LOAD FORECASTING AND CAPACITY PLANNING:

CURRENT AVAILABILITY AND USEAGE

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FOREWORD

This report was prepared by The National Regulatory Research Institute (NRRI) under Contract No. EC-77-C-01-8683 with the U. S. Department of Energy (DOE), Economic Regulatory Administration, Division of Regulatory Assistance. The opinions expressed herein are solely those of the authors and do not reflect the opinions nor the policies of either the NRRI or the DOE.

The NRRI is making this report available to those concerned with state utility regulatory issues since the subject matter presented here is believed to be of timely interest to regulatory agencies and to others concerned with utility regulation.

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INTRODUCTION

Because of the high cost of energy and of the uncertainties associated with the expected growth of the demand for electricity in the 80's, load forecasting and capacity planning are becoming critical issues for regulatory commissions. This report provides an overview of four forecasting and planning situations and a discussion of state regulatory commission activities in forecasting and planning. By providing this material as background, this report aims to identify the needs of regulatory commissions in the areas of forecasting and planning.

The report is divided into four sections. The first section provides an overview of the planning and forecasting areas. The second section presents a discussion of state regulatory commission activities in these areas. The third section explores opportunities for future work. A summary at the end of the report indicates the potential benefits of that work.

OVERVIEW OF FORECASTING AND PLANNING

This section highlights the major situations where forecasting and planning are needed at the level of state regulatory commissions. These are:

1. load forecasting;
2. capacity planning;
3. operating cost forecasting and analysis; and
4. financial analysis.

Load Forecasting

Load forecasting seeks to predict, and explain changes in, the future demand for electricity. These predictions motivate the evaluation of alternative planning strategies to meet that demand. Explanations of demand provide insight into the sensitivity of load growth to external forces and can facilitate certain planning aspects such as the attainment of the appropriate generation mix (base, cycling, peaking).

The result of the load forecasting activity is a necessary input into capacity planning, financing, projections of operating strategies, and rate design activities.

Load forecasting begins with a model of the forces influencing electric energy demand. Often, these models represent a balance among simplicity, technical feasibility, and cost of operation and development. Models attempt to explain demand by recognizing the most important factors or by using proxies which reflect changes in these factors. In the past, forecasting techniques achieved sufficient accuracy by simply assuming relatively constant rates of growth. Recently, the slowing of growth as well as the need to account for changes in the underlying structure of the demand for electricity, necessitate the adoption of more sophisticated forecasting methods.

As with other goods and services, the demand for electricity is a complicated function of its price, the prices of substitution, the price of appliances which use electricity, the income of the users and the number of users. Since electricity is not a finished product, the demand for it is "derived" from the demand for goods and services that use electricity.

Load Forecasting Methodologies*

The importance of capital goods in the determination of electricity's long-run demand helps to explain the existence of two, often competing, methodologies for estimating future levels of demand.

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*See Long Range Forecasting Properties of State of the Art Models of the Demand for Electric Energy, prepared by Charles River Associates, Inc., EPRI EA-221, Project 333, Volume I, December 1976 for overview of techniques.

These are econometric forecasting and the engineering approach. There is a third approach, one which assumes an exponential future growth. Models of the third category are rarely used now and are not desirable since they do not recognize underlying determinants of demand. Therefore, these will not be discussed.

The two primary approaches currently used for forecasting are distinguished by their different methods of dealing with electricity-consuming capital goods in the modeling process. The first approach, called econometric forecasting, abstracts from the interrelationship between the demand for capital goods and electricity, and models electric demand as a function of a number of appropriate variables. The second approach, referred to as the engineering approach, deals explicitly with capital goods in modeling the demand for electricity.

Although many specific forecasting models are hybrids of the two approaches, the following discussion treats them separately.

Econometric Models

Econometric models seek to explain the demand for electricity as a function of the level of electricity prices, prices of substitutes, prices of appliances, income, population, and other factors. These variables are chosen in order to represent important characteristics of the market for electricity. Many of these factors also indirectly represent important characteristics of the market for electricity-consuming capital goods.

Good econometric models begin with an economic model. An economic model seeks to explain one or more variables (the dependent variable(s)) in terms of other variables (the independent variable(s)). The economic model also provides insight into the nature of the responsiveness of the demand for electricity to changes in the independent variable.

In addition, changes in the energy demand produce changes in the value of the independent variable used to project that level.

In general, econometric models enable estimation of the impact of general economic indicators on the level of demand. By abstracting from the problems of estimating the demand for capital goods, econometric models provide insight into some of the underlying forces influencing the demand for electricity.

Engineering Models

Engineering forecasting models seek to determine future levels of demand by physically modeling the characteristics of electricity-using devices. In the past, utility load research was primarily directed toward determining the physical operating characteristics of electricity-using equipment. The fundamental engineering approach seeks to build the utility load curve from its constituent parts. In the extreme, the engineering approach would determine the load characteristics of everything from lighting to air conditioners, determine the level of "saturation," and construct the system load by adding all of the parts together. In practice, the engineering approach concentrates on a few major components of the load.

Engineering models, in general, require significant data collection efforts and expense but provide for greater flexibility in evaluating load management alternatives. This is especially true in the short run, since changes in overall demand are a result of shifts in the rate of utilization of a given stock of appliances. In the long run, however, it is probably the case that a utility can more effectively forecast demand for electricity by modeling that demand directly. Attempting to forecast appliance saturation rates and load curves for the distant future rather than overall electricity demand, would require data that is simply unavailable. Furthermore, the explanatory variables used for estimating saturation rates are the same as those used for estimating total demand. Since historic electricity consumption figures are more generally available, the estimates from an econometric type model will probably yield more accurate forecasts of long-run electricity demand.

At best, load forecasting is a difficult job. The impact of higher prices and changes in rate design on demand is not known. The extent to which technological change (industrial cogeneration, heat pumps, solar heating and cooling systems) and government incentives (solar equipment and weatherization tax incentives) will change demand is very uncertain. This uncertainty carries through all the planning activities of the utility.

Capacity Planning

The capacity planning activity seeks to determine the appropriate unit size, on-line date and generation technology of additions to the electric utility's plant. In the past years, load growth was so regular that capacity planning did not require complex analysis. Today the uncertainty in forecasting future demand compounds itself in the planning function.

Generating unit choices can be distinguished by technological and economic characteristics. For example, units differ with respect to fuel type (coal, oil, nuclear, etc.) and power output. Economic distinctions can be made among units based upon input factor prices and risk which may reflect the alternative technologies. In general, the system planner seeks to identify the least-cost unit based upon economic and reliability-related criteria.

Two existing capacity planning models in the public domain are the Wein Automatic System Planning (WASP) model and the EPRI "OVER/UNDER" model. The WASP model, developed by the Tennessee Valley Authority (TVA), is a modular program for analyzing electric power generating systems. The economically optimal capacity-expansion pattern is found for an electric utility subject to various constraints such as system reliability and the type and size of plants which can be constructed. Specialized personnel may be needed to use the model. WASP has, nevertheless, been used by regulatory commissions.

The EPRI "OVER/UNDER" model is an attempt to model the impact associated with planning for the future, realizing that uncertainty exists in future demand. Since the model has just recently been placed in the public domain, it is too early to determine if the model can be utilized by the regulatory community as a policy analysis tool.

Proprietary models, such as the Optimized Generation Planning (OGP) of General Electric, exist and may be used in the regulatory environment through their respective vendors.

OPERATING COST PROJECTIONS AND ANALYSIS

The objective of operating cost projections and analysis is to provide insight into the future values and determinants of operating costs. Operating cost analysis is employed in the evaluation of operating efficiency, and as an input to capital investment planning and financial budgeting. Electric utility operating cost projection generally focuses upon fuel use since it is the largest "controllable" expense. Most major electric utilities have computer programs that calculate fuel costs under various assumed or simulated operating conditions. Frequently, such models include the simulation of the optimal dispatching of the systems' plants, plant outages, and maintenance scheduling.

Production cost simulation models can be very useful regulatory analysis aids in a variety of situations. Two situations are the verification of expenses claimed by utilities and the evaluation of incentives for efficiency implicit in automatic adjustment clauses mandated by PURPA.

Automatic adjustment clauses are employed and defended on the argument that fuel costs are "independent" of the utility's actions. In economic terms, this means that the utility cannot affect the price it pays for fuel. In fact, the utility can and does undertake many activities that affect the total cost of fuel burned.

In the short to intermediate term, the total fuel cost of a utility is a function of the unit fuel cost, heat rate and equivalent operating availability of each operating unit. Improving either heat rate or availability of efficient units will reduce the total fuel cost. Generally, some investment is required to improve either heat rate or availability. The investment may involve new equipment or changes in maintenance practices.

Production cost simulation models have been used to calculate the fuel cost savings associated with specific investments or actions to improve heat rate or availability. The analytical process involves changing unit parameters in the dispatching code and performing the simulation in a "before and after" manner. The annual cost streams associated with the fuel savings can be compared to the investment costs.

Production cost simulation models have also been employed to examine the "excess capacity" issue. It is sometimes argued that the firm should not earn on any capacity not necessary to meet peak load plus some reasonable reserve margin. These arguments generally rely upon definitions of adequate capacity, e.g., peak plus some percentage. In economic terms, an additional unit would be desirable if the present value of the reduction in energy costs exceeded the present value of the additional capacity taking into account all other costs.

This rule is similar to the plant investment criterion: if average total costs of the new plant are less than average variable costs of the existing plant, the new plant should be built.

Financial Forecasting

A corporate finance model is a mathematical description of the financial and accounting relationships underlying the basic financial statements. Given forecasts of construction and capital expenditures and historical data on the firm, such models can generate pro forma income statements, balance sheets, and statements for sources and uses of funds.

Corporate finance models can be used for two purposes. First, corporate finance models are useful in determining the revenue and profit implications of various ratemaking alternatives. For example, a finance model can be used to determine the revenue, cash flow, and external financing implications of various regulatory treatments of deferred income taxes and investment tax credits, adopting different rates of return, or including construction work in progress (CWIP) in the rate base. Second, corporate finance models can serve as a unifying framework for complex analysis involving all aspects of the firm or regulatory environment. The financial model might be thought of as a "core" model around which to build more extensive or sophisticated models of system simulation.

The ability to integrate and summarize the effects of several simultaneous policy actions also increases analytical efficiency. The use of the finance model enables the analyst to investigate alternative policies quickly, consistently, and accurately.

STATE REGULATORY ACTIVITIES

The National Regulatory Research Institute, in an information gathering activity conducted in the fall of 1978, contacted regulatory personnel from approximately 45 state regulatory commissions. During these meetings a number of topics were discussed. Among these was the level of involvement state commissions had in utility forecasting and planning activities. This section discusses the trends in state regulatory commission involvement in forecasting and planning.

Since, by the nature of a rate case, the forecasts and plans of electric utilities are reviewed by each regulatory commission, the level and type of review define differences of approach among the commissions. The depth of review and the ability to perform independent forecasts is directly related to the resources of the regulatory commission. These resources are measured in the number of staff, capabilities of the staff, and other support resources such as computer capability. There is a direct correlation between the computer capability of a commission and the number and complexity of forecasting and planning analysis models which are utilized by the commission. This capability to utilize the computer also correlates to state commissions performing independent forecasting and capacity planning analyses.

In addition to the rate case process, many commissions review, to varying levels of depth, utility forecasts and capacity planning questions as part of the process of certifying the need for new capacity. Again, the depth of this review is a direct function of commission resources and capabilities.

In a number of cases, a commission, not having the capabilities, will rely on those of the companies it regulates. Since, for the most part, the regulated utilities have developed forecasting capabilities, the commission may use this fact to advantage by having commission staff define alternate scenarios for the utility to analyze. This tactic enables the commission to perform sophisticated sensitivity analyses with minimum resources.

It is becoming increasingly common that utilities submit to their regulatory commission, on an annual basis, a long-term (10 year) plan independent of siting hearings or rate cases, which provides state agencies with forecasted energy demands and capacity siting requirements for the report period. To some degree these reports are reviewed by the commission staff.

In recent years state regulatory commissions have become much more involved in reviewing and analyzing the energy demand forecasts of electric utilities. Commissions are developing the capability to independently forecast energy demand. State legislatures are beginning to statutorily require commissions, or other state agencies such as a state energy office or state department of energy, to independently forecast the energy needs of the state as a whole or the energy demand on individual companies.

The North Carolina Commission has been independently forecasting energy demand for the state for three or four years. Other state commissions which independently forecast energy requirements include but are not necessarily limited to Florida, Iowa, Michigan, New York, and South Carolina. Numerous other states review the forecast submitted by the electric utilities they regulate.

In general, the area of load forecasting has become extremely controversial. In past years, prediction of load growth was relatively simple to the point that, over a ten year planning horizon, load forecasts were generally off by no more than one year. However, today with the dramatically changing energy situation the uncertainty contained in load forecasts is extremely high. Since a company's decision to build generating capacity is directly related to the projected load growth, state regulatory commissions, power siting councils, and state energy offices are evaluating those projects.

State regulatory commissions have become more active in assessing the capacity planning of electric utilities. This activity is directly tied to the forecasting analysis performed by the utilities and the commissions. Since in a number of states the regulatory commission must certify the need for new facilities and/or allow the company to issue debt to finance these facilities, the commission staff has taken an active part in the review of the forecasts and capacity planning. Based on the information gathered in the fall of 1978, few commissions are utilizing capacity planning models. However, the Florida Commission is utilizing the WASP expansion planning model to analyze the joint planning of capacity by groups of utilities in the state of Florida. The Ohio Commission has also utilized the WASP model in some capacity planning analysis. Other commissions have looked at utilizing capacity planning models. The major problem with available capacity planning models is that they require large amounts of data and significant computer resources. There are few commissions having the staff to maintain and utilize a capacity planning model for each electric utility it regulates.

The utilization of production costing analysis by state commissions has been on the increase due in part to ensure that automatic fuel adjustment clauses are indeed economically reasonable. The Virginia State Corporation Commission is utilizing the Production Cost Simulation (PCS) model to assist in determining the reasonableness of fuel usage and of forecasts thereof by five utilities serving Virginia. Ohio has utilized a similar model in a number of rate case proceedings to measure the impact of unit-specific operating availabilities and system reserve margins. It is expected that more commissions will become actively involved in utilizing production costing models or performing production costing analysis because of the requirement in PURPA to analyze automatic adjustment clauses as to their economic efficiency.

Recently, a number of state regulatory commissions have focused attention on financial analysis. The introduction of the Regulatory Analysis model (RAm) has ignited the interest of state commissions in utilizing this model for policy analysis and rate case work. Due in part to the NRRI's presenting of financial analysis workshops during the last year, the RAm model is now being used or about to be used in approximately 12 states. Among these are Florida, Ohio, California, Virginia, New York, Illinois, North Carolina, Kansas, Nevada, Arkansas, and Pennsylvania. This model is receiving significant attention due in part to the fact that it was designed for use as a policy analysis tool by regulatory commissions.

It is the desire of almost all of the state commissions contacted to increase their forecasting and planning capability in the future. This desire is limited of course by the resource capability of the commission which, in almost all cases, is limited to the budget allocation of the state legislatures.

The passage of the National Energy Act and the issuing of PURPA grants to state regulatory commissions will hopefully allow the commissions to expand their resources, such that the capabilities required to undertake forecasting and planning analysis will be developed.

FUTURE WORK

Forecasting and planning analysis will be increasing at state regulatory commissions primarily due to the required review of the ratemaking standards of PURPA. The need for determining the long term impact in relation to these standards is required. This section discusses briefly some of the specific activities that need to be accomplished in the areas of demand and energy forecasting, expansion planning, fuel usage forecasting and financial forecasting.

Demand and Energy Forecasting

This activity will require continued development of techniques and capabilities to more accurately project energy and demand. Unless the capabilities of commissions, in terms of staff members with expertise in this field and support resources, are enhanced significantly, this activity will tend to rest with the energy utilities, not with the regulatory commissions. Fortunately a sizable amount of expertise has been developed in the private sector that can lend itself to assisting state regulatory commissions and the utilities in preparing energy forecasts.

Analysis development which is required in this particular area is that of projecting peak demand independent of projecting energy demand. Currently the projected system peak is calculated by projecting future energy demand and dividing that demand by the product of the system load factor and the number of hours in the year. The projection of system load factor involves significant uncertainty. Since the decisions relative to the amount of capacity required in the future depends directly on the projected peak, the importance of accurately projecting peak cannot be overstated.

Analysis techniques which would assist a commission to evaluate the accuracy and methodology of a submitted forecast could be very valuable. This activity of evaluation is something that is within the resource capability of most commissions. By acquiring standard procedures for evaluation of forecasts and forecast methodologies, the commissions would be greatly aided in dealing with utilities' submitted forecasts. This would also allow a commission to develop alternative scenarios for the utility to use in forecasting.

Capacity Planning

Capacity planning models are designed for system planners and require large amounts of data. Since regulatory commissions tend to regulate more than one electric utility, developing and maintaining the data base to perform independent capacity expansion plans for each of these utilities requires significant resources on the commission's part. As with forecasting, a capacity analysis model is needed which allows regulatory commissions to analyze utility-submitted expansion plans in terms of various policies. The ability to accurately and rapidly analyze expansion plans or alterations to those plans is very important, since a major aspect of implementing the standards of PURPA is the benefit derived from reduced capital needs in the utility industry. The long term shifts in load patterns due to time-of-day rates and the implementation of load management techniques bear directly on the capacity planning function of a utility. It is important for a regulatory commission to understand the potential results that implementing the standards of PURPA may bring about on the utility in terms of its current generating plant and future additions to that plant.

Fuel Usage Forecasting

A number of fuel usage projection models do exist in the public sector. One of the more recently developed models, the Production Cost Simulation model (PCS), is designed to fulfill the specific need of projecting utility fuel usage in relation to a fuel adjustment clause in the Commonwealth of Virginia. Such models are very important to some of the considerations of regulatory commissions, especially relative to PURPA. Since one of the major goals of PURPA is to more efficiently utilize resources, fuel projection models will help to ascertain the degree to which resources can be efficiently utilized and to identify areas where improved utilization could result. In addition, this type of program will provide information to capacity planning models as well as to financial analysis models. As can be seen, these models in all analysis areas do interrelate. In fact, changes which occur in one area (e.g. fuel projection) impact on other areas (e.g. financial situations and technology used to expand the system). Work is needed in this area to make the current models more applicable and usable by commissions within their resource constraints.

Financial Analysis Forecasting

This area is unique in that the Regulatory Analysis model (RAm) was specifically developed for commission use and is being employed by a large number of commissions. The model can be utilized by commissions to assist in the analysis of a number of PURPA issues. The Nevada Commission staff is currently utilizing the RAm model to model the potential financial impacts on electric utilities serving the state of Nevada relative to the implementation of load management. The Florida Commission is looking at the financial implications on Florida utilities of curtailing fuel oil usage by one half in accord with President Carter's directive. Future work in this area consists of continued assistance to commissions in acquiring and utilizing the model.

Other Work

Given that in each of these categories, as well as in the rate design area, the analysis techniques have been developed and are being utilized by state regulatory commissions. A sizable amount of work remains in the area of coordinating all of these analysis techniques into a usable package which allows a regulatory commission to quickly, accurately and confidently perform sophisticated analysis which will assist it in making policy decisions in implementing the standards of PURPA. It should be pointed out that these analyses assist commissions in their work; they do not replace or give infallible answers. The judgment of each commission is still required.

SUMMARY

In summary, over recent years the capability and activity of state commissions in the forecasting and planning area has increased; however, significant advancement is still necessary. Work is currently being undertaken to improve the capabilities of state regulatory commissions, and it is envisioned that this work will continue in the form of PURPA grants, the innovative rates program, and general technical assistance provided by the Department of Energy. The results from these activities will be extremely beneficial.