of the International Association of Energy Economists, Washington, DC, October.

Southern California Edison Company 1989, *Least-Cost Resource Planning*, Rosemead, CA, March.

Temple, Barker and Sloane, Inc. 1986, *Department of Energy Least-Cost Utility Planning Research Agenda*, prepared for the U.S. Department of Energy, Washington, DC, May.

USAM Center 1988, *UPLAN - III, The Integrated Utility Planning System*, Los Altos, CA.

Wisconsin Electric Power Company 1989, *Integrated Resource Plan in Support of the Concord Generating Station*, Milwaukee, WI, May.

A. K. Wolfe 1988, "Risk Communication: Who's Educating Whom?," *Practicing Anthropology 10*(3-4), 13-14.

Xenergy, Inc. 1989, *Final Report, Commercial Audit Pilot*, draft, prepared for New York State Electric and Gas Corp., Binghamton, NY.

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