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Volume 2: Technical Appendix

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LEAST-COST PLANNING IN THE UTILITY SECTOR: PROGRESS AND CHALLENGES

Volume 2: Technical Appendix

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PREFACE

This report is the technical appendix of an LBL/ORNL study that was commissioned by the Department of Energy to review recent progress in least-cost utility planning in the United States, entitled "Least-Cost Utility Planning in the Utility Sector: Progress and Challenges."[1] This appendix contains the contributions of many authors on important topics related to integrated resource planning. The editors used this material as the basis for the study and formulation of recommendations regarding priorities for future work on least-cost planning.

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

1. THE PROCESS OF LEAST-COST PLANNING

1.1 Setting Up an LCUP Framework

Lead Author: Eric Hirst

Background

Least-cost utility planning is much more than the data and models used to analyze alternative resource portfolios in the effort to identify those that are "least-cost". LCUP is, more than anything else, a process. This section discusses some of the elements of that process, reviews what we know about progress in the area, and suggests additional research that DOE's LCUP program might sponsor.

Issues

Perhaps the most important ingredients of successful LCUP processes are the three Cs: communication, cooperation, and consensus. These elements are important goals to strive for within a utility and also between a utility and its key stake holders (PUC, customers, potential intervenors).

Surprisingly little information is available in the literature on these ingredients of the planning process. Compared to the amount of material on quantitative planning methods (data and models) and on the results of utility plans, there is very little available to guide utilities and commissions on development of useful planning approaches. We are aware of a few publications in the "grey" literature, including papers on planning at Wisconsin Electric Power Company, the Salt River Project, and Puget Sound Power and Light Company (Hirst and Knutsen 1988). There are also a few publications that describe the process and results associated with Nevada's development of its LCUP rules in 1984, and planning activities in a few other states (California, Wisconsin, Massachusetts, and Florida).

Traditionally, much of the planning within electric utilities was decentralized. The generation planners, T&D planners, market researchers, and rate analysts worked independently of each other. Integrated resource planning, however, requires that these functions be coordinated. This requires that the various groups develop common languages and methods to identify, compare, and assess alternative approaches to meeting future customer needs. In some utilities, the generation planners have little regard for those in market research (the people who plan the company's demand-side management programs).

Generation planners sometimes believe that the DSM proponents have virtually no data to support their estimates of the benefits and costs of DSM programs and that, in any case, these programs are likely to have only negligible effects on system load shapes and trends. Staff in the market research and customer service departments, on the other hand, believe that generation planners are too narrow in their "engineering" approach to the utility's current situation. Fortunately, in many utilities, analysts and planners are able to work cooperatively. A few case studies of successful utilities would help to identify the factors that lead to truly integrated planning. In particular, guidance on the role of corporate structure is needed.

In addition to internal cooperation, it may be helpful to improve relations between utilities and their regulators. Here, too, there is much history to overcome. Staff in many utilities and PUCs are skeptical about the motives of their counterparts because of the often bruising confrontations associated with rate cases and prudency reviews during the past several years. On the other hand, utility and commission staffs in several states are beginning to meet informally, outside the hearing room and away from lawyers. In some cases, the staffs have been able to agree on certain programs that are then taken to the commissioners for their formal approval (the stipulation process). More needs to be learned about how such informal negotiations can best be structured to yield agreement on difficult issues and how to ensure that potential interveners have access to this process. Doubts have been raised about the social benefits of greater informal communication between utilities and commissions; some fear that this may lead to a situation in which the commission no longer represents the public view and is too closely aligned with the utility. Thus, more work is needed to assess the benefits and problems associated with additional contact between utility and commission staffs.

A critical concern in developing an integrated planning process is assuring that alternative resources are given "appropriate" consideration. This involves much more than agreement on the economic tests to use in assessing programs. It involves the consistency of levels of effort (executive attention, staff time, and money) that a utility makes with respect to different types of resources. For example, if preliminary analysis suggests that comparable amounts of demand and supply resources are available at comparable costs, then one would expect the utility to devote comparable efforts to defining and acquiring supply and demand resources.

Relevant DOE/LCUP and Other Projects

The ongoing DOE/LCUP projects in Wisconsin, Minnesota, and Texas may shed light on issues related to improved cooperation within utilities and between utilities and commissions. In Minnesota, staff at the PSC are using an integrated planning model to develop least-cost plans for two Minnesota utilities, one winter peaking and one summer peaking. The input data and resource strategies to consider are being developed cooperatively by utility and PSC staff. It will be useful to see what effects a commission's use of planning models have on utility plans and their planning processes.

In Wisconsin, the PSC staff worked with staff at utilities and the University of Wisconsin to establish cooperative research and analysis activities related to electric-utility DSM programs.

The Austin, Texas LCUP project deals with the integrated planning process within city government. Two municipal departments are involved in planning: the utility department and the resource management department. This LCUP project will document Austin's internal activities to better coordinate and integrate planning for demand and supply resources.

The Ohio and Renewables Institute projects may also improve understanding about successful LCUP processes. The Ohio project is intended to ensure that nonutility cogeneration resources are adequately considered in resource planning and the Renewable Institute process has a similar goal for renewable energy projects.

There is surely a great deal of work underway within individual utilities, individual commissions, and between commissions and utilities on these issues. Unfortunately, the results of these activities are generally not available to others. For example, a particular utility might review alternative ways to gain public participation in its planning process, select an approach to try, and gain experience in this area. However, because utility staff have little incentive to publish, the utility's insights and knowledge about public participation are largely unavailable to others. There are also questions about the extent to which experiences in one state can be generalized to other locations and situations.

Future Work

- Conduct case studies with a few utilities and/or commissions to document the processes used by these organizations. Focus less on the quantitative aspects of planning and more on the planning process. Compare efforts among utilities to collect, organize, and synthesize information on supply vs. demand resources.
- Review the public involvement processes adopted by various utilities to determine the ingredients of success. Success is defined here as a process that allows early and easy access to the utility's planning. The approach adopted by the Northwest Power Planning Council would be a useful one to study.
- Assess the process used by different commissions to review the long-term resource plans filed by their utilities. Assess the comprehensiveness of these reviews and the commission's consistency in adhering to their least-cost planning rules and procedures.

1.2 Tracking the Status of LCUP Policy and Programs

Lead Author: Mark D. Levine

Background

As discussed above, substantial changes which have affected electric utilities over the past 15 years have led to considerable changes in planning tools and planning processes. Efforts are needed to continue these improvements and to disseminate results from leading edge utilities and commissions to others.

Issues

One of the primary objectives of DOE's LCUP program is to influence the overall utility planning process to achieve results in the "real world." To assess developments in the industry, it is first necessary to track the activities of utilities and their regulatory commissions. This involves an assessment of (1) least-cost planning among utilities and regulatory commissions, (2) actual programs resulting from least-cost plans and their impacts, and (3) the effect of DOE's LCUP activities in catalyzing the acceptance of least-cost approaches among utilities and commissions.

Relevant DOE/LCUP and Other Projects

A recent survey by the Arizona Corporation Commission (1987) found that 17 PUCs are directly involved in least-cost planning, while 12 states are considering or are in the midst of developing such a program. The Arizona survey and a similar review conducted by the Energy Conservation Coalition (1987) present information about the status of PUC regulations, legislation, and other actions relating to least-cost planning at the state level.

Although the two reviews provide valuable information about the progress of LCUP throughout the country, they do not say anything about the content of these efforts. Much more information is needed about the content of these plans, utility implementation of their LCUP plan, the relationship between the plans to the overall process in the state, and how utilities have responded or will respond in the future (in terms of actual programs) to the various planning activities.

Understanding regional electricity supply and demand balances provides an important context for understanding state LCUP programs. LBL's Statistical Indicators study found that information on regional electricity supply and demand balances is useful in assessing what can and cannot be expected from utilities and PUCs at different times. If utilities in a region have excess generating capacity or believe that substantially more capacity will come on-line than is needed to meet demand, DSM activities will generally appear in least-cost plans in only a limited way. On the other hand, a utility that has experienced rapid demand growth and needs additional generating capacity is more likely to include a wide variety of demand-side programs.

Several ongoing projects provide information about the status of LCUP in the different states. Projects in Colorado (ERC), the City of Austin, Rhode Island, and New York are directly involved in LCUP. The Rhode Island effort analyzed conservation potentials in the commercial sector promote utility implementation of DSM programs. The New York study supports a major data collection effort (NORDAX) that will provide the foundation for assessing demand-side programs. The Wisconsin and Illinois planners are creating new institutions that will be involved in a variety of LCUP activities, primarily to promote consensus among participants.

Finally, the key role of NARUC in the DOE effort provides a vehicle for understanding the role of LCUP in regulatory agency decision making. The NARUC Handbook (1988) describes the utility planning process and the ways in which LCUP influenced it. Examples in the handbook provide considerable data about the status of LCUP in different states. The NARUC Conservation Committee provides one of the best sources of information about the impacts of LCUP on regulatory agencies at the state level; their participation in the DOE/LCUP effort provides DOE with access to this information.

Future Work

- An important objective of the DOE/LCUP program is to help improve the planning processes affecting utility supply/demand decisions. Keeping track of progress in LCUP by PUCs and utilities is an important element of the DOE program.
- DOE needs to gather and analyze material relating to improvements in the utility planning process. This material may include least-cost resource plans, state LCUP legislation, technical and economic assessments of DSM resources, and key elements of rulemakings, rate cases, resource plan hearings, and similar activities related to LCUP. This information, combined with a knowledge gleaned from NARUC and utility contacts, can provide valuable information on what is being accomplished in the utility planning process at the state level.
- It is important to determine the degree to which the planning activities are translated into programs implemented by utilities. A system that tracks utility LCUP programs would be useful. The NORDAX effort appears to be a first step in this direction for DSM programs in at least one region of the country. (NORDAX is intended to accomplish more than tracking utility implementation, but it also performs this function).

1.3 Increasing Profitability of DSM Investments to Utilities

Lead Author: Steve Wiel

Background

Several speakers at NARUC's April 1988 Conference on Least-Cost Utility Planning expressed frustration that electric utilities are reluctant to implement customer conservation programs. One major reason, they claim, is that loss of utility revenues from reduced electricity sales is large. It is often large enough to override other incentives offered by regulators. Consequently, NARUC's Conservation Committee formed a technical advisory group to explore this dilemma. The Committee met with the advisory group in July 1988. The Committee adopted a position statement recognizing that a utility's least- cost plan is often not its most profitable plan and calling upon PUCs to adjust their ratemaking formulas to make a utility's least-cost plan its most profitable plan. This statement reads as follows:

> A utility's least-cost plan for customers should be its most profitable plan. However, because incremental energy sales increase profits, traditional rate-of-return calculations generally provide substantially lower earnings to utilities for demand-side resources than for supply-side resources. For this reason, profit motive generally encourages utilities to invest in supply side resources even when demand-side alternatives are clearly identified in its resource plan as being the least-cost resource.
>
> The loss of profits to utilities from relying more upon demand- side resources is a serious impediment to the implementation of least-cost planning. This obstacle to least-cost planning should be addressed. There are identified mechanisms for offsetting the profit-erosion problem.
>
> Therefore, it is the position of the Energy Conservation Committee that state commissions: should require their utilities to engage in least-cost planning; should consider the loss of earnings potential connected with the use of demand-side resources; and should adopt appropriate mechanisms to compensate a utility for earnings lost through the successful implementation of demand-side programs which are a part of a least-cost plan and seek to make the least-cost plan a utility least-cost plan a utility's most profitable resource plan.

The Committee met with its technical advisory group again in October 1988. Also attending that meeting were several utility executives who provided feedback to the Committee on how the utility industry reacted to the Committee's initiative. The Committee is now attempting to identify ratemaking formulas that will induce utilities to actively seek and promote energy efficiency. If such formulas are found, the Committee will urge their adoption within NARUC.

Issues

A utility's least-cost plan should be its most profitable plan. However, incremental energy sales increase profits and traditional rate-of-return calculations generally provide substantially lower earnings to utilities from DSM resources than from supply-side resources. Conservation reduces sales, which in turn reduces profits. Thus, the profit motive encourages utilities to invest in supply-side resources even when demand-side alternatives are clearly identified in their resource plans as being the least-cost resource. The loss of profits to utilities is a serious impediment to the implementation of least-cost planning and the resulting efficient use of the nation's energy resources.

It is important for PUCs to address this obstacle to least- cost planning. The NARUC Committee has identified several mechanisms for offsetting the profit erosion problems. These range from removing the disincentives by unlinking company profits from short-term sales to allowing electric utilities to earn a profit from providing services on the customer's side of the meter.

Ideally, the ratemaking formula should either reward improvements in energy efficiency sufficiently to overcome the lost profits from sales for inefficient use, or it should not reward increased sales. In addition, a change in ratemaking formula must avoid potential biases from forecast errors, fuel price fluctuations, and weather fluctuations. It must avoid the opportunity for cheating by either the utility company or its customers. It must not be overly subject to PUC discretion. It must pass the "front page test" of customer acceptability. And, of course, it must not discourage the use of electricity for providing new services.

Relevant DOE/LCUP and Other Projects

NARUC's Conservation Committee plans to continue its analysis of the reluctance of electric utility companies to achieve all the efficiency improvements they can. It will continue to explore how well specific formulas satisfy the Committee's criteria. An alternative ratemaking formula has been introduced in the State of Maine for consideration. This proposal would tie a utility's profits to achievements in maintaining a low average bill for its customers. Other states are being encouraged to try experimental modifications to their ratemaking formulas over the next year. The Committee expects to have a proposal for ratemaking adjustments to NARUC by its November 1989 convention.

Future Work

- Consider allocation of costs among rate classes;
- Consider the loss of earnings potential connected with the use of demand-side resources when determining utility electric rates;
- Adopt appropriate mechanisms to compensate a utility for earnings lost due to successful implementation of DSM programs which are part of a least-cost plan. Also, seek to make the least-cost plan of a utility its most profitable resource plan.

1.4 Deregulation of and Competition Among Electric Utilities

Lead Author: Eric Hirst

Background

The electric-utility industry may be undergoing fundamental restructuring. Changes likely to occur over the next several years include mergers among utilities, deregulation of electricity production (e.g., use of bidding to obtain new electricity supplies from independent power producers, PURPA Qualifying Facilities, and other utilities), deregulation of transmission, and increased competition for retail customers (e.g., from other fuels, especially natural gas, from improved energy efficiency and fuel switching, and from other electricity suppliers).

Issues

Although these issues are hotly debated among utilities, regulators, investors, and others, there has been virtually no discussion of the relationships between these possible structural changes and the need for, and benefits of, least-cost planning.

Some argue that deregulation and increased competition obviate the need for integrated planning. Others claim that uncertainties about the future structure requires even more planning; for example, some ask how a utility can conduct an auction for new supply resources without a carefully developed least-cost plan that provides a benchmark against which new resources are compared.

Future Work

- Examine the relationships between bidding, for both demand and supply resources, and least-cost planning. Should planning be a prerequisite to bidding, as proposed in a December 1988 rule by the Massachusetts Department of Public Utilities? Or will the need for utility planning be greatly reduced by encouraging competition for the provision of new electricity resources? How can utility planning identify the extent to which there is "workable" competition among potential suppliers of new demand and supply resources?
- Review the effects of industrial bypass, increased competition from other fuel suppliers, and other forms of retail competition on utility least-cost plans. How does the increased uncertainty about future load growth implied by additional competition affect the utility's ability to plan and its traditional obligation to serve?

2. BROADENING THE SCOPE OF LEAST-COST UTILITY PLANNING

2.1 Bidding for Demand-Side Resources

Lead Author: Charles A. Goldman

Background

Several PUCs have (or are in the process) of adopting competitive bidding systems to provide future electric capacity. States that have approved bidding systems include California, Colorado, Connecticut, Maine, Massachusetts, New York, and Virginia. Regulations are being developed in Michigan, New Jersey, and Vermont. Utilities in several states, including Maine, Massachusetts, and Virginia, have actually conducted auctions for power. In addition, the Federal Energy Regulatory Commission (FERC) issued a Notice of Proposed Rulemaking (NOPR) on regulations that would govern bidding programs as part of its comprehensive review of electricity regulations. FERC's bidding NOPR gives states the option of choosing bidding programs as an alternative to administrative determinations of full avoided cost. FERC would allow all potential supply sources to compete in the auction for new capacity. In addition, FERC requested comment on how state bidding programs might take into account viable and economically feasible demand-side alternatives to capacity expansion.

PURPA established a federal program, implemented by the states, under which utilities are obliged to purchase power from cogenerators and small power producers based on "avoided cost," the cost that the utility would have incurred in the absence of QF generation. In some parts of the country, PURPA has been quite successful in the sense that it elicited a tremendous response from QF developers willing to build new capacity. However, PURPA has been a mixed blessing, and thus, in one sense, competitive bidding has been proposed as a solution to implementation problems associated with PURPA. For example, proponents of bidding argue that it allows ratepayers to obtain a portion of the cost savings that would otherwise go to private developers in cases where developers' actual costs are less than the utility's full avoided cost. In addition, some states have adopted bidding systems primarily as a means to allocate an unforeseen oversupply of QF capacity and energy (e.g., California, Colorado). Finally, bidding systems have a natural appeal for proponents of increased competition and deregulation because it offers a mechanism that allows all potential suppliers, including utilities and non-QF independent power producers, to compete with QFs in supplying new capacity.

Issues

Based on recent trends, we expect that market-oriented mechanisms (e.g., auctions, RFPs) will become even more prominent in those regions that are considering building new electric generating capacity. Demand-side bidding proposals raise the fundamental issue of the role of conservation resources in securing new power supplies. At what point in the process should end-use programs be considered - prior to a determination of need for new capacity or as one among many potential resource options that can be acquired after a determination of need? Under what conditions is it better to develop demand-side resources through competitive bidding? Most proponents of demand-side bidding tend to view it as one among many options for improving end-use efficiency. Other options include building codes, appliance standards, direct utility investment in conservation measures.

One key issue raised by demand-side bidding proposals involves the choice of auction format: separate auctions for supply and demand resources or an integrated auction. Thus far, the few utilities that have implemented bidding programs have favored separate auctions for supply and demand-side resources. This approach is attractive on both theoretical and practical grounds. From a practical standpoint, it is probably easier to evaluate supply bids separately from demand-side bids, particularly if the utility conducting the auction places a high value on non-price factors. In addition, auction design and implementation is simplified if separate auctions are conducted. A separate auction also prevents bidders from offering inexpensive conservation resources at prices that are just below the costs of supply-side capacity (Michaels, 1988). However, a separate auction approach requires that the utility develop a process to reconcile the results. Several options have been either used or proposed, including specifying demand and supply targets in advance for each auction based on the results of an integrated resource planning process or holding the demand-side auction prior to the supply-side auction, using a predetermined avoided cost price ceiling (Nemtzow, 1988).

The theoretical literature on auctions suggests that one of the reasons for holding an auction is to assure judgment-free normality, in part because the agent is not completely trusted. For example, in the case of a PURPA power auction, a utility or a third-party agent must be able to rank bids based on pre-established criteria. In PURPA power auctions, winning bidders agree to supply electricity to the utility. There is no judgment with regard to the quantity offered, although judgment is often involved with regard to the valuation of non-price factors. However, on the demand-side, the issue of the level of demand in the absence of a demand reduction contract is both inevitable and inherently judgmental. The quantity of DSM resources offered is conditional, involving technical and market uncertainties. The technical uncertainties involve issues related to measuring the actual impact of DSM measures (e.g., engineering estimates vs. metering, persistence of savings, load-shape impacts). The market uncertainties relate to the fact that customers maintain an incentive to invest in conservation measures even without utility DSM investments. The utility is then required to determine whether or not the host customer's proposed decrease in demand would have occurred in the absence of the conservation investment (a process which is inherently subjective). Thus, the essence of the auction process, its judgment-free normality, is undercut.

We have raised several reasons why an integrated auction raises difficult problems. However, the recent experience of Central Maine Power (CMP), which implemented an integrated auction, suggests that these problems are not intractable. CMP's bidding process allows demand-side management programs to compete directly with cogeneration and small power production. Results of the CMP auction indicate that conservation resources received the highest rated scores, although the conservation resource offered was not large compared to the utility's resource needs (e.g., conservation accounted for only 5% of the total MW). There are several possible explanations for this situation: the technical potential for conservation in CMP's service territory is not that large, or that the potential resource is not being fully exploited because of the immaturity of the ESCO industry. The CMP auction and results merit further study. Some of the most critical issues associated with DSM bidding relate to program implementation issues. Many of these topics are not unique to DSM bidding; they arise in any utility program that invests in demand-side resources.

Key issues that must be addressed by DSM bidding programs include: criteria for participation or selection of winning bidders (e.g., price bidding, qualifications bidding, combined bidding); performance guarantees and quality assurance (e.g., forms of security, site inspections); measurement of impacts; and ensuring that conservation resources that are purchased would not have been installed by customers anyway (e.g., limitations on types and paybacks of measures that can be included in DSM bidding program, methods to encourage installation of medium to long payback measures, exclusion of short-payback measures).

Relevant DOE/LCUP and Other Projects

LBL and ORNL are currently conducting a DOE/LCUP project that is examining the use of competitive bidding mechanisms to meet future electricity needs with demand-side resources. The project is in its initial phase and is scheduled to be completed by the summer of 1989. The project will (1) describe and analyze the experience to date with demand-side resource bidding, (2) evaluate the treatment of demand-side resources in supply-side auctions, (3) analyze the issues in measuring the resources resulting from demand-side auctions, and (4) address the issue of integration of demand- and supply-side competitions in the utility resource planning process. LBL and ORNL will interview PUCs, utilities, and energy service company providers on their experiences and views on competitive procurement practices.

The New England Electric System (NEES) has conducted two auctions in which it accepted bids for 13.6 MW of conservation from Energy Service Companies (ESCOs). NEES selected among competitive bids for DSM projects and the bid format allowed direct comparison to bid prices in a supply auction (i.e., price per equivalent kW basis). NEES is beginning an evaluation of its DSM competitive bidding program. This evaluation is of interest because the utility will be comparing its bidding program with a utility-run custom rebate program for the same customer class. Preliminary results should be available by Fall 1989.

New York State Energy Research and Development Authority (NYSERDA) is funding an evaluation of an Orange and Rockland Utilities (ORU) pilot demonstration project that will examine performance contracting for demand-side management programs. ORNL is assisting NYSERDA in reviewing the evaluation plan for the ORU bidding project. Finally, EPRI is sponsoring a project that will develop methods and guidelines to help utilities design, evaluate and manage demand- and supply-side resource bids.

Future Work

- Examine the relationship between bidding programs and the integrated resource planning process. Focus on the links between the results of bidding programs and the utility's integrated resource plan (e.g., resource mix of winning bidders, incorporation of the impact of DSM bidding program winners into the demand forecast, timing issues for competitively-acquired resources if the utility's demand forecast changes significantly after the auction);
- Conduct case studies with utilities to compare utility experience with integrated auctions vs. auctions that have separate bid solicitation methods. Evaluate these bidding programs (e.g., identification of problem areas, key lessons learned, customer and ESCO response) as well as program outcomes (e.g., peak load reduction, cost-effectiveness);

- Use case study results to develop guidelines for DSM bidding programs that can be used by PUCs and utilities (e.g., whether it is appropriate to conduct DSM bidding programs; if desirable, in which market segments);
- Develop new methods to measure demand reductions in the context of competitive procurement processes. Develop guidelines for particular measures and end-use sectors that address trade-offs between accurate measurement of savings and the increased transaction costs from more reliable savings estimates. Focus on persistence of savings over time, load shape impacts, and value of DSM measures that are subject to utility control.

2.2 Electricity Pricing as a "Resource"

Lead Author: Eric Hirst

Background

Overall price levels and rate structures have been used for decades as mechanisms to provide utilities with their revenue requirements and to send economically correct price signals to customers. The crucial role of pricing in affecting both the level and shape of electricity loads is increasingly recognized within utilities and PUCs as a "resource" that can complement traditional supply-side and demand-side alternatives.

Issues

The 1978 Public Utility Regulatory Policies Act directed PUCs to review several electricity-pricing alternatives for their relevance to their state's utilities. Since then, debates about marginal-cost pricing have occurred in virtually every state. Participants generally agree that pricing electricity close to its marginal cost is desirable in terms of economic efficiency. Differences occur, however, on how to define marginal costs, on whether to use short-term or long-term marginal costs, and the feasibility of applying such pricing schemes to customers that do not use much electricity. There is also substantial interest in using pricing as a marketing tool, as a way to encourage customers to participate in a utility's DSM programs. For example, a utility could offer special rates to customers that install a heat pump. Some utilities offer special rates for industrial development or to avoid industrial bypass, self-generation, or cogeneration.

Future Work

- Review the literature on the theory, practice, and practicality of different forms of marginal-cost pricing. Assess recent advances in microcomputers, telecommunications, and other technologies that affect the cost of time-of-use metering and billing;
- Examine the possible roles of alternative electricity-pricing schemes to improve energy efficiency and/or load factors (i.e., energy or demand resources). Consider various forms of interruptible rates, time-of-use rates, and incentive rates for participation in conservation programs;
- Assess the importance of various assumptions (e.g., splits between energy and demand, definition of the marginal supply resource) in computing marginal costs and in converting costs to prices.

2.3 Treatment of Fuel Choice

Lead Author: Alan Meier

Background

Most least-cost planning focuses on a single fuel, almost always electricity. The focus on a single fuel is only natural given the institutional framework in which such studies take place: an electric utility seeks to determine the lowest cost combination of DSM and supply options for their customers. However, if the customer switches to another fuel, he is no longer a customer and therefore outside the study's scope. Indeed, an often unstated assumption (or constraint) of LCUP is that the utility will conserve energy while preserving its customers. Issues related to fuel-choice and fuel switching are gaining recognition as key elements in LCUP.

Fuel-choice constraints have resulted in incomplete, if not distorted, plans. At the microeconomic scale, omission of fuel-switching measures has led to socially suboptimal selections of conservation measures. In the electricity sector, a series of increasingly complex (and expensive) measures might be proposed to extract the last possible kWh from an end use when in fact a fuel switch would have been more economical with a 100% savings of the electricity. On a broader scale, the fuel-choice constraint has sidestepped major issues related to fuel choice, environment, and national security.

Past Research into Fuel Switching

There have been surprisingly few multi-fuel least-cost studies. This is so because a multi-fuel least-cost study involves more participants, a broader analysis, and more money than does a single fuel study. As a result, the literature on fuel choice and fuel switching is scanty. The gaps exist for both the individual aspects of fuel switching (i.e., costs, savings, and behavioral, programmatic, and institutional effects) and the regional impacts (i.e., aggregate savings, electric and gas system impacts, and environmental effects).

One of the earliest estimates of fuel-switching potential was made by Meier et al. (1984) for California's residential sector. In this study, fuel switching measures were included in supply curves of conserved electricity. While it was limited to residential retrofits, the study found major electricity savings through conversions of water heaters, clothes dryers, and ranges. Krause et al. (1987) examined fuel-switching measures in a similar study for Michigan. This study only considered houses already having gas service. Even there, the potential electricity savings from fuel-switching matched the largest standard conservation measures. They were also very cost cost-effective, so they appeared early in the sequence of measures. Other small studies have been undertaken, but they have not been widely disseminated. For example, Washington Electric Co-op considered several fuel-switching measures in their least-cost plan. Meier investigated the peak power implications of fuel switching in Sacramento, California.

The issue of fuel choice in new buildings has emerged in New England. There, both the utilities and regulatory agencies recognize that the rapid increase in electrical demand is partly a result of the high saturation of electric heating even where gas is a feasible (and cost-effective) alternative. However, the discussions are handicapped because no careful estimates of electricity savings from fuel switching have been undertaken.

Future Work

- The technologies associated with fuel selection or shifting are generally well-known, but their costs and energy savings are scattered and not presented in formats suitable for analysis. For example, it is possible to estimate the load-shape impacts of fuel-switching with existing data, but nobody has done so. Compilations of these technologies and their economics do not exist; as a result, it is difficult to realistically assess the value of fuel selection. Modest research in these areas could greatly reduce the information gap that presently exists;
- At the aggregate level, the lack of precedents (i.e., past studies on fuel selection and switching) has deterred some studies. These are needed to provide methodologies, benchmarks, and data without which even a small study would require extensive work. A few case studies of fuel selection and switching would be sufficient to create a "precedent base" to encourage other analyses. These studies could be conducted in collaboration with utilities or PUCs.

2.4 LCUP for Gas Utilities

Lead Author: Charles Goldman

Background

The electric utility industry has been the focal point for most LCUP activities. At present, least-cost planning in the gas industry focuses mainly on supply planning for local distribution companies (LDCs). For example, PUCs in several states require LDCs to prepare and file long-term gas acquisition plans. The LCUP requirements in some states assume that the supply planning function formerly performed by pipelines would be performed jointly by distributors and PUCs and that acquisition plans would have regulatory pre-approval (e.g., Washington, New York, Washington, DC). This contrasts with traditional regulatory procedures in which decisions regarding gas purchases were made after they had occurred and only in the context of whether costs associated with the decision could be recovered in the utility's rates.

In recent years, the following trends have dominated the gas industry: (1) deregulation of natural gas producers, (2) transformation of interstate pipeline regulation, which now require pipelines to serve as common carriers, (3) elimination of barriers to pipeline competition and (4) unbundling of gas services and rates by LDCs. Local gas companies operate in two basic markets: a core market, which consists of residential, commercial, and small industrial customers that continue to depend on the LDC for gas procurement and distribution, and a noncore market, which consists primarily of large industrial customers and electric utilities. In the noncore market, the LDC offers two products: the gas commodity, for which there is competition with gas marketers and independent producers, and transportation of gas (i.e., the delivery of that gas commodity), for which the LDC continues to have a natural monopoly.

Issues

Efforts to encourage least-cost planning in the gas industry must be tempered by an understanding of differences with the electric utility industry in terms of industry structure, regulatory practices, institutional barriers, markets, and current and projected supply/demand balances. For example, the gas industry is not dominated by vertically-integrated firms that control and are responsible for all aspects of production (e.g., generation, transmission, and distribution). Until recently, the gas industry was discouraged from competing in some markets based on the rationale that gas supplies should be targeted at premium uses because of future supply resource constraints. For a LDC, meeting peak season demands involves fundamental tradeoffs between storage and pipeline capacity coupled with more limited obligations to serve industrial customers because they typically have alternate fuel capabilities. In contrast, bulk storage of electricity is quite limited and availability of backup generation equipment is not standard.

The gas industry's primary interest in LCUP relates to fuel choice and fuel switching. In particular, the gas industry has promoted gas technologies that mitigate the peak load problems of electric utilities (e.g., gas cooling). This emphasis results in part from the situation confronting almost all gas utilities, which is characterized by excess capacity, plentiful gas supplies, and in many cases, declining sales. Thus, gas utilities are primarily interested in load-retention and load-building programs, rather than programs to encourage increased end-use efficiency.

Moreover, many gas utilities argue that gas conservation programs would have substantial negative rate impacts on non-participating customers, and that there is relatively small potential for utility programs to achieve cost-effective savings in the residential sector because national appliance standards already mandate improved efficiency for residential gas furnaces and water heaters and because a significant fraction of the existing stock has been weatherized to cost-effective levels. Finally, few LDCs are contemplating major capital expenditures; thus, the benefits of demand-side options are limited to avoided energy costs, which are quite low at present, and not avoided capacity.

Future Work

- Conduct surveys of gas utilities, industry organizations, and regulators to assess current LCUP practices, review current DSM activities of gas utilities, analyze regulatory practices, and summarize key issues identified by regulators;
- Study the relevance of LCUP techniques to the gas industry; focus on a comparative analysis of the electric and gas utility industries (implications of differing technological options, institutional arrangements, industry structure, and regulatory practices).

2.5 LCUP's Role in Environmental Quality

Lead Authors: Howard Geller and Florentin Krause

Background

Three major studies have examined the role that accelerated electricity conservation can play in reducing acid rain emissions and lowering the overall cost associated with acid rain clean-up. These studies examine provision of energy services and protection of the environment in an integrated manner. One study pertains to the ECAR power pool region of the Midwest (Geller et al., 1987), a second study is specific to Ohio (Centolella et al., 1988), and a third study focuses on two major coal-intensive utilities, American Electric Power Co. and TVA (Clean Air Policy, forthcoming).

All of the studies consider different scenarios for electricity demand growth and pollution control, including more aggressive pursuit of conservation than is currently planned in the respective regions. The studies compare factors such as SO_2 emissions, electricity rates, and energy service costs over time for the different scenarios.

The studies show that conservation can reduce utility acid rain emissions and the costs of acid rain control by reducing the use of existing power plants and by deferring the purchase of emissions controls or cleaner, more costly fuels. The reduction in SO_2 emissions, however, is not enough to meet the requirements typically discussed in acid rain legislation.

Issues

These studies also consider how acid rain control legislation should be formulated to encourage end-use conservation and least-cost energy services in conjunction with pollution control. They all conclude that acid rain legislation should provide full credit for the emissions reductions achieved through electricity conservation. The use of statewide emissions ceilings, i.e., "SO_2 tonnage caps", does this. The use of emissions rate limits i.e., limits on pounds of SO_2 emitter per MMBtu of fuel burned, provides limited or no credit, and therefore should be avoided as the mechanism for forcing acid rain control.

Acid rain legislation should direct states to consider end-use efficiency improvements and to strive for least-cost energy services when they develop their acid rain compliance plans. But requiring utilities or states to determine the electricity savings and corresponding emissions reductions resulting from their conservation programs is unnecessary and impractical.

Future Work

- There is a need to evaluate some of the issues raised in the conservation acid rain studies in greater depth, as well as to conduct studies along the lines described above in other jurisdictions. The concept of least-emissions dispatch (i.e., dispatching a utility's generating units according to their emission rate rather than operating cost) deserves additional study. To be most valuable, examination of least-emissions dispatch should include a detailed production cost and dispatching analysis including plant-by-plant emissions and emissions control costs.
- The financial effects on a utility from different strategies for conservation and emissions control need more analysis? Do utilities have a financial incentive to clean-up emissions and manage load growth in a manner that minimizes energy service costs? If not, how can such an incentive be provided?

- How a state and its utilities can best plan for and implement an aggressive electricity effort in the context of acid rain control deserves careful analysis. Besides addressing the usual issues related to implementing conservation (e.g., minimizing free-riders or the persistence of savings), such a study should consider acid rain control and compliance. Relevant issues include timing of savings, uncertainty of savings, minimizing the risk of non-compliance if conservation is aggressively pursued, and contingency planning;
- Analyzing innovative electricity supply technologies along with end-use efficiency measures is another issue that deserves further study. Some promising electricity generating technologies, such as steam-injection gas turbines or combined-cycle plants with coal gasification, are very clean from the point-of-view of SO_2 emissions. It would be interesting to model the combination of innovative supply- and demand-side options and to develop optimal pollution control strategies involving both;
- It would be useful to conduct detailed studies of the relationships between additional conservation and acid-rain control for states such as Massachusetts, New York, Minnesota, and Wisconsin which have passed state acid rain control requirements. These states have a practical interest in seeing that environmental protection is implemented with as little economic hardship as possible. Detailed studies pertaining to major utilities in these cases would also be useful.

3. ADVANCING THE TECHNIQUES OF LEAST-COST PLANNING

3.1 Review and Standardization of Utility Plans

Lead Author: Charles Goldman

Background

Review, evaluation, and approval of DSM and integrated resource plans by PUCs are central elements of the LCUP planning process. Often, regulatory staff are overwhelmed with massive utility filings. Moreover, the information provided by utilities varies significantly in terms of format, presentation, and level of detail, which further complicates PUC review.

Issues

Are there tools and techniques that regulators can use to compare and assess utility plans? What are the key data reporting, data quality, and analysis/methodology needs?

Often, regulators provide utilities with substantial latitude in developing long-range plans. While this approach recognizes the diversity and different situations confronting utilities in a particular state, it complicates efforts to evaluate and compare utility DSM programs. In addition, it may have the perverse effect of fostering an adversarial environment between utilities and intervenors because intervenors are likely to be distrustful of the utility's evaluation of DSM options, particularly if key input data are omitted, incomplete, or difficult to check because sources for assumptions are not included. If regulators adopt this approach, they may want to specify performance goals for the utilities, which is not an easy task in itself. Commissions might also evaluate plans against such criteria as:

- consider a wide range of resources;
- assess various resources in a consistent fashion;
- involvement of the public in both preparation and review of the plan;
- establish reasonable links between the long-term resource plan and the utility's action items for the next few years (e.g., staff, budget, milestones); and
- monitor and evaluate the action plan.

In contrast, some states (notably California) developed a standardized approach that is used in DSM and integrated resource plans. Typically, this involves: (1) reporting requirements, established through public workshops in which all parties participate, and (2) end-use and sector data, DSM plans, and supply-side resource activities, reported on standard forms (e.g., the California utilities report inputs in their Common Forecasting Methodology filing). This type of process can be expensive and time-consuming and increases the regulatory burden on utilities, although it greatly facilitates independent assessment of plans by regulators and intervenors. Proponents of a standardized approach also argue that the additional public scrutiny may help reach consensus on resource requirements and avoid expensive mistakes.

In the long-run, a standardized approach is probably preferable, possibly one that is geared toward satisfying the minimum data requirements needed by regulators to independently evaluate utility plans. However, it is important to recognize that it is far easier for utilities to generate data on standard forms than it is to assure quality control and consistency in resource planning.

The key objective is to facilitate understanding of the inputs that are used to characterize potential demand and supply resources, so that attention can be focused on the policy choices and trade-offs embodied in a utility's resource plan.

Relevant DOE/LCUP and Other Projects

LBL collaborated with the New York Public Service Commission to review the long-term DSM plans of the state's utilities. The project identified the most important data and analysis needs for NY regulators trying to evaluate DSM plans. These include: improved stock characterization, explicit treatment of Qualifying Facilities (QFs) in the resource mix, a comprehensive assessment of the achievable potential for DSM options for all end uses and sectors, research on customer response to DSM options (incentives required to achieve certain penetration rates), and avoided cost projections. The study also concluded that DSM programs would be more aggressively implemented if the utilities and regulators could decide on the use of specific economic tests for initial screening and final selection of DSM options, and timing of DSM programs to minimize short-term negative rate impacts while preparing for long-run expansion of DSM programs. In Phase II of the project, LBL will review the integrated resource plans of the NY utilities. ORNL conducted a similar project, which involved review of ten utility plans and one PSC long-term resource plan. Although the focus of this review was on the methods used to treat uncertainty in analysis, other aspects of the plans were examined. The plans were reviewed for their frequency of preparation, the time period covered in the plan, the factors whose uncertainties were explicitly analyzed, the types of resources recommended for acquisition, approval of the plan by utility management, implementation of the plan, and consideration of new information as a basis for plan revision. Several additional least-cost plans will be reviewed in FY-1989; this expanded review will include some site visits to explore the planning process in greater depth, with both utility and PUC staffs.

Future Work

- Conduct case studies with PUCs that have a standardized approach to DSM and integrated resource plans and with PUCs that do not have such a process; discuss experiences with approaches, obtain views of utilities, PUC staff, and intervenors, and assess the applicability of different approaches to other states;
- Develop guidelines for regulators evaluating utility plans that can be used to assess these plans;
- These guidelines should be based on a comprehensive review of utility plans. The review would cover several topics, including:
  - Conformance of plan with PUC rules;
  - Motivation for plan;
  - Methods used to treat uncertainty;
  - Data sources on resources analyzed;
  - Modeling tools used in analysis of resource alternatives;
  - Usefulness of plans as decision aids to both the utility and the PUC;
  - Role of DSM resources within the utility's overall resource strategy; and
  - Relationship between long-term resource plan and short- term action plan;

- This review would also compare the strengths and limitations of different plans and planning approaches. It would identify measures of successful utility planning and search for correlations between utility success in planning and its planning process. Results of this review would yield information on the state-of-the-art in planning methods, data sources, resource selection, and treatment of uncertainty. The review would serve as a valuable technology transfer mechanism to help disseminate information and ideas from more active utilities to other utilities.

3.2 Modeling Approaches

Lead Author: Joseph Eto

Background

Models and other analytical tools have value for LCUP only to the extent that they facilitate planning by manipulating data in ways that are meaningful, understandable, and helpful to decision makers. Technically, the structure defines the range and manner in which issues can be addressed. Institutionally, the structure promotes the use of common definitions. This discussion focuses on technical challenges and on understanding the role of models in the planning process, which is probably more important than the models themselves. The observations of TBS (1986) are still relevant today: the state of the art in modeling generally outstrips the quality of the data used to run the models.

Key modeling issues related to the integration of DSM programs into a utility resource plan include:

- Consistency between estimation of demand side program load shape impacts and the system energy/load shape forecast. Does the model account for the interactive effects of several programs or the effect of a single program on other components of the forecast? Or does it simply subtract demand side program load shape impacts from a base-line forecast in a way that may overcount or undercount load impacts?
- Integration of DSM programs into the generation expansion plan.
- The relationship between DSM programs, load shapes, and rate design. Are demand-side programs large enough to alter retail rates, and, if so, how are rates affected? How do rates, in turn, affect future loads?
- Representation of demand-side programs that rely on prices to modify demands.

Recent DOE/LCUP and Related Work

LCUP requires evaluation of at least six subjects: load forecasts of energy and load shapes; cost and performance of demand- and supply-side options; consumer acceptance of these options (primarily of ones on the demand side); long- and short- run utility production costs; impact on a utility's financial position; and interaction effects between and within the above five items. The sixth subject, regulatory environment, of course, underlies all of these subjects.

Utilities and regulatory agencies typically utilize one or more of three broad approaches with respect to the modeling aspects of LCUP (Krause and Eto, 1988).

Screening models provide rapid turn-around time and answers useful for preliminary planning. The shortcoming of this approach is an inability to capture interactive effects, such as the impact of large programs on marginal costs. The APPA DOE/LCUP project's computer model, COMPLEAT, is an example of this type of model. LBL's ARCH program, which is implementing the supply curve concept on a PC, also fits in this category.

Linked detailed stand-alone models involve the sequential use of several models, each of which was originally developed solely for evaluation of one aspect of the planning process (e.g., customer acceptance, load forecasting, production costing, or financial analysis). The challenge is to ensure consistency in data, such as the link between an end-use load forecast and the load data required by the production cost model. The Purdue DOE/LCUP project follows this approach with emphasis on integrating steel industry demands into a statewide LCUP process. The Stone and Webster DOE/LCUP project is also as a example of this approach, using EGEAS. EPRI's case study of the Sierra Pacific Power Company using end-use forecasting, integrated planning models, and a generation planning model is another example of this approach (EPRI, 1987). Previous work by LBL examining the financial impacts of appliance standards on individual utilities also falls in this category (Eto, et al. 1987).

Integrated planning models attempt to capture interactive effects of the different steps of the analysis dynamically. Recently available integrated planning models include CPAM, LMSTM, MIDAS, and UPLAN. The issue here is whether linkages are appropriately represented; the advantage is the unification of traditionally distinct planning functions (and planners) within a single piece of software. LCUP work on Puget Power's DARE program and the Minnesota DOE/LCUP project both relied on MIDAS (Hirst and Knutsen, 1988). LBL's case study of thermal energy storage and high efficiency residential appliances for the Pacific Gas and Electric Company using LMSTM is also an example of this approach (Kahn et al., 1987). The Lotus Consulting Group has completed many LCUP studies using UPLAN (1988).

Issues

- How do models compare against each other in technical accuracy, in ease of use, data requirements, and integration into existing resource planning capabilities?
- What modeling capabilities do we currently lack?

The proprietary interest of software vendors precludes widespread dissemination of the results of model comparisons. EPRI's Demand-Side Information Directory (EPRI 1985), for example, lists over 80 computer models for demand-side management and its integration into resource plans, yet no independent evaluation is provided of the strengths and weaknesses of these models. To our knowledge, no comprehensive comparison has been performed between the major production cost models widely in use by the industry. The California PUC has taken an important first step in this process through legislative action that facilitates open discussion of the production cost models used to set avoided costs for QFs (CPUC, 1985). The Stone and Webster DOE/LCUP project reviewed existing models, but ultimately selected EGEAS, which they helped develop. The lack of reliable, unbiased information on the capabilities, limitations, and results from applying available models is of particular concern for the class of screening models, many of which are no more than sophisticated spreadsheets.

The handful of case studies cited above describe some of the models currently in use, but poorly reflect the collective experience of utility and regulatory planners. The valuable lessons gathered from the process of developing the required data, calibrating the models, and, most importantly, the role of the models in the overall planning process are rarely reported. Information about how models are used or misused is at least as important as the technical capabilities of the models, themselves.

There are at least two areas in which modeling efforts remain primitive. The first area lies in the treatment of uncertainty. At this time, barriers to effective treatment of uncertainty lie fundamentally in our inability to grasp the underlying causes of uncertainty, not in the lack of modeling approaches. ORNL has made notable efforts to more precisely characterize these uncertainties for demand-side programs (Hirst and Schweitzer 1988). One of the most successful efforts to treat uncertainty from a modeling perspective has been carried out by the Northwest Power Planning Council (1986). Their success, however, stems largely from the accumulated years of experience the Council has gathered on planning in the Northwest. Ford developed an integrated planning model (CPAM) that provides a comprehensive framework for treating the interactive effects of uncertainties on supply and demand systems. But, again, the lack of a fundamental understanding of the underlying causes of uncertainty is the primary barrier to effective utilization of any modeling approach.

The second area is incorporation of environmental considerations in LCUP. To date, explicit treatment of the links between LCUP (defined on narrow economic grounds) and broader environmental issues is uncommon. A rare example is ACEEE's work on acid rain mitigation through conservation (Geller et al., 1987). The absence of well-defined approaches to the topic required the researchers to utilize the model linkage approach, in which a combination of off-the-shelf software along with custom-built software was employed. As the working definition of least-cost expands to include environmental considerations, new modeling approach will be required.

Future Work

- Identify leading LCUP models, review their technical capabilities, disseminate results widely through conference presentations, model user workshops;
- Evaluate the recently available chronological production cost models, which are potentially quite valuable as an LCUP tool because of their ability to incorporate the load shape data from DSM programs;
- Support collaborative case studies with utilities and/or PUCs engaged in LCUP activities. Make use of models an explicit, but not central component of the evaluation. Pay specific attention to the use of strategic planning models. Assess the treatment of uncertainties, both about the resources considered and about external factors, in the planning process.

3.3 Treatment of Uncertainty

Lead Author: Eric Hirst

Background

In principle, resource planning at electric utilities is straightforward. A forecast is made of future loads and this forecast is then compared with the electricity that can be produced with existing resources. The gap between growing loads and existing resources must be met with new resources. A variety of demand and supply resources is assessed in terms of their capital and operating costs and compatibility with the overall power system. The least expensive resources that match the system are then acquired.

Unfortunately, utilities face substantial uncertainties about both the resources that might be deployed and about exogenous factors. As demonstrated by the erratic trends in load growth during the past decade, future loads are highly uncertain. In addition, the lifetimes and operating costs of existing resources are subject to many unknowns. Finally, the costs and performance of new resources are also uncertain.

Issues

Because the future facing utilities is almost certain to bring major changes, new phrases such as uncertainty, risk, diversity, and flexibility are frequently raised in discussions of resource analysis, planning, and decision making. Utilities and their commissions have generally not yet agreed how to balance risk against cost, how risk-averse utility decisions should be, and how the extra costs (i.e., the insurance premium) of a diverse and flexible mix of resources should be shared between customers and shareholders.

The most important element of uncertainty is agreement on and definition of the decisions to be made. The uncertain factors that affect such decisions can conveniently be divided into two categories. External factors are largely outside the control of the utility, such as inflation rates, regional economic growth, and the prices of fossil fuels. Internal factors are those at least partly under the influence of the utility, such as construction schedules, operation and maintenance costs, and marketing of demand-side programs.

The most widely used methods to analyze uncertainties are listed in Table 3.

Table 3. Primary Methods Used to Analyze Uncertainties in Electric-Utility Long-Term Resource Planning
Sensitivity Analysis
Define preferred plan (mix of resources) for base-case, values of key factors are then varied to test plan against uncertainties associated with key factors
Scenario Analysis
Define alternative futures, create plan to match each future
Portfolio Analysis
Define alternative corporate goals, develop plan for each goal
Probabilistic analysis
Assign probabilities to uncertain factors, yields cumulative probability distributions for outcomes

Relevant DOE/LCUP and Other Projects

A scoping study at ORNL assessed alternative approaches to treatment of uncertainty. Long-term resource plans from ten utilities and one PUC were carefully reviewed and detailed telephone interviews were conducted with planning staff in all these organizations (Hirst and Schweitzer, 1988).

Several utilities are developing and using an impressive array of analytical techniques to explore uncertainties. Some of the leading utilities include New England Electric System, Northeast Utilities, Southern California Edison, Pacific Gas and Electric, and Bonneville Power Administration. The Northwest Power Planning Council has also developed interesting and valuable planning methods.

The Stone and Webster DOE/LCUP project is reviewing models used by electric utilities for resource planning. Their report will probably comment, for each of the models, on its ease of use and applicability to strategic planning. The Minnesota project is using the EPRI MIDAS model to develop least-cost plans for Minnesota; they surely will employ various uncertainty analysis techniques in their plan development.

EPRI's Planning and Evaluation Division and their Energy Management and Utilization Division sponsor projects intended to develop and demonstrate improved planning methods. For example, the Planning and Evaluation Division funded development of a PC-based strategic planning model, MIDAS, which embeds a simulation model within a decision-tree structure.

A new analytical approach is also needed to better address uncertainty. Most of the models currently used by electric utilities for long-term resource planning are derivatives of large single-purpose models. These earlier models focused on production costing, capacity expansion, or financial planning. They are typically large, data intensive, mainframe models. Because of their size, they are difficult to learn and time consuming to use (in part because of the complexity and detail of the inputs and outputs). These models are intended for detailed analyses of specific options and not for strategic (e.g., screening, uncertainty) analysis. Kahn (1988) notes:

> The inherent difficulty of testing probabilistic models "against reality" has made the tendency toward complexity pronounced in electricity production simulation modelling, exacerbating the irresistible tendency for simulation models to grow increasingly complex. ... There are, however, pragmatic limits on the degree of complexity that is tolerable. Complex models can be difficult to debug, require substantial computing time and have too many independent parameters to yield uniform results. ... The tool becomes a "black box".

For this reason a case can be made for some degree of simplification. Models should be usable, flexible and understandable. They are often needed to help probe uncertain or unknown conditions rather than to produce estimates that are precise to seven digits. Simpler models are required where strategic planning questions are concerned, or analysis of uncertainty is important. These applications require analysis of many scenarios which differ substantially. The large, complex models are not well adapted to examining broad ranges of variation.

Future Work

- The review of utility plans discussed above (Review and Standardization of Utility Plans) would include assessment of the data sources and analytical methods utilities use to treat uncertainty;
- A new type of simulation model is needed, one that emphasizes simplicity of use and the decision process itself. Such an approach would emphasize the inputs important to decision making, the uncertainties associated with these inputs, the effects of frequent (e.g., annual) decision making, the effects of permitting decisions to be modified over time, and the iterations over time between decisions and subsequent results.

4. DEMAND-SIDE INPUTS TO LEAST-COST PLANNING

4.1 End-Use Load Shapes and Other Baseline Data

Lead Author: Jeffrey P. Harris

Background

Temple, Barker, Sloane (1986) identified important data needs in the areas of technology cost and performance, program experience and market penetration, and impacts of DSM measures on utility system loads, operations, and finances. These information needs, however, can be successfully met only when there is an accurate, detailed understanding of the baseline conditions that define energy demand by end-use. Put differently, one cannot successfully manage a resource -in this case, demand-side energy resources- without first knowing how large a resource base is available. Without such information, a utility could very well be planning programs to save more energy.

To support DSM planning and programs, a utility needs three basic types of end-use data: (1) baseline data on how energy is now used (and why): building and equipment stocks, stock characteristics that affect energy use, stock turnover rates, underlying demographic and geographic trends, and usage patterns (daily, weekly, seasonal) for energy-using equipment. These data are usually obtained from utility-sponsored surveys; (2) end-use load profiles that can be linked with the stock, characteristics, and usage data mentioned above. These load profiles are important for understanding which loads (and types of facilities or customers) contribute the most to utility peaks. Some utilities are also interested in identifying marketing opportunities to sell more power in off-peak periods. End-use loads are often estimated, based on operating schedules or computer models of building thermal performance. However, several utilities have initiated large end-use monitoring projects; (3) expected future changes in end-use loads due to individual demand-side or normal market responses to electricity rates and other factors. Typically, load-shape impacts are estimated by calculations or computer models, or, in some cases, with on-site monitoring of a building or piece of equipment.

The key questions faced by utilities in collecting end-use data are:

- What level of accuracy is required; to what extent are measured data needed, and when can we rely on estimates or calculations?
- In which cases can data from other utility service areas be used?
- If a measurement project is called for, how many buildings (end-uses) must be measured, for how long, to what level of accuracy, and how should the sample be designed?
- What associated data are needed, on building and occupancy characteristics, to interpret and extrapolate from the limited sample and monitoring periods?
- Who will use the resultant data, and what are the exact data needs (and formats) of our planning and forecasting models, or other analysis and decision processes, that will make use of the measured data?
- How can the measurement (and subsequent data-reduction and analysis) be done as cost-effectively as possible?

In attempting to address these questions, the Sierra Pacific Power Co. concluded that their inability to specify confidence levels for most of the existing data from other utilities (or for prototype simulations or statistical estimates) was the strongest argument for initiating their own end-use metering (Caldwell, 1987).

Issues

In general, utilities are faced with:

- few readily available sources of reliable, well-documented measured data;
- considerable disagreement among existing data sources, some of which may be definitional rather than real;
- better data and estimates for the residential sector than for commercial buildings, and essentially none for the non- process (space conditioning and lighting) end-uses in industrial buildings.

End-Use Load Profiles

The requirements for detailed end-use data are far more stringent for demand-side planning than they were under traditional (supply-side) utility planning (Caldwell, 1987; Hauser et al., 1987; Purcell, 1987). A supply-oriented utility planning process requires that the utility predict future energy demand at only an aggregate level (Braithwait and McDonald 1987). Moreover, many utilities that use detailed end-use forecasting models are constrained by the data requirements of these models (EPRI, 1985 and 1987). EPRI developed standard data libraries, based almost entirely on computer simulation models or statistical inference methods (Georgia Tech., 1985 and 1986). Utility analysts are often reluctant to use these data libraries, because they are uncertain about the extent to which standard values, even where they account for general climate differences, can be reliably applied to an individual service area (Caldwell, 1987).

One recent EPRI project compared commercial end-use intensity (EUI) estimates developed by different sources, and methods of calibrating others' EUI estimates to their own load research or sales data (RERI, 1988). Two observations from that study are worth noting: the comparison of 5-8 sources of EUI's, estimated for each end-use and commercial building type, showed many cases where results varied by factors of 2, 3, or more; none of the estimates were based on actual end-use metering of a statistical sample of buildings.

It is possible that some of these observed differences in energy-use EUI's represent "real" differences in the building stock across regions of the country. Other discrepancies, however, may be due to inaccurate estimating techniques, non-representative samples or building prototypes, or differences in definitions of building type, end-use, or even floor area. Such inconsistencies in definitions probably mask some genuine differences that need to be noted and analyzed. A recent EPRI-sponsored project computed average non-HVAC energy intensities and developed algorithms to estimate heating and cooling EUI's based on climate and other parameters (Turiel and Lebot, 1988). A spreadsheet computer program to calculate EUI's was developed, including seven end-uses for eleven building types.

In further response to utility needs for end-use load data, EPRI sponsored a project to develop "reference load shapes" for residential and commercial baseline end-uses and load-shape impacts of selected DSM measures. This study was still forced to rely mainly on computer simulation results or indirect estimates, rather than measured data.

About 40 potential sources of measured end-use load profiles data were identified. However, only five of these sources of measured data were in fact used in the EPRI study and none of these included end-use load profile metering for all major end-uses in the same household.

A study underway at LBL is now compiling and comparing measured end-use load shape data for the residential sector, from utility sources in California and other states. The two major data sources are metering projects by the Pacific Gas and Electric Co. (PG&E) and by the Southern California Edison (SCE). The objective of the project is to improve the accuracy of baseline load profile data used in the LBL Residential Hourly and Peak Demand Model.

Peak Demand Model

The End-Use Loads and Conservation Assessment Program (ELCAP), sponsored by the Bonneville Power Administration, is another major source of measured end-use load profile data (Hauser et al., 1987). This study is the largest field measurement project to date in the U.S., covering 430 residences and 140 commercial buildings at the end-use level. The project has already produced voluminous data, but few final products that are available as public data sources. Issues of data access by other utilities are not yet fully resolved. However, the ELCAP project has led to development of sophisticated software for data validation, editing, analysis, and data base management of very large end-use load data sets. This software may be applicable to monitoring projects by other utilities.

Several other commercial end-use load monitoring projects are underway or in the planning stage, including projects in Florida, Wisconsin, Southern California, and Northern California (Baker and Guliasi, 1988). In addition, LBL with the sponsorship of DOE, PG&E, and SCE, has been working on techniques for low-cost monitoring of building and equipment performance, through remote-access to computerized energy management systems (EMS) already in place for purposes of building control (Heinemeier et al., 1987). This continues to be a promising approach for reducing the costs of detailed data collection, and obtaining consistent energy performance data over a multi-year period.

Baseline Data

The baseline data requirements for DSM are even more demanding than those for end-use forecasting. This applies to "stock characteristics" data, as well as to end-use energy and load profiles. For example, a reliable forecast of lighting loads can be based on average lighting power densities for a particular type of buildings, corresponding total floorspace, and a diversity factor reflecting usage of lights during the peak hour(s) of interest. However, to design effective lighting programs and reliably estimate their savings potential, a utility must also have some information about the type of lighting equipment (lamps, ballasts, luminaires) used, lighting control systems, (manual, time-clock, occupancy or daylight sensors, circuit layouts), and availability of daylight in perimeter zones, etc.

These requirements raise the possibility of using other existing data sources, such as on-site energy audits, in creative combinations with monitoring, EMCS or other data, to improve the quality and lower cost of baseline data. For example, the Rhode Island LCUP project used an extensive existing data file from energy audits (which emphasized lighting equipment and operating practices) to develop improved estimates of technical opportunities for lighting DSM programs.

The national surveys of residential (RECS) and non-residential buildings (NBECS) conducted every 2-4 years by the DOE Energy Information Administration (EIA) offer another example of the opportunity for joint planning and coordination of large field projects to gather baseline energy and stock data. The RECS and NBECS surveys cover thousands of buildings, based on carefully constructed national sampling frames. However, they are limited in technical detail on the building, system, and operations and include no end-use or load profile detail other than monthly utility bills. Only recently has the EIA begun to release data on monthly peak loads (Burns, 1988). Conversely, many utility on-site surveys are hampered by limited samples and inadequate time or expertise to devote to the design of sophisticated sampling strategies. There is an opportunity to link these two efforts, with EIA providing the sampling frame and selected utilities agreeing to conduct detailed on-site audits (and even end-use load monitoring) and to make such detailed data available to EIA for analysis, thus allowing for extrapolation of findings to the broader building stock.

Future Work

- Help utilities avoid unnecessary, duplicative, or inefficient data collection, by:
  - identifying which results are transferable from other studies and how,
  - promoting closer collaboration among utility and non-utility data collection projects,
  - sponsoring an ongoing effort to compile, analyze, compare, and publish measured end-use load data from many sources.
- Develop and disseminate information on more cost-effective monitoring and analysis methods, including:
  - techniques for accurately disaggregating whole-building load profile data into major end-uses;
  - the use of in-place computerized energy management systems (EMS) as a source of detailed load data;
  - efficient methods for data reduction and management of the large data sets produced by end-use monitoring; and
  - promoting the use of standard definitions for building types, physical and operating features, end-uses, and common indicators of electricity use and load profiles.
- Initiate efforts to fill the most important gaps in end-use load profile data:
  - reliable data on cooling energy use;
  - data on non-process (space conditioning and lighting use) in industrial buildings;
  - data on miscellaneous end-uses in residential and non- residential buildings; and
  - creative linkages between broad-scale surveys such as RECS and NBECS and intensive but small-sample auditing or end- use metering projects.

4.2 Assessment of Individual Technologies

Lead Author: Alan Meier

Background

In the utility planning context, technology assessment means not just the monitoring, testing, and field assessment of individual technologies, but also the proper integration of such technology data with baseline data, load-shape impacts, and utility system data. A common application of technology assessments occurs when a utility undertakes a DSM study. Typically, staff rely on a variety of technology assessments to construct the DSM plan, including reports by consultants, EPRI, GRI, and national laboratories.

Issues

Technology assessments should be regularly updated because they shape DSM plans. If the assessments are out of date, then the DSM plan will likewise be lacking. The assessments are most likely to be weak where technologies are undergoing rapid evolution (e.g., thermal storage) or where new goals are being established (e.g., peak power impacts). Thus, one policy to improve DSM studies involves regularly updating technology assessments. This is already done to a great extent by EPRI, GRI, and some consulting firms. Special efforts, however, are needed where new technologies or planning goals are rapidly emerging.

One type of technology assessment also deserves special support. This concerns information which is not economical, yet provides community benefits. In this situation, the assessment tracks developments in a technology by compiling new data as it comes available and reporting on changes or trends. find the toxicity information of particular chemicals. In the LCUP area, the building energy compilations (BECA) compile measured energy use (or savings) and compare projects. This permits identification and documentation of particularly cost- effective technologies or problems with existing installations.

Technology assessments need to draw upon more measured data. Most DSM assessments rely on hypothetical situations (or prototypes) to simplify comparisons. Engineering calculations or computer simulations are used to estimate energy savings and physical impacts. This approach, while essential, is often misused, and leads to inaccurate conclusions. The problem can often be traced to the failure to link the assessments to measured or field data. If the assessment is not carefully benchmarked in the first place, then the impact of modifications is likely to be unrealistic.

Future Work

- Establish an improved on-going activity at the national laboratories to perform clearinghouse and updating functions on DSM technology cost and performance;
- Support exemplary demand-side assessments in specific utility service territories. This project can serve as an example for the modeling, analytical techniques, and baseline data generation procedures utilities should follow and will help establish the order of magnitude of the savings that can be expected from thorough assessments;

4.3 Market Penetration

Lead Authors: Florentin Krause and Edward L. Vine

Background

In addition to studying the technical potential of energy-efficient technologies, one needs to examine the market potential of these technologies. For example, how fast can energy- efficient technologies be introduced into the marketplace, at what cost, and over what time period? And how does customer acceptance of these technologies vary with different types and levels of promotion? Temple, Barker and Sloane, Inc. (1986) noted that market penetration analysis "... was clearly the most often mentioned research challenge in the least-cost planning area."

There has been a wide range of utility experience in implementing DSM program, ranging from utilities that have spent considerable amounts of money on many conservation programs to utilities that have not started any conservation programs but are conducting research to determine how to proceed. Similarly, there is a large diversity in the evaluation of the experience of DSM programs. For example, most of the program experience reports written by EPRI and others in the utility field cover a wide range of end uses that have a primary focus on shifting peak loads. These reports typically cover a large number of programs (most recently, commercial programs) on a superficial basis: information commonly reported include start-up date of the program, number of participants (not market penetration or saturation), and estimated savings and costs.

In contrast to this approach, many in-depth program evaluations have also been conducted. In these cases, sophisticated evaluation methodologies are used (e.g., use of control groups, weather normalization of energy use, and multivariate statistical analysis). Information commonly reported include measured energy savings and costs, cost-effectiveness (from different perspectives), market penetration, determinants of success or failure, perspectives of target audience, and goals and objectives of program sponsors. The programs covered are primarily residential, although more commercial programs are currently being evaluated.

Issues

Many DSM programs are being implemented without collecting and analyzing information on program effectiveness (e.g., cost- effectiveness and market penetration rates). As a result, the amount of quantitative data available is negligible in most cases (there are exceptions, e.g., the Pacific Northwest). Many programs are being conducted without learning from the efforts of similar programs being conducted elsewhere. Aside from a few cases (home energy rating programs, appliance rebate programs, new construction programs), there has been very little synthesis of existing programs. Moreover, the synthesis of these programs is difficult due to data availability and differing utility objectives. This problem may reflect the general reluctance of utilities to use data from other utility program experiences because of such factors as: service territory specific distinctions of customer demographics and preferences, customer segment mix, availability and performance of alternatives, weather, and regulatory treatment (Temple, Barker, and Sloane, 1986).

Improved information on predicting customer acceptance of DSM programs is needed to predict the market penetration of DSM options. There is a large range of acceptance of programs (2 to 50%). We need to know which delivery techniques work best. We need to be able to generalize delivery technique experiences, but they must be placed in the context of the readiness of the market and infrastructure support. One way to learn more about market penetration is by varying the different types and levels of promotion and program delivery systems. Because there are risks of failure, it is unlikely that large-scale programs will be implemented. Consequently, there is a need for experimenting with small-scale programs. So far, the amount of program experimentation is small (some of the better examples are in New York, Wisconsin and New England). However, opportunities exist for implementing innovative programs, especially at a small-scale level, in conjunction with impact and process evaluation.

The compilation of utility DSM program data and provision of such data in a usable form is more demanding than initially expected (NORDAX, 1988). Initial findings from the NORDAX experience indicate that:

- Data forms are detailed and time-consuming;
- Data quality and consistency pose a continuing challenge;
- Significant utility staff time is required and therefore data cannot be collected with significant utility commitment;
- Regular updates are needed to avoid the data base becoming rapidly outdated;
- Database capabilities often exceed the quality and depth of data currently available.

Accordingly, faced with these problems, utilities typically seek assistance from experts outside their company because (1) the utility doesn't have the expertise in DSM technologies, program design, implementation, and evaluation, (2) the quick turnaround for designing problems does not allow sufficient time for evaluation of technologies, and (3) the utility is not willing to commit its own resources to the tasks at hand. Resolving these problems will necessarily entail a major commitment on the part of utilities as well as a major reallocation of resources within utilities for the serious promotion of DSM programs.

Relevant DOE/LCUP and Other Projects

LBL recently completed program experience reports (on multiple programs) in the following areas: home energy rating systems (Vine et al., 1988), new residential and commercial construction (Vine and Harris, 1988), and thermal energy storage (Piette et al., 1988). LBL is also completing a program experience report on lighting. These reports are a synthesis, or meta-evaluation, of detailed case studies. They include the available published and "grey literature" on specific DSM programs, as well as primary data collection activities.

A survey of appliance rebate programs was completed by the Consumer Energy Council of America Research Foundation and the American Council for an Energy-Efficient Economy (ACEEE, 1987).

Future Work

- Prepare program experience reports on existing commercial, existing residential, and new and existing industrial;
- Develop evaluation protocols and manuals to maintain consistency among program evaluations by utilities;

- Within the NORDAX project, future priorities include:
  - detailed user's manual;
  - refinement of data collection instrumentation;
  - upgrading data in general, and more measured data, in particular;
  - archival data collection;
  - national DSM director;
- Encourage utilities to experiment with DSM programs on a small-scale basis to see how market penetration and cost-effectiveness vary with type and level of promotion and program delivery system.

4.4 Aggregate Demand-Side Potentials

Lead Author: Alan Meier

Background

To ensure that utility resource plans reflect the least-cost mix of demand and supply resources, it is important to ensure that demand-side resources are comprehensively assessed. For this to occur it is necessary to employ consistent technology review, selection, and accounting procedures. These procedures to estimate the aggregate potential for conservation have three primary goals:

- to establish a consistent framework for assessing the energy savings and economics for a heterogeneous collection of conservation measures;
- to rank conservation measures in terms of cost- effectiveness and other criteria;
- to directly compare the aggregate technical potential for energy savings with energy supply options.

Unlike the highly visible, concentrated nature of supply sources, conservation opportunities are hidden and diffuse. As a result, gauging the aggregate impact of DSM measures requires careful examination. For example, there is a wide range of measures which are often difficult to combine or compare. Yet, estimating the aggregate conservation potential is a key step in LCUP.

The first estimates of aggregate conservation potentials appeared about ten years ago (Rosenfeld, 1977). These were crude estimates but for the first time demonstrated that energy savings from simple measures could displace many power plants and oil fields. About 1978, the concept of a "supply curve of conserved energy" appeared. The goal was to develop estimates of conservation potential that closely paralleled supply curves for coal, oil, uranium, and gas. Major potentials studies were undertaken in California (SERI, 1981), in the Pacific Northwest (Usibelli et al., 1983), in Texas (Hunn et al., 1986), Michigan (Krause et al., 1987), and in Florida (Capehart, 1982); see also Pirkey and Scheer (1988), and Meier (1988). Most studies focused on the residential sector, but Texas, Florida, and BPA also included commercial conservation measures. BPA began treating all its supply and demand measures in a similar fashion, that is, the cost of supply or conserving a kWh (Northwest Power Planning Council, 1986).

Most studies focused on annual energy savings, although Texas also estimated peak power savings. In response to integrated planning needs, recent studies (e.g. Krause et al., 1987) have introduced a number of refinements, notably the inclusion of measured hourly end-use load-shapes and measured savings. Improved sensitivity analyses were also employed (Meier, 1982).

Another attempt to refine the technical potential estimates is based on extrapolating from a group of case studies where the savings were measured (Meier et al., 1988). This contrasts with the earlier technical potentials studies which derived energy savings from engineering calculations and simulations.

All of the pre-1986 studies tried to estimate the technical potential for conservation, based on the maximum feasible penetration of each measure, might be reasonably achieved through conservation programs. By 1986, a considerable body of conservation program experience had evolved. This allowed estimates of the annual penetration rates that can be achieved with various kinds of program designs. One of the first aggregate potential studies to incorporate this kind of information was the Michigan Electricity Options Study (MEOS) to which LBL contributed the residential analysis (Krause, 1987). The studies of the Northwest Power Planning Council also included program plans. In this new kind of analysis, the final input to the integrated planning process is the achievable potential of demand-side resources, based on achievable penetrations of each measure for a given set of programs. The technical potential is used mainly as a yardstick to gauge the degree to which actual programs implement the full technical potential.

Relevant DOE/LCUP and Other Recent Projects

The residential analysis for Michigan (Krause et al., 1987) was the only analysis funded under the DOE program to date. Other recent projects not funded by DOE include the technical potentials study of the Conservation Law Foundation for New England (CLF, 1987), and the achievable potentials study for Long Island Lighting Co., performed by BHC with the help of LBL staff.

Future Work

- Extend the conservation potentials technique to commercial and industrial sectors and subsectors, which present many methodological difficulties related to consistency and double counting of energy savings. In the industrial sector, investments in productivity need to be distinguished from investments in energy efficiency;
- Develop software to simplify data collection and analysis. To date, most potentials studies have been forced to develop their own software and analytical procedures. This effort consumes an enormous fraction of the time invested in the study. Common software will save time and encourage comparisons among studies;
- Prepare specifications for the three types of data needed to perform a potentials study (baseline data, technology performance, and program experience);
- Develop techniques for extrapolating stockwide potentials from limited (generally nonrandom) samples of measured data.

5. TECHNOLOGY TRANSFER

5.1 Peer Matching and Program Experience Exchange

Lead Author: Karen Anderson

Background

For the past five years, the American Public Power Association (APPA) has sponsored an Energy Services Exchange (ESE) program designed to aid its member electric systems in acquiring information about the application of technology and techniques to improve system effectiveness and efficiency. The growing interest in DSM strategies, increased public participation in utility policy-setting, and environmental and financial uncertainties of traditional supply options has prompted the formation of this program to exchange expertise and data among local, consumer-owned electric systems.

Most problems and challenges faced by utilities are not new. They have been encountered before or are presently being dealt with by other utilities. The successes and failures of all utilities in responding to problems represents a valuable bank of information that can be shared through ESE. Successful utility programs offer proven solutions to similar problems. Less successful experiences may be even more instructive in providing insights on application which do not work. In all cases, shared knowledge offers managers and program staff enormous savings in time, money, and manpower.

"Hands-on" inspection of an innovative project can be instrumental in persuading others that a good idea is more than a concept. ESE formalizes this traditional transfer of information among public power systems in a program designed to provide one-to-one assistance on energy service programs as diverse as appliance rebates and waste-heat sales.

The exchange has two basic elements: it offers public power systems the opportunity to obtain information about successful projects, copies of helpful documents, and even the help of a utility technical adviser who will provide on-site assistance ("peer-matching"); small group seminars are conducted at innovative utilities; attendees meet with utility managers, program operators, and technical staff for an in-depth look at the project and insights on how a similar program could be implemented at their utility.

Issues

ESE promotes the sharing of expertise and experience among public utilities. Under the program, a network of technical advisors from public power systems has been established. These individuals are available by telephone, letter, or on-site visit to assist another community by explaining how they carried out an energy service project and how the same option could be exercised at another location. APPA serves as a "broker", taking inquiries from local public power system official and referring them to other utilities that have knowledge and experience in that particular area

Relevant DOE/LCUP and Other Projects

Many utilities have used APPA's innovations report published annually in *Public Power* as a starting point for researching ideas and technologies of interest. The ESE takes this a step further. Utility personnel visit another community with an innovative project or program or, alternatively, arrange for a technical adviser to visit their utility and provide personal assistance in getting a project off the ground.

APPA holds about fifteen workshops each year. Energy service programs that hold broad interest for a number of other utilities are highlighted in ESE on-site workshops. Several of these small-group sessions have been conducted with the co-sponsorship of WAPA. Subjects include:

- Energy efficiency;
- Electric system efficiency improvements;
- Load management and communications technologies;
- Non-electric energy services;
- Electric generating alternative energy sources;
- Integrated municipal services; and
- Planning and economic development.

The contacts made at these informal workshops soon turn into working networks. Attendees return home armed with basic planning tools and the knowledge that an experienced counselor is available, should set-backs occur. Often, an idea explored through the ESE becomes the seed for a research project, which is then discussed at technical meetings and becomes part of the innovations data bank -- stimulating in turn another idea.

Future Work

- Review the transferability of ESE activities to other types of utilities and to nonutility organizations involved with LCUP (especially PUCs and state energy offices). Assess the desirability of linking such information-exchange systems with the data exchange system discussed below (NORDAX).

5.2 Development of Regional Program Experience Databases

Lead Author: Carol Sabo

Background

Good data on the performance of DSM programs are very limited. With the absence of standardized reporting formats and definitions, the data available from various utilities are often not useful because they are incomplete and difficult to interpret. The Northeast Region Demand-Side Management Data Exchange (NORDAX) was initiated with the help of DOE's LCUP program to improve data availability. Phase I of NORDAX developed standardized, flexible formats for collecting and reporting DSM program performance data. The lessons learned in NORDAX can facilitate the development of other regional databases.

Issues

The major goal of NORDAX was to produce a database that would provide all the necessary DSM performance data needed for LCUP studies. To fulfill this objective, the database included the following types of information:

- Characteristics of the reporting utility, particularly those that might influence the results of the DSM program;
- Data on the technologies being promoted and the technologies targeted for replacement;
- The objectives, design, and marketing methods of the DSM program;
- Costs, market penetration, and other program performance data;
- Target market, number of participants and "free rider" estimates;
- Load and energy impacts calculated from the technology and program participation information; and
- Sources of data and relevant footnotes.

NORDAX is a multi-phased project that will include the creation of a formal organization during Phase II to continue the work of developing, updating, and expanding the database. Phase I has successfully met its goals for formulating a framework for collecting and reporting DSM program results. Data on approximately 100 programs will be included in the initial database. The NORDAX success has piqued the interest of other utilities and regulators outside the Northeast. Based on the NORDAX experience, it is clear that the development of other regional databases is feasible. But there are problems that need to be resolved, including:

- Developing a plan for using the NORDAX experience to facilitate the creation of other regional databases;
- Determining the organizations and/or individuals who should participate in the planning of other regional databases and defining the roles of the participants;
- Identifying other regions, states and/or utilities that are interested in sponsoring a DSM database development project;
- Developing linkages to transfer information among the regional databases.

Relevant DOE/LCUP and Other Programs

A number of organizations are already involved in informal discussions on how to proceed with the development of other regional databases. Interested parties should meet and formulate a plan to ensure a coordinated effort. Such a meeting could be used to identify participants, roles of participants, schedules, related projects, and resource requirements. Attendees could included people from DOE, EEI, EPRI, NORDAX, national laboratories and other organizations.

The various organizations involved in NORDAX played different roles in contributing to its success. Major steps included the following: (1) DOE acted as a catalyst by providing a share of the start-up costs for the project and enhancing its national recognition and credibility; (2) EEI staff provided advice and a mechanism for communicating results of the project to interested parties; (3) Staff from BNL, LBL, and EPRI provided technical advice and ensured coordination with other regional and national projects; (4) The NORDAX Project Manager handled the administrative aspects, oversaw the technical contractor, and reported on activities to the NORDAX members; (5) Staff from other organizations, such as the New York State Public

Service Commission and the New York Power Pool provided project advice and assistance. The roles of the various groups involved in the development of other regional efforts should be defined appropriately, taking into account the qualifications of each participant.

New York State Electric and Gas Corporation (NYSEG) acted as the lead utility in Phase I of the NORDAX project. The Project Manager from NYSEG was given full support by NYSEG management to commit a significant amount of time and other expenses to ensure the success of the project. It is important for other regional efforts, particularly in the early stages, to identify organizations and individuals willing to "champion" the effort. These champions must have the respect and support of the utilities that provide the data to the database to achieve their goals. Finding these individuals may be the most important and most difficult task in initiating a regional project.

An important goal of NORDAX was to communicate the progress and results to all interested parties. Several hundred people from utilities, regulatory agencies, research organizations, and special interest groups regularly received information on the project through the NORDAX newsletter. Presentations were given at numerous conferences and workshops by various members of the project management team, including a NORDAX workshop held in September 1988.

A number of deliverables are available from the Phase I effort to facilitate the develop of other regional efforts. These include:

- National Directory of DSM planners, implementers, researchers, and evaluators;
- The Data Collection Instrument used to collect the data in a consistent format;
- Several technical reports and papers describing the project and its results;

The value of developing other regional databases patterned after NORDAX is the ability to share data between databases, thus increasing the amount of useful information available to all utilities. Although there is some concern about the transferability of certain types of DSM program data, a standardized format would allow the comparison of program results from region to region as well as utility to utility.

Approximately $300,000 for NORDAX were provided by the utilities, EPRI, EEI, NYSERDA, and the DOE/LCUP grant. The DOE grant award covered approximately 25% of the funds needed for Phase I. Internal resources, such as utility staff time and other expenses, added another 50% of the total cost of Phase I. The Phase II work of maintaining, improving, and expanding the database, is expected to be funded primarily through NORDAX membership fees.

Future Work

DOE should play a role in the initiation of other regional efforts. Future efforts should focus on the following activities:

- Providing a forum for coordinating the efforts of interested parties by sponsoring meetings;
- Co-sponsoring activities to identify organizations and/or individuals to spearhead projects in their regions;
- Communicating the results of the regional database development projects to interested parties through DOE newsletters and other media;

- Co-sponsoring the development of useful products related to the NORDAX project that would help facilitate the development of other regional efforts; and
- Providing monetary assistance, if necessary, to the lead organizations to help cover the costs of project management for new regional efforts.

5.3 Information Exchange and Documentation

Lead Authors: Arthur H. Rosenfeld and Cheryl Wodley

Issues

Because integrated utility planning, and demand-side management are new fields, the management of documents and information is still in the initial stages of development. Authors of reports and papers for conferences proceedings are not trained to submit their results to Energy Abstracts or the equivalent systems operated by EPRI, GRI, NARUC, or NORDAX. In addition, there is no way to consistently review or analyze the value of each paper. Duplication and inconsistencies among the different on-line reference services mean that for every on-line search done many irrelevant citations may be retrieved.

Developing an Information Systems Network (ISN) is an opportunity to provide researchers, planners, and decision-makers with appropriate information in a more efficient manner than is currently possible. Establishing a network relationship among the existing on-line reference service requires an organized information system which would provide the following services:

- information on where the relevant research will be found (description of the various databases by subject);
- information about alternative sources, including people to contact as well as published sources;
- a booklet (also on-line as help screen) describing how to conduct searches; and
- information about abstracting services and how to get reports into the appropriate the system.

While working toward a long-term goal of better-integrated reference systems, a number of interim steps are feasible to improve the quality, completeness, and accessibility of written information on integrated resource planning and demand-side management. At present, perhaps half the documents needed by utility and PUC planners and managers have been abstracted by one of many information services. If the document is abstracted in a database system, it may be difficult to decide which of several options to search. A few choices are:

- Energy Abstracts, the DOE Energy Document Data Base operated by OSTI, and available through DIALOG, a commercial database management system;
- The EPRI bibliographic database which is also accessible through DIALOG, or the Demand-Side Information System (DSIS) which is in the initial stages of development;
- GRI's document database through the NTIS database on DIALOG;
- NARUC's on-line bibliography, set up and maintained by the Michigan PSC; and
- The NORDAX database, which is available primarily to member utilities and to other sponsors. (At present this systems contains program information and data only, not the bibliographic documentation).

The material that currently exists in an on-line reference system may be difficult to access because of the use of different indexing terms or because different software/hardware programs have been employed. Some systems have developed their own keyword indexes (for example, the Energy Data Base, Engineering Index, and the EPRI/DSIS often use different terminology).

Confidentiality, which is inherent at some levels of information-gathering, among utilities especially, makes the utility researchers reluctant to submit their abstracts to any indexing service. In addition, historically, utilities have never been concerned with collecting and referencing their material.

Because the various online services receiving the reports only index and abstract the material, there is no quality control review process involved. One proposed solution is to establish a new review journal on demand-side planning, implementation, and evaluation. This could be done with EPRI, GRI, and NARUC.

LCUP has matured to the point that it now has a definite place in the utility world. Moreover, a growing community of professionals need, and can support, a vehicle for regular communication. A journal devoted to LCUP would provide such a vehicle for this communication. The journal would establish high standards by careful review and editing of articles. In addition, each issue would include invited review articles. The format of the journal will reflect the perceived needs of the least-cost professional community. Short reviews of recent books, reports, and software would also be published. Needs for a journal include:

- reviews of current research;
- presentation and discussion of new methodologies;
- extension of least-cost planning to environmental issues; and
- extension of least-cost energy planning concepts to other utility agencies, i.e. water, transportation systems, and sewage treatment.

Future Work

- Work with EPRI and others to develop a common "thesaurus" of keywords that can be used as a cross-reference among the major sources of on-line information;
- Prepare and regularly update a list of reference sources, which summarizes the major features, contents, organization, etc., of the various on-line or hard-copy sources of LCUP-related bibliographical and project references;
- Continuing efforts to identify (and where possible, resolve) major gaps or inconsistencies in coverage of LCUP topics by the existing reference sources;
- Help fill the important gaps in coverage by providing one or more of the reference services with abstracted references on some of the most important items from the (unpublished) "grey" literature, for example, recent publicly available reports prepared by a single utility or consulting firm;
- Publish the LCUP journal; and
- Continue communications among DOE, national laboratories, NARUC and industry LCUP practitioners through workshops, training sessions, white papers, newsletters, etc.

5.4 Strengthening Institutional Collaborations

Lead Author: Linda Berry

Background

Regional collaboration can facilitate the development and exchange of information and research results among utilities, PUCs, manufacturers of energy equipment, researchers and policy makers. Collaboration often makes possible the development of databases and research projects that are useful to many stakeholders but could not be supported by any of the participants acting alone. The main purposes of collaboration are to prevent duplication of effort, to build on the experience of others, and to produce widely useful information, methods or research results through the joint investments of many stakeholders. The communication and cooperation among stakeholders required to launch a collaborative regional effort also may help to promote consensus.

Issues

Identification of common needs for specific types of information is the first step in planning a collaborative effort. Organizational issues are central to the process of developing regional collaborations. Who will join the effort? At what cost? For what benefits? The main questions that must be addressed are membership, budgets, and research agendas. Organizational mechanisms to accomplish these tasks must be established.

Relevant DOE/LCUP and Other Projects

Many of the DOE/LCUP projects involve some degree of collaboration. The Chicago, Wisconsin, and NORDAX projects are all regional collaboration efforts. Chicago organized the Northern Illinois Alliance to Support Least-Cost Utility Planning, which is a cooperative forum of utilities, public agencies, consumer and industrial groups, research organizations, manufacturers of energy-related technologies and other parties interested in least-cost planning issues.

The main goal of the Wisconsin project was to identify and help overcome organizational barriers to the performance of demand-side research that could be used for integrated utility planning in Wisconsin. The project consisted of two phases, each designed to reduce organizational barriers to the successful performance of demand-side research in Wisconsin. The first phase, which is now complete, was aimed at developing a coordinated statewide research agenda for demand-side research. The second phase is aimed at the formation of an independent, statewide organization to conduct demand-side research. An advisory group consisting of Wisconsin Public Service Commission staff, senior executives in Wisconsin utilities, and technical experts from universities has had an important role in the development of the new state- wide research organization.

NORDAX has two phases, as discussed above. The goals of Phase I, which is now complete, were to develop a workable format for collecting and presenting data on demand-side technologies and programs and to produce a high quality, detailed database. Phase I also includes the development of software, user manuals, a directory of demand-side management planners, and a final report. Phase II involves the establishment of a regional organization to maintain and update the database.

Three other DOE/LCUP projects that involve regional collaboration are the Rhode Island, Colorado and Minnesota projects. For example, the goal of the Rhode Island project is to assist the three utilities in the state in implementing new, cost-effective commercial lighting and industrial motors conservation programs. The cooperation of the utilities, the Public Utilities Commission and the Governor's Office of Energy Assistance is a strength of this project.

A conclusion suggested by the DOE/LCUP project experiences is that successful regional collaborations require a high level of involvement and commitment from all the major stakeholders. Having the interest and support of both the regulatory agencies and the utilities seems especially important.

The national laboratories have provided technical assistance to efforts at regional collaboration in a variety of ways. ORNL and LBL staff, for example, participated in the NARUC conference at Aspen in April 1988 and participated in an October 1988 conference sponsored by the North Carolina Utilities Commission, the South Carolina Public Service Commission, the North Carolina Alternative Energy Corporation, and the Energy Division of the North Carolina Department of Commerce. In addition, LBL staff served on the NORDAX advisory committee, and are reviewing utility plans for the New York Public Utilities Commission.

We are not familiar with the range of other efforts at regional collaboration that are taking place within the utility sector in the U.S. We can, however, present a few examples. Regional collaboration seems likely to continue in the New England area for two reasons. First, a looming shortage of capacity makes demand-side resources especially attractive. Secondly, New England utilities have come under great pressure from state governments and intervenors to use conservation as a resource. One example of collaboration in New England is between Northeast Utilities (NU) and the Conservation Law Foundation (CLF). CLF, which has been an active intervenor in rate cases, offered to cooperate with NU in planning demand-side programs. NU accepted and the two organization now are doing cooperative planning.

In the Pacific Northwest, the Northwest Power Planning Council (NPPC) and the Bonneville Power Administration (BPA) often engage in collaborative efforts. NPPC has been a leader in improving analytical tools for demand-side planning for utilities in this region. There is also a good deal of public involvement in the NPPC/BPA planning processes.

Future Work

There are many opportunities for collaborative efforts in least-cost planning at the state and regional levels. At the state level, efforts involving several utilities and the PUC and/or state energy office could often be useful. The Wisconsin DOE/LCUP project staff reviewed the state-level R&D mechanisms operating in New Jersey, North Carolina, New York, Kansas, California, Florida, and New Mexico. These states, along with the evolving Wisconsin organization, offer models other states could follow.

DOE funding could play an important role in the beginning phases of efforts to create additional collaborative efforts. It would not be productive for DOE to attempt to start up collaborations independently, however. The best role for DOE is to respond with funding and technical support to requests from participants for help in beginning regional efforts. The DOE role, in other words, is not to lead, but to catalyze. DOE support for continued National Laboratory participation in efforts to develop regional collaborations would also be helpful. The National Laboratories should continue to offer technical support by attending conferences, organizing workshops, and serving in advisory roles at the request of organizers of regional groups.

6. REFERENCES

Arizona Corporation Commission (ACC), "Regulatory Institutions for Least-Cost Energy Planning," Appendix I, *1987 Report of the Committee on Energy Conservation*, National Association of Regulatory Utility Commissioners, Washington, DC, 1987.

Baker, M. and Guliasi, L., "Alternative Approached to End-Use Metering in the Commercial Sector: The Design of Pacific Gas and Electric Company's Commercial End-Use Metering Project." Proceedings of the *1988 ACEEE Summer Study on Energy Efficiency in Buildings*, vol. 10, pp. 27-41, American Council for an Energy- Efficient Economy, Washington, DC, 1988.

Braithwait, S.D. and McDonald, C., "End-Use Load Data for DSM Analysis: Results from EPRI's DSM Project." Proceedings of the *Third National Conference on Utility Demand-Side Management Programs - DSM Strategies in Transition*, chapter 10. EPRI-EM-5452, Electric Power Research Institute, Palo Alto, CA, October 1987.

Burns, E.M., "Peak Electric Demand in Commercial Buildings: A Pilot Study of 1983 Data." Proceedings of the *1988 ACEEE Summer Study on Energy Efficiency in Buildings*, vol. 10, pp. 27-41, American Council for an Energy-Efficient Economy, Washington, DC, 1988.

Caldwell, R.W., "End-Use Data Requirements for Demand-Side Planning," Proceedings of the *Third National Conference on Utility Demand-Side Management Programs - DSM Strategies in Transition*, chapter 12. EPRI-EM-5452, Electric Power Research Institute, Palo Alto, CA, October 1987.

California Public Utilities Commission. "Second Report to the California Legislature on Implementation of Assembly Bill 475 1985: Production Cost Models Used by California Utilities", San Francisco, CA.

Capehart, B.L. (editor), "Florida's Electric Future: Building Plentiful Electric Supplies on Conservation", Florida Conservation Foundation, Winter Park, FL, 1982.

Centolella, P.A. et al., "Clearing the Air: Using Electricity Conservation to Reduce Acid Rain Compliance Costs in Ohio". Ohio Office of the Consumers' Energy Counsel, Columbus, OH, July, 1988.

Electric Power Research Institute, "Demand-Side Planning: Sierra Pacific Power Company Case Study", EPRI-EA-4314, Electric Power Research Institute, Palo Alto, CA.

Electric Power Research Institute, "DSM Information Directory", EPRI-EM-4326, Electric Power Research Institute, Palo Alto, CA, 1985.

Electric Power Research Institute, "REEPS Code: User's Guide", EPRI-EM-4882-CCM, Electric Power Research Institute, Palo Alto, CA, 1987.

Energy Conservation Coalition, "A Brighter Future: State Actions in Least-Cost Electrical Planning", Washington, DC, December, 1987.

Eto, J.H. et al., "Integrated Analysis of Demand-Side Programs." Presented at 1987 *IEEE Power Engineering Society Summer Meeting*, San Francisco, CA, June, 1987. LBL-22628, 1987.

Geller, H.S. et al., *Acid Rain and Electricity Conservation.* American Council for an Energy-Efficient Economy and the Energy Conservation Coalition, Washington DC, June, 1987.

Georgia Institute of Technology, "The COMMEND Planning System: National and Regional Data and Analysis", EPRI-EM-4486, Electric Power Research Institute, Palo Alto, CA, March, 1986.

Georgia Institute of Technology, "An Implementation Guide for the EPRI Commercial Sector End-use Energy Demand Forecasting Model: COMMEND". Volume 2: Publically Available Data Sources, EPRI-EM-4049, Electric Power Research Institute, Palo Alto, CA, June, 1985.

Hauser, S.G. et al., "The Benefits of Using End-Use Load Shape Data for Effective Demand-Side Management," *Proceedings of the Third National Conference on Utility Demand-Side Management Programs - DSM Strategies in Transition*, chapter 11. EPRI-EM-5452, Electric Power Research Institute, Palo Alto, CA, October, 1987.

Heinemeier, K. et al., "An Assessment of Monitoring Capabilities of Energy Management Systems to Obtain Detailed Building Energy Data", LBL-24258, Lawrence Berkeley Laboratory, Berkeley, CA, December, 1987.

Hirst, E. and Knutsen C., "Developing an Integrated Planning Process: An Electric Utility Case Study", ORNL/CON-247, Oak Ridge National Laboratory, Oak Ridge, TN, 1988.

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

Hunn, B. et al., *Technical Potential for Electrical Energy Conservation and Peak Demand Reduction in Texas Buildings*, Center for Energy Studies, University of Texas, Austin, TX, February, 1986.

Kahn, E., *Electric Utility Planning and Regulation*, American Council for an Energy-Efficient Economy, Washington, DC, 1987.

Kahn, E. et al., "Least-Cost Planning for Pacific Gas and Electric Company, Stage 1: LMSTM Calibration", LBL-22702, Lawrence Berkeley Laboratory, Berkeley, CA, 1987.

Kahn, E. et al., "Least-Cost Planning for Pacific Gas and Electric Company, Stage 2: Case Studies", LBL-23780, Lawrence Berkeley Laboratory, Berkeley, CA, 1987.

Krause, F. et al., "Analysis of Michigan's Demand-Side Electricity Resources in the Residential Sector", LBL-23025/23027, Lawrence Berkeley Laboratory, Berkeley, CA, 1989.

Krause, F. and Eto, J., "The Demand-Side: Conceptual and Methodological Issues," volume 2 of *Least-Cost Utility Planning Handbook for Public Utility Commissioners*, Lawrence Berkeley Laboratory, Berkeley, CA, 1988.

Lotus Consulting Group, "Least-Cost Integrated Planning for Maine PSC", Los Altos, CA, 1988.

Meier, A.K. et al., "Estimating Conservation Potential Using BECA Data", Draft Report, Lawrence Berkeley Laboratory, Berkeley, CA, February 1988.

Meier, A. et al., *Supplying Energy Through Greater Efficiency*, University of California Press, Berkeley, CA, 1984.

Michaels, H., "Bulk Purchase of Conservation by Competitive Bid," Proceedings of the *1988 ACEEE Summer Study on Energy Efficiency in Buildings*, vol. 6, pp. 58-70, American Council for an Energy- Efficient Economy, Washington, DC, 1988.

Nemtzow, D., "Competing for Demand-Side Resources", Harvard University, Kennedy School of Government, July, 1988.

Northwest Power Planning Council, "Northwest Conservation and Electric Power Plan", Portland, OR, 1986.

Piette, M.A., Wyatt, E. and Harris, J.P., "Technology Assessment: Thermal Cool Storage in Commercial Buildings." LBL-25521, Lawrence Berkeley Laboratory, 1988.

Pirkey, D.B. and Scheer, R.M., "Energy Conservation Potential: A Review of Eight Studies," Proceedings of the *1988 ACEEE Summer Study on Energy Efficiency in Buildings*, vol. 5, pp. 99-111, American Council for an Energy-Efficient Economy, Washington, DC, 1988.

Purcell, L.P., "The Effective Interpretation of Load Research Data for Design and Implementation of Programs," Proceedings of the *Third National Conference on Utility Demand-Side Management Programs - DSM Strategies in Transition*, chapter 10. EPRI-EM-5452, Electric Power Research Institute, Palo Alto, CA, October 1987.

Regional Economic Research, Inc. (RERI), "Commercial End-Use Data Development Handbook: COMMEND Market Profiles and Parameters," Volume 2: *COMMEND Data and Parameter Development Techniques*, EPRI-EM-5703, Electric Power Research Institute, Palo Alto, CA, April, 1988.

Renewable Energy Institute, *Manual for Evaluation: 10 Steps to Cost-Effective Renewable Resource Development in the Utility Sector*, Washington, DC, 1988.

Rosenfeld, A.H., "Some Potentials for Energy and Peak Power Conservation in California", LBL-6865, Lawrence Berkeley Laboratory, Berkeley, CA, 1977.

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

Turiel, I. and Lebot, B., "Development of a Simplified Tool to Calculate Commercial Sector EUI's", draft, Lawrence Berkeley Laboratory, Berkeley, CA, June 1988.

Usibelli, A. et al., "Residential Conservation Data Base for the Pacific Northwest", LBL-18107, Lawrence Berkeley Laboratory, Berkeley, CA, 1983.

Vine, E.L., Barnes, B.K., and Ritschard, R.L., "Implementing Home Energy Rating Systems." *Energy, the International Journal*, v. 13, no. 5, pp. 401-411, 1988. LBL-23926, 1987.

Vine, E.L. and Harris, J.P., "Planning for an Energy-Efficient Future: The Experience with Implementing Energy Conservation Programs for New Residential and Commercial Buildings." LBL-25525, vols. 1 and 2, Lawrence Berkeley Laboratory, 1988.

XENERGY, Inc., "Statewide Commercial/Industrial Technical Potential for Energy and Demand Savings", prepared for Rhode Island Least-Cost Planning Committee, Providence, RI, March, 1988.

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