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BY THE U.S. GENERAL ACCOUNTING OFFICE

Report To The Subcommittee On Energy Conservation And Power Committee On Energy And Commerce House Of Representatives

Analysis Of Electric Utility Load Forecasting

The Chairman requested that GAO review electric utility load forecasting. He was specifically interested in forecasting methodologies, key variables, state of the art, and how conservation and small decentralized power resources are addressed.

This report presents a summary of electric utility load forecasting as currently accomplished by utilities of various sizes. It highlights the many controversies surrounding forecasting and discusses how utilities are attempting to deal with the uncertainty inherent in forecasts of future power demand.

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UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

RESOURCES, COMMUNITY,
AND ECONOMIC DEVELOPMENT
DIVISION

B-211952

The Honorable Richard L. Ottinger
Chairman, Subcommittee on Energy
Conservation and Power
Committee on Energy and Commerce
House of Representatives

Dear Mr. Chairman:

In accordance with your December 2, 1982, request, this report discusses electric utility load forecasting. The report specifically examines: current forecasting methodologies, the state of the art in forecasting, the variables and assumptions used, efficiency improvements and dispersed electric generation, and the weaknesses of forecasting procedures.

As requested by your office, unless you announce its contents earlier, we plan no further distribution of this report until 7 days from the date of the report. At that time we will send copies to interested parties and make copies available to others upon request.

Sincerely yours,

J. Dexter Peach
Director

GENERAL ACCOUNTING OFFICE REPORT
TO THE SUBCOMMITTEE ON ENERGY
CONSERVATION AND POWER
COMMITTEE ON ENERGY AND COMMERCE
HOUSE OF REPRESENTATIVES

ANALYSIS OF ELECTRIC UTILITY LOAD FORECASTING

DIGEST

Electric utility load forecasting is the process by which utilities project the demand for electricity at various points of time. The forecasts are then used by utilities to decide the amount of resources needed to meet projected demand. Load forecasting has become increasingly important over the past few years as the demand for electricity has declined and the cost of generating sources has increased.

On December 2, 1980, the Chairman, Subcommittee on Energy Conservation and Power, House Committee on Energy and Commerce, asked GAO to develop information on electric utility load forecasting that would help the subcommittee respond to possible legislative proposals regarding electric utility regulation. Specifically, GAO was asked to review forecasting methodologies, the state of the art in forecasting, key variables that are considered, how conservation and cogeneration, i.e., power produced as part of an industrial process, are addressed, and to identify any weaknesses in current load forecasting procedures.

FORECASTING METHODOLOGIES

Utilities are currently using several forecasting methodologies. These methodologies range from simple trend analysis to complex techniques with extensive data requirements. The methodology that a particular utility uses is influenced by factors such as size, technical expertise, and financial resources. Smaller utilities still rely on traditional methods such as trending. Large utilities use more complex methods such as econometric and end-use. (See pp. 6 to 18.)

Trend forecasting

Many small utilities that lack the resources necessary to utilize the sophisticated forecasting techniques still rely on trend

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analysis. This methodology predicts future power demand by assuming that the factors that influenced demand in the past will continue to do so in the same way in the future. Although this methodology is simple and easy to use, it does not address changes in economic or social conditions. It works well only when the factors affecting electricity consumption are stable. (See p. 11.)

Econometric method

Econometric forecasting uses mathematical equations based on the relationship between past demand and economic and demographic conditions to forecast future demand. A major assumption underlying this type of forecast is that the relationship will continue in the future. Uncertainty over this assumption is the major weakness of this technique. Strengths of econometric forecasting include

--small data requirements and

--ease in providing a range of forecasts by modifying variables. (See pp. 6 to 8.)

End-use method

End-use forecasting breaks electricity consumption into sectors--residential, commercial, and industrial. The sectors are further broken down into individual uses. The need for extensive inventory data on such things as the extent of home electrical appliance and industrial equipment use is the primary drawback of this technique. This data is expensive and time consuming to collect and maintain. The advantage of end-use forecasting is that it readily reflects changes in consumer tastes, increased efficiency of energy-using products, and changes in the economy, particularly technological shifts in our industrial base. (See pp. 8 to 10.)

Sum-of-the utilities forecast

A forecasting technique often used to give a regional or national perspective on utility demand is the sum-of-the utilities approach. This is not a separate and distinct forecasting methodology but rather a combination of individual utility forecasts. As with all national forecasts this approach, because of its aggregated nature, is of limited use to individual utilities in planning new resources because the service areas are significantly smaller than the area covered by the forecast. (See p. 12.)

FORECASTING STATE OF THE ART

According to utility officials, forecasting state of the art involves several techniques to mitigate and minimize the uncertainty inherent in forecasting. This includes forecasts using more than one methodology and forecasting a range of possible future demand levels. Large utilities are currently using a combination of the econometric and end-use methodology to predict future demand. This methodology combines the strengths of both methods but has the disadvantage of tremendous data requirements. Also, the large utilities are dealing with the uncertainty of forecasting by using a range of forecasts rather than a single one. By using a range of forecasts, the effects of changes in key assumptions and variables can be readily observed. (See pp. 12 to 18.)

VARIABLES AND ASSUMPTIONS ARE CRITICAL TO FORECASTS

Variables are the basic input data for forecasts. Variables are items that are known to have an effect on the demand for electricity. Assumptions deal with the relationship between the inputs and future demand. GAO found there are variables common to all forecasting methodologies:

--Population of the service area.

--Income of customers.

--Price of electricity.

--Economic growth.

--Conservation measures. (See pp. 10 to 11.)

In addition, there are specific variables related to individual methodologies. For example, alternative fuels is a specific variable in econometric forecasts. If alternative fuels are available it can impact on electricity consumption. In this regard, oil and natural gas availability at cheaper prices may cause a decrease in electricity use. Appliance usage data is a critical variable for the end-use methodology because the total number of appliances is multiplied by the usage to derive total consumption. (See pp. 8 to 10.)

GAO found that a forecaster must make four controversial assumptions in preparing a forecast. These assumptions, which are as important to the forecast as the methodology selected, deal with (1) how much electricity is consumed relative to its price (price elasticity), (2) the relationship between economic growth and electricity consumption, (3) the cost and availability of alternative fuels, and (4) the impact of conservation. (See pp. 19 to 22.)

CONSERVATION AND DISPERSED GENERATION

For the most part, utilities do not factor conservation into their forecasts because they assume it will have a marginal impact on ultimate demand. Those utilities that do are generally responding to legislatively mandated conservation goals e.g., in Florida, the Energy Efficiency and Conservation Act establishes conservation goals. For these utilities conservation is addressed in, or related to, the forecast in three ways (1) through the price elasticity variable in econometric forecasts, (2) through appliance efficiency standards and the extent of appliance use in end-use forecasts, and (3) by determining the impact of conservation programs on demand and subtracting this from the base forecast.

Forecasters encounter difficulty in quantifying the savings from conservation due to limited experience and a lack of historical data on which to base projections. Several problems were also identified in assigning impacts to utility-conservation programs. These include (1) total conservation savings will be less than the individual programs, i.e., the impacts of individual programs are not additive, (2) the receptiveness of conservation programs by the consumer, (3) consumers may turn up their thermostats once conservation savings take place, and (4) newness of programs makes it difficult to measure future effects. (See pp. 26 to 27.)

Dispersed generation, which includes customer generated electricity from wind or other alternative technologies as well as cogeneration, is factored into forecasts only if it is a significant source of energy in the utility's service area. Cogeneration, the production of electricity as part of an industrial process, is the most prevalent form of dispersed technology. When dispersed generation is a signficant variable, it is treated much the same as conservation. However, dispersed generation is different from conservation in that its impacts are relatively easy to quantify. (See pp. 27 to 28.)

COMMENTS BY PANEL OF EXPERTS AND GAO's EVALUATION

Comments on a draft of this report were not requested from any Federal or State agency since it is not an evaluation of a Federal or State agency's performance. However, GAO convened a panel of experts representing a broad range of economic, utility industry, and regulatory background to review and comment on a draft of the report. (See app. III for a list of participating panelists.) All five panel members commented on the draft, two in writing (see app. IV).

Generally, the review panel believes the report is balanced, accurate, and a good summary of load forecasting, which emphasizes the uncertainty of forecasting, the importance of the relationship between the economy and electricity growth, and the importance of the electric utility industry's response to forecasting uncertainty.

All the panel members commented on the economy/electricity relationship. For example, one panel member stated that all of the recent forecasts, including end-use forecasts, have been too high because they fail to reflect the growing trend of less electricity use per dollar of Gross National Product (GNP). He went on to state that the combined effect of more efficient buildings and machines and an economy that contains a less energy-intensive mix than in the past is not reflected in most load forecasts. Another panel member's comments, however, reflect the position that there has been a very high correlation between electricity and GNP in the past and once the economy picks back up the load growth for electricity will follow.

This divergence of opinion among panel members only serves to highlight the theme of this report--that there is a great deal of uncertainty associated with load forecasting and the methods used. The economy/electrical growth issue appears to be the most prevalent area of disagreement among individuals knowledgeable of load forecasting. Because of the disagreement, GAO plans to cover the topic in future work related to the overall issue of supply and demand of electricity. (See p. 22.)

Several panel members also had comments concerning conservation. One member stated that a fundamental error in most forecasts was that utilities do not factor in conservation because they believe it will have only a small impact on demand. He suggests that utilities should use conservation and load management as an active program that constitutes a source of supply. Another member stated that in terms of total number, utilities do not factor conservation into their forecasts, but this is not true for utilities that have most of the generating capacity. (See p. 28.)

GAO recognizes that how much conservation is achieved is difficult to measure. This is particularly true, as brought out in this report, because of the lack of data being collected on the effects of conservation. Again, this serves to point up the fact that the assumptions used are critical to the forecasting process.

In addition, several panel members commented that the report does not discuss that most utility forecasts have been too high. These panelists indicated that utilities are reluctant to under estimate for fear that the "light may go out." While GAO recognizes that recent forecasts, for the most part, have been too high, it was not GAO's objective in this review to analyze possible reasons for high forecasts.

Panelists also provided technical comments that have been incorporated where appropriate. (See pp. 6 to 8.)

Contents

ABBREVIATIONS

BPA	Bonneville Power Administration
DRI	Data Resources Incorporation
DOE	Department of Energy
EEI	Edison Electric Institute
EPRI	Electric Power Research Institute

GAO	General Accounting Office
GNP	Gross National Product
NERA	National Economic Research Association
NERC	North American Electric Reliability Council
NPPC	Pacific Northwest Planning Council
MW	megawatt
TVA	Tennessee Valley Authority

GLOSSARY

Alternative fuel	Generating and generation-displacing options to coal-fired and nuclear electric generation facilities. Options include natural gas and oil.
Conservation	Improving the efficiency of energy use; using less energy to produce the same product.
Demand forecast	Projection of the future demand for electricity. Various types of demand forecasting models include trending, econometric, and engineering or end use.
Dispersed electric generation	Electricity that is generated either by industry (cogeneration) or by customers of a utility.
Econometric model	A forecasting model based on assumed relationships between electricity consumption and general demographic and economic variables such as gross national or State product, prices of electricity and competing fuels, prior year's electricity sales, and population.
End-use (engineering) model	A forecasting model relying on a detailed enumeration of all energy-using equipment that is expected to be functioning during the forecast period. A use-rate is applied to each type of equipment to forecast total energy consumption.
Explicit variable	Data or constraints which are used in the form of mathematical formulas that are contained in forecasting models to calculate load growth.
Gross national product	The total value of the Nation's annual output of goods and services.

CHAPTER 1

INTRODUCTION

On December 2, 1982, the Chairman, Subcommittee on Energy Conservation and Power, House Committee on Energy and Commerce, asked us to provide information on electric utility load forecasting that would help the subcommittee respond to possible legislative proposals regarding electric utility regulation. Specifically, we were asked to examine:

--On what basis do electric utilities forecast loads?

--What are the key variables that are, or should be, accounted for in load forecasting?

--How are customer-side-of-the-meter efficiency improvements[1] and dispersed electric generation factored into load forecasting?

--What are the weaknesses of existing utility load forecasting procedures?

--Is there a state of the art in load forecasting, and if so, how widespread is the use of this or these techniques?

BACKGROUND ON ELECTRIC UTILITY LOAD FORECASTING

Load forecasting is the process of determining what the demand for electricity will be at various points of time in the future. Until the late 1960's forecasting electricity demand was generally a simple exercise, consisting of straight line projections of historical consumption trends. With stable prices and economic growth, these power forecasts proved to be reasonably accurate and provided the information that utilities needed to plan and develop new resources. With the coming of the 1970's this changed as inflation, higher fuel and capital costs, longer resource development leadtimes, and declining economic growth combined to dramatically alter historic consumption patterns and to introduce new uncertainty into load forecasting. In addition, the same factors increased the risks associated with over or under development of resources increasing the utility's need for accurate forecasts.

Utility role in forecasting

The need to forecast future electrical demand flows directly from the characteristics of the electric utility industry.

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[1] Customer-side-of-the-meter efficiency improvements in this case are defined to mean conservation.

Utilities are under State charters, which require that they provide adequate and reliable service to all customers in their service area. This means that a utility must maintain adequate power resources. If it were possible to purchase generating facilities or conservation programs "off shelf" and plug them into the system on short notice, this would pose no problem. Utilities would develop new resources on an "as needed" basis with limited risk. However, virtually all types of generating facilities require substantial leadtimes for planning, licensing, and construction. The process of licensing and building a coal-fired plant takes 8 to 10 years, longer for a nuclear plant. It may take consumers several years before they fully implement and accept conservation programs. Therefore, it is necessary to anticipate the need for new resources several years in advance.

The purpose of demand forecasting is to produce information utilities need to reduce their resource-development risks. Good forecasts reduce the risk of developing inadequate and unnecessary resources to meet customer needs. The high cost of new resources also makes it incumbent that utilities accurately predict future power demand and develop only those resources necessary to meet that demand. If the projected demand does not materialize, billions of dollars may be invested as fixed costs in resources which prove to be unneeded. These costs must then be borne either by the consumer through higher rates or by a utility's stockholders through reduced profits. Conversely, if future demand is underprojected, utilities may be forced to rely on high cost resources, such as oil and gas turbines which can be developed in a short timeframe.

For the most part, individual utilities do their own load forecasting for their service area primarily because resource development programs are developed and implemented on a service area level. A utility will first forecast what it expects its system's loads to be and then will develop on its own or acquire from other utilities resources to meet those loads. In some instances, a large utility will include the service area of a smaller utility in its forecast and its power planning process.

Other forecasting entities

Although utilities are the primary forecastors of future power demand, there are also many other parties who also get involved, including States, intervenors, reliability councils, consulting groups, and the Department of Energy (DOE).

With the increased costs and risks associated with over or underforecasting, some State public utility commissions have taken a more active role in the process. State forecasts are used as a check and balance against utility projections in determining the need for new resources. State involvement varies widely across the Nation. North Carolina, New York, Florida, Wisconsin, and California have some of the more active Commissions. In the State retail rate review process and in powerplant approval decisions, intervenors and special interest groups may also present alternate forecasts to the State commission to debate or support utility projections.

National forecasts are also done by DOE and the North American Electric Reliability Council (NERC), an electric utility industry association. On a regional and national level, the nine regional councils of NERC compile the individual utilities forecasts and resource projections to lend a regional perspective. NERC then compile these regional projections into a national forecast. In general, these forecasts are based on national data, and the trends are used to provide an indication of the Nation's overall supply/demand picture. Although this information is useful in analyzing industry-wide capital needs or the impacts of regulation or other factors on resource development, the data is of little use in planning specific resources or in balancing supply and demand on an operating system level.

A regional non-utility oriented forecast is done by the Pacific Northwest Planning Council (NPPC) for loads served by the Bonneville Power Administration (BPA). Mandated by the Pacific Northwest Electric Power Planning and Conservation Act (16 U.S.C. 839), this forecast is the basis for acquisition of power resources by BPA to meet future Pacific Northwest loads.

OBJECTIVES, SCOPE, AND METHODOLOGY

Our objectives were to provide information on the five questions concerning load forecasting that the Chairman, Subcommittee on Energy Conservation and Power, House Committee on Energy and Commerce, requested. The audit work on the review took place from December 1982 to March 1983.

To determine on what basis electric utilities forecast loads,[2] we spoke to economists from 10 major utilities who are responsible for preparing load forecasts. These utilities were selected because they represented diverse geographical regions of the country. These utilities are also in areas of the Nation where conservation (both Government and utility) and cogeneration efforts are prevalent. We also interviewed representatives of four utility associations who do research, collect information on utility operations, and represent investor-owned, public or private utilities. Appendix I contains a complete list of our contacts. These representatives were able to provide a nationwide perspective on how utilities generally predict demand for electricity.

Representatives of the Electric Power Research Institute (EPRI), an organization funded by the Nation's electric utilities,

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[2] For purposes of this discussion, we have defined the basis for forecasting as the methodologies that the utilities use to forecast loads.

provided much of the information on methodological "state of the art" in load forecasting and the use of different forecasting techniques. EPRI has done, and is currently performing, research on improving the methodologies used. This was supplemented with various documents and articles prepared by industry officials. We especially relied on past reports that were issued by the Tennessee Valley Authority (TVA) and BPA and our past and ongoing work at these agencies.

The key variables that are or should be accounted for in load forecasting were obtained through discussions with utility economists and from several technical documents on load forecasting published by the industry.

The question of customer-side-of-the meter efficiency (conservation) and dispersed generation (cogeneration) asked for practical experience on how this information is factored into the forecasts. Therefore, utility economists who prepare load forecasts were the major sources of information on how this is done.

We determined the weaknesses of existing utility load forecasting procedures, which are discussed throughout the report, principally through various technical critiques, informational documents provided by industry representatives, and our past reviews of BPA and TVA forecasting efforts. Appendix II contains the major publications, articles, and past GAO reports that we relied on in answering the questions.

As requested, this report provides a general overview of electricity load forecasting done by utilities. As such, it does not discuss the many complex, technical aspects of the various forecasting methodologies nor does it provide a detailed analysis or critique of their strengths and weaknesses. The information we obtained from utility experts was accepted at face value, and we did not verify the accuracy of the information or data gathered. Except as noted above, we made our review in accordance with generally accepted government audit standards.

The following chapters discuss the load forecasting process including the methodologies used, key variables and assumptions, weaknesses, the state of the art, and other factors addressed in the subcommittee's questions.

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Comments on a draft of our report were not requested from any Federal or State agency, since this report is not an evaluation of a Federal or State agency's performance. However, GAO convened a panel of experts representing a broad range of economic, utility industry and regulatory background to review and comment on a draft of the report. (See app. III for a list of participating panelists.)

The review panel believes the report is balanced, accurate, and a good summary of load forecasting which emphasizes the uncertainity of forecasting, the importance of the relationship between the economy and electricity growth and the importance of the electric utility industry's response to forecasting uncertainty.

Several panel members did comment that the report does not discuss that most utility forecasts have been too high. There is a belief that utilities are reluctant to under estimate for fear that the "lights may go out." We recognize that recent forecasts, for the most part, have been to high. However, analyzing why they have been too high was outside the scope of our audit.

Panelists also provided technical comments which have been incorporated where appropriate.

Two of the panelists chose to comment in writing. Their comments are presented in appendix IV. The remaining panelists provided oral comments.

CHAPTER 2

METHODOLOGIES AND KEY VARIABLES

Electric utilities use a variety of techniques to forecast future electric demand. These techniques range from relatively simple historical trend projections to sophisticated models that simulate the behavior of energy users. A utility's choice of forecasting methods is influenced by its technical expertise and financial resources, load diversity, and ability to collect the necessary data for the particular method it chooses to use. Smaller utilities, usually municipals and co-operatives, still rely on traditional methods because of extensive data requirements and expertise required for the more advanced methods. Large utilities, generally investor owned, use two complex techniques--the econometric approach and end-use approach--which provide a better basis for projecting electricity use.

To deal with the inherent uncertainties surrounding load forecasting, some utilities are refining the basic end-use and econometric techniques by combining the strengths of each. Some utilities are also using a range of forecasts. According to people we interviewed these techniques represent the forecasting state of the art.

Forecasting today, because of its sophisticated and detailed nature, requires substantial data on many explicit variables. Some of these variables are common to most methodologies while other variables are unique to a particular methodology. Major variables are concerned with economic and population growth, conservation programs and practices, fuel and electricity prices, and technical-engineering factors such as saturation rates and appliance usage data.

ECONOMETRIC AND END-USE FORECASTS

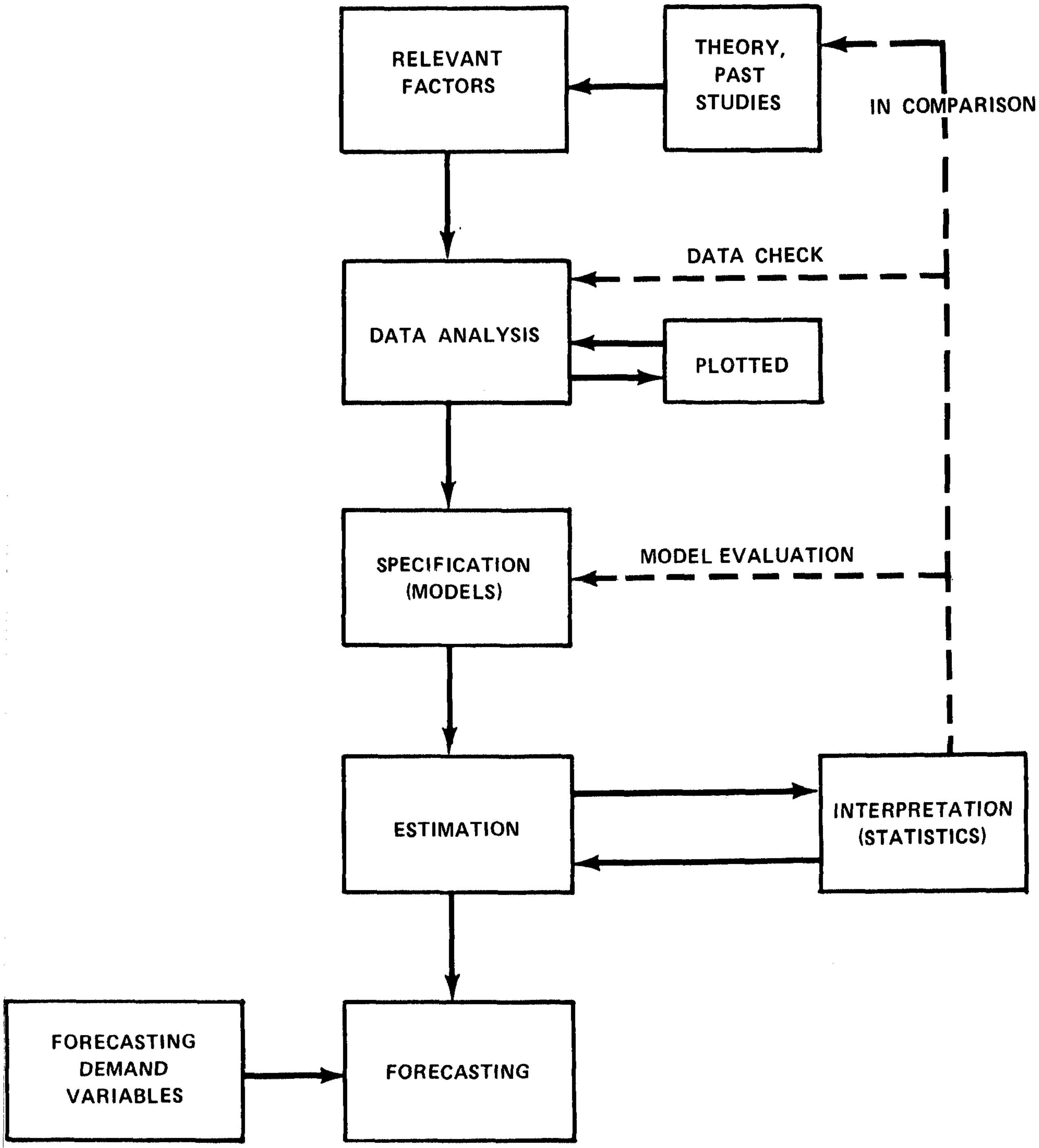
Most major utilities use the econometric and end-use forecasts. The econometric methodology mathematically forecasts future demand by examining how past demand was influenced by historic economic and demographic conditions. An end-use forecast predicts future demand for electricity by examining how electricity was actually used and projecting it into the future.

Econometric method

Econometric forecasting is based on the relationship between electricity use and demand influencing variables such as the price of electricity and competing fuels, consumer income, population, and economic activity. Mathematical equations are established by examining how past demand was influenced by historic, economic and demographic conditions. For a long-term forecast, this information can go back 10 to 20 years. The forecaster then estimates the future value of the demand-influencing variables and plugs

FIGURE 1

AN ECONOMETRIC MODEL



Source: American Public Power Association, "Forecasting Electricity Sales and Loads: A Handbook For Small Utilities."

them into the equations to forecast future electricity needs. Figure 1 shows an example of an econometric model.

Econometric models have several strengths. For example, they (1) require a relatively small amount of data, most of which are readily available, and (2) allow the forecaster to easily modify the variables to produce a range of projections. These ranges allow planners to observe how sensitive forecasting results are to possible variable changes. Such adjustments highlight the uncertainty involved in forecasting and enable power planners to avoid the pitfalls of relying on single load forecasts.

Unfortunately, this approach also has shortcomings. A major assumption underlying econometric forecasts is that the relationship between the demand variables and electricity consumption will remain the same in the future. Changes in these relationships can affect forecasting accuracy. Such relationship changes add to the uncertainty of projecting important demand influencing variables such as fuel prices over a 10 or 20 year period.

Econometric variables

The econometric approach contains standard variables such as population and economic growth. In addition, another variable becomes important--alternative fuels. Over time, as new construction takes place, the price and availability of alternative fuels will have an important effect on the consumption of electricity. This is true for all classes of customers, residential, commercial and industrial, regarding for spaceheating, cooking, and hot water heaters. The more permanent a price, increase or decrease, the greater shift away from or to electricity. If, for example, higher electricity prices compared to alternative fuels is thought to be of short duration, few if any consumers will convert to oil or natural gas.

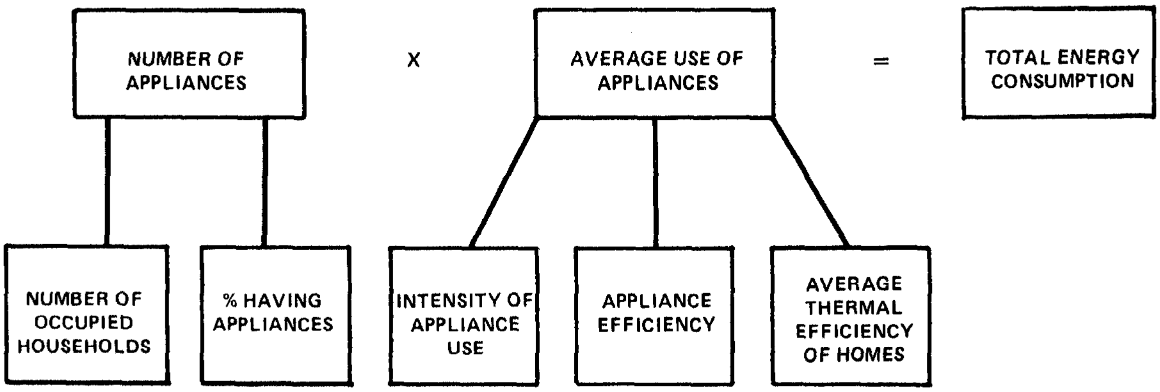
End-use method

Another major forecasting technique is the end-use approach. End-use models focus on how electricity is used. This approach relies on a detailed census and estimates of energy-using equipment. Within a consuming sector--residential, commerical, industrial--use is broken down by major energy-using products. For example, in residential consumption models, the forecaster takes an inventory of each major household appliance and projects the total number to be in use during the forecast period. This projection is adjusted by utilization rates based on variables such as expected changes in appliance efficiency, intensity of use, and product life. These judgments are made in light of economic activity, the price of electricity, consumer income, population, and other economic or demographic factors. Similar forecasts for all major electrical appliances are combined to arrive at an overall forecast for the residential sector.

With the current emphasis on energy conservation programs, an important variable reflected in these forecasts is the efficiency of energy-using products. Since the focus is on electricity usage, end-use forecasts are valuable in evaluating the effects of regulatory actions like new building code requirements or appliance efficiency standards. This approach provides a good basis for measuring energy cost savings as these standards are implemented overtime. In addition, end-use models are capable of describing behavioral changes of consumers. Figure 2 shows the components of a residential end-use model and how the ultimate forecast is derived.

Figure 2

Residential Forecasting Model



Source: Bonneville Power Administration Forecasts of Electricity Consumption In the Pacific Northwest, 1980-2000: (July 1982).

The end-use approach also has shortcomings. End-use models typically require an extensive amount of data. Particularly in the industrial sector but also in the residential and commercial sectors, this information is frequently not available and must be obtained through usage surveys, which are expensive compared to data gathering procedures under alternative forecasting methods. Like econometric models, end-use forecasts rely heavily on several separate projections, which are used as inputs into the models. Errors in projecting the number of energy using equipment, improvements in efficiency, amount of usage, and other input variables can affect the accuracy of the forecasts.

End-use variables

End-use models have extensive data requirements of their own. The degree to which this data can be obtained is a major factor in determining whether the end-use methodology should be used by any utility. Appliance saturation data that are most important for the residential sector are electrical space heating, refrigerator, water heater, and air conditioning. These appliances are usually responsible for two-thirds of the average household's electricity consumption. Some utilities collect appliance saturation data according to housing type because apartment and single family homes usually contain some different appliances. In addition, some utilities collect appliance data based on the year of manufacture because appliances of different years use different amounts of electricity and have different lengths of usefulness.

In the commercial sector, the most important appliances are space heating, air conditioning, and lighting. Saturation data is difficult to obtain because of the different types of appliances in the commercial sector. Utilities find it difficult to obtain an accurate count for these appliances.

Appliance usage data is an important variable use in end-use methodologies. The total number of appliances is multiplied by average usage to determine total energy consumption. The most accurate method used to obtain this data is to place meters on major appliances or equipment for residences, businesses, or industry. This is expensive because it involves the purchase of equipment and the tabulating of a great deal of data. Many households must be metered to ensure that the utility's service territory is represented accurately. Utilities may also use data collected by other sources. Some data on heat pumps, electric water heaters, and cooling devices are available from national surveys of metered appliances that were collected by EPRI. In most cases, it is not practical for utilities to collect end-use data for the industrial sector because the type of equipment used varies widely depending on the industrial mix. In order to be useful, this methodology requires accurate projections of changes in saturation rates and electricity use per equipment.

VARIABLES COMMON TO MOST METHODOLOGIES

In addition to the variables that are specific to the econometric and end-use methodologies, a number of variables are common to all forecasting techniques.

Population - The number of customers in each customer class (residential, commercial, industrial) is an important variable regardless of the type of analysis being used. Typically, population is most important in residential analysis[1] where sales are measured on a per customer basis. This is true for end-use and econometric and may also be true in trending. If other variables are held constant, the demand for electricity varies directly with the population.

Economic activity - In most cases, some calculation must be made of the level of economic activity in the future to determine

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[1] Forecasts usually divide consuming sectors into residential, commercial, and industrial.

electricity consumption. The particular data that is required differ from customer class to customer class and include personal income for the residential and commercial sectors, floor space for the commercial sectors, and some measure of activity for the industrial sector.

Data on economic activity or economic projections are rarely developed by utilities. Many large utilities subscribe to a forecasting service that projects economic growth for them. For example, TVA uses the Wharton Forecasting Associates and Data Resources, Incorporated (DRI), one California utility obtains its information from the University of California, BPA's forecast is based on projections of DRI, and several large Florida utilities use data collected by the State. These forecasts are usually national projections that the utilities adapt to fit their local service areas. When adapting the national projections, utilities consider the most important aspects of local economic growth, for example, the price of coal in the TVA service area, the status of the phosphate industry in Florida, the price of oil in New England, and the timber and aluminum industries in the Pacific Northwest.

Electricity rates - Electricity rates are an important variable in econometric models and may also be of some consequence in the more complex end-use models. Electricity prices are unusual because it is one of the few variables that can be influenced by both utilities and regulatory agencies making load forecasts. The utility forecaster will have a better knowledge on how the values of electricity rates may change in the future than they do on potential trends in other variables. However, the utilities and regulatory agencies have no influence over many other variables (elasticity, construction costs, Government policies, conservation, price of alternative fuels) which in turn determine the rates to be charged for electricity. Therefore, it is difficult for utilities and regulatory agencies to predict with accuracy what electricity prices will be in the future.

Conservation measures - Conservation occurs both as a reaction to higher electricity rates and in response to the utilities' conservation programs or Government programs. Conservation due to price is incorporated in econometric forecasts. Government standards, such as appliance efficiency and building insulation standards, are incorporated in end-use forecasts. (See ch. 4 for a detailed discussion of conservation.)

OTHER FORECASTING METHODS

Trending - Many utilities in the 1970's experienced unprecedented changes in consumer behavior caused mostly by changes in the price of electricity and competing fuels, which dramatically affected the demand for electricity. Until this happened, utilities generally based their forecast of electricity demand on trend projections: using past electrical consumption trends to project future demand. The basic assumption underlying trending is that the factors influencing demand in the past, such as economic and population growth, will continue to do so in the future. Trending methods are simple and can provide a glance at short-term load growth. However, the basic assumption that future growth will continue as it has in the past can lead to inaccurate forecasts because important factors such as changes in economic or social conditions are ignored. Trending methods work well when energy prices, economic growth, population, and other factors affecting electricity consumption are stable as was the case in the 1950's and 1960's. Smaller utilities--municipalities and co-operatives, that usually do not generate power--use trending to forecast future loads. This is most economical for them because the more advanced methods are expensive and require large data bases.

Sum-of-the-utilities - This forecasting technique is not a separate and distinct methodology but a compilation of individual utility forecasts. This is a common approach used in forecasting energy demand over large geographic areas. Sum-of-the-utilities forecasts are only as reliable as the individual forecasts which comprise them. Although these forecasts provide energy planners with a simple and inexpensive means to determine electricity needs for large areas and allow comparisons with individual forecasts, they provide little use to utilities with service areas significantly smaller than the area covered by the forecast. Such broad-based forecasts seldom reflect the specific characteristics (e.g., population, economic activity, income, climate, appliance use) of an individual utility's service territory.

STATE OF THE ART

According to industry officials, the state of the art in forecasting is the most advanced techniques used by the larger investor-owned utilities. This includes combination forecasts, a range of forecasts and forecast models developed by EPRI. The key to forecasting accurately is flexibility. In order to have flexibility, large utilities are adopting combination forecasts as their current forecasting methodology. This approach allows them to combine the strengths of both the econometric and end-use methodologies. Also, to deal with the uncertainty of forecasting, a range of forecasts is being developed, which allows utilities to determine how important the variables are to their forecasts. Although large utilities generally prepare an annual forecast, the process is not static. As new data becomes available, forecasts are updated and resource requirements are adjusted.

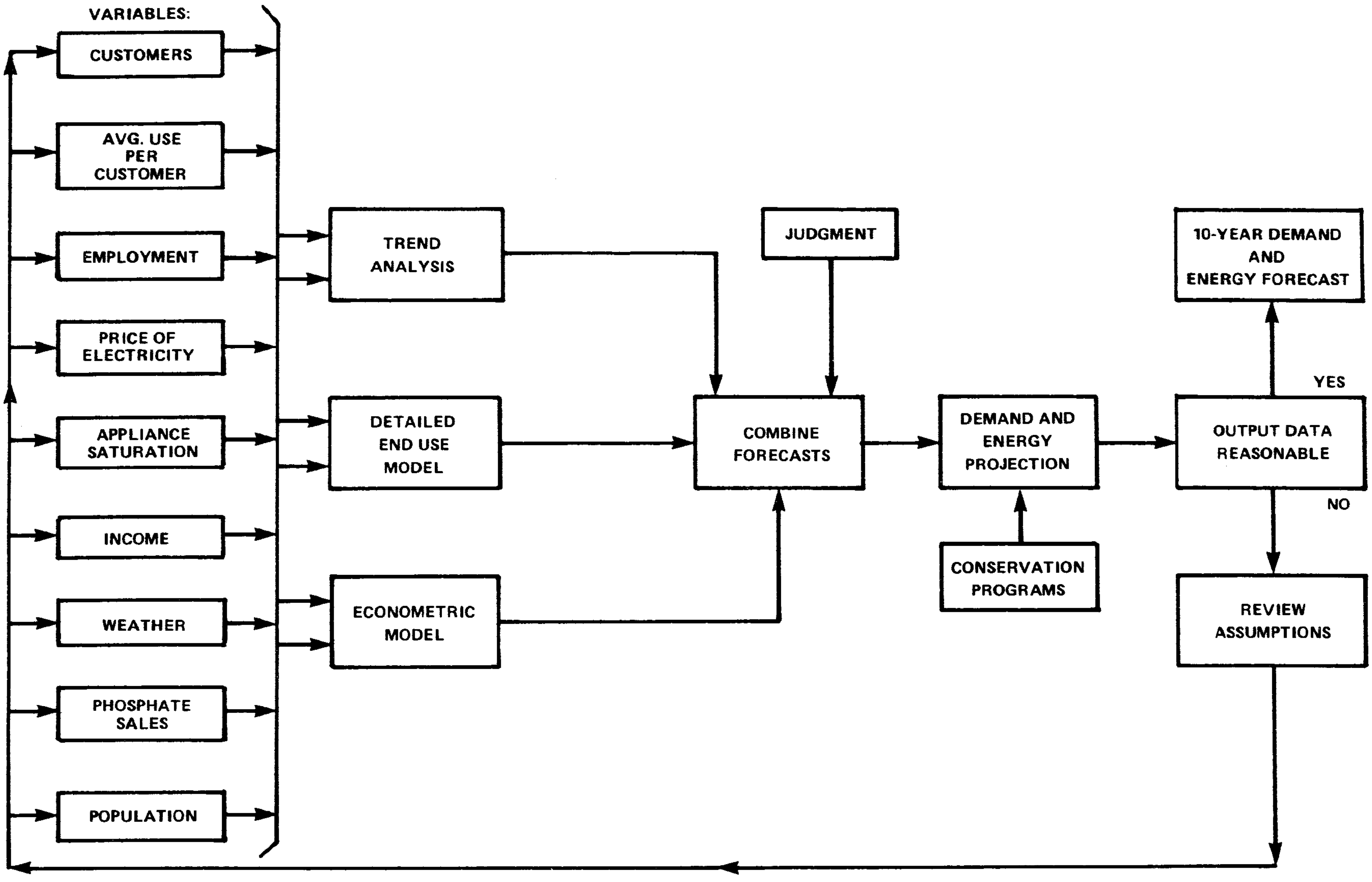
Combination forecasts

To increase forecasting accuracy, some utilities are refining the basic end-use and econometric techniques by combining the strengths of each. The following are examples of specific forecasting methods and how utilities use them.

One utility we contacted uses a combination of the trending, end-use, and econometric models to forecast load. As shown in figure 3, many variables are used in developing forecasts from the

FIGURE 3

COMBINATION OF FORECASTS



Source: Tampa Electric Company, "Ten-Year Site Plan For Electrical Generating Facilities and Associated Transmission Lines," Jan. 1982 to Dec. 1991.

various methods. The output data from each of the techniques are combined to produce one forecast. Several checks are made on load factors, growth rates, usage per customer, and saturation rates to determine the reasonableness of the projections. If a forecast does not satisfy this check, the assumptions are reviewed, and the process is repeated. This method is also used to produce low, medium, and high forecasting scenarios. The phosphate sales projections in figure 3 are prepared independently and combined later with the three main forecasting techniques. This utility's conservation program is expected to have a significant effect on load growth. Conservation is included in the model by reducing total demand, once the forecast is prepared.

Another example of combined forecasting techniques is the REEPS model developed under EPRI sponsorship.[2] REEPS is a hybrid econometric end-use model used for forecasting residential electricity demand. Like the end-use approach, the REEPS model itemizes major household appliance activities and predicts consumer appliance choices and energy consumption resulting from the use of appliances. These appliance purchases and utilization decisions are related to price and income variables, and the exact structure of these relationships is estimated econometrically from individual household survey data. The aim, according to EPRI representatives, is to capture the benefits of a forecast that is detailed down to the level of individual appliance use without ignoring the important economic factors that can be critical in shaping consumer behavior. Because the model combines the advantages of end-use and econometric methodologies, it should be a valuable tool for assessing the impact of mandatory conservation, as well as the more elusive effects of conservation incentives, such as Federal tax incentives.

An emerging model, also under development at EPRI, will forecast hourly loads systemwide over the long term. The model is designed to trace the implication of developments such as new energy management strategies and end-use technologies that are brought on by rising energy prices. The model is also capable of accounting for the load shapes impact of changes in socioeconomic factors, economic activity, weather conditions, and the stock of energy-using equipment.

Range of forecasts

In addition to refining their forecasting techiques, some utilities are also shifting to a range of forecasts instead of the traditional single forecast. The range is developed by varying the assumptions made on the variables such as level of future economic growth and price of electricity. Probabilities are then attached to the various scenarios to assist utility management in deciding what level of growth they will develop resources to accommodate. The following example explains how TVA implements this approach.

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[2] REEPS stands for residential end-use energy planning system.

The TVA load forecast is based on economic trends, treating electricity demand as a function of economic activity, the price of electricity and competing fuels, and the effects of price changes on conservation and fuel substitution.

The national economic projections from Wharton Econometric Forecasting Associates are the starting point of the forecast. A 20-year projection of key economic variables for the United States is linked to a regional economic simulation model developed by TVA. This regional model projects economic growth for the TVA service area. A forecast of TVA's own rates is prepared based on the cost of equipment in service or to be constructed, projected fuel prices, and the cost of labor. Projections of competing natural gas prices and oil prices are taken from national forecasts.

The load forecast attempts to account for uncertainty in five key variables that affect the forecast: (1) the level of economic activity, (2) substitution of other fuels and price-induced conservation, (3) the effects of TVA's conservation programs, (4) the price of electricity to TVA customers, and (5) the level of sales to the Department of Energy for uranium enrichment. (In 1981, DOE purchased 1,590 megawatts (MW) of electricity from TVA for uranium enrichment at Paducah, Kentucky and Oak Ridge, Tennessee.)

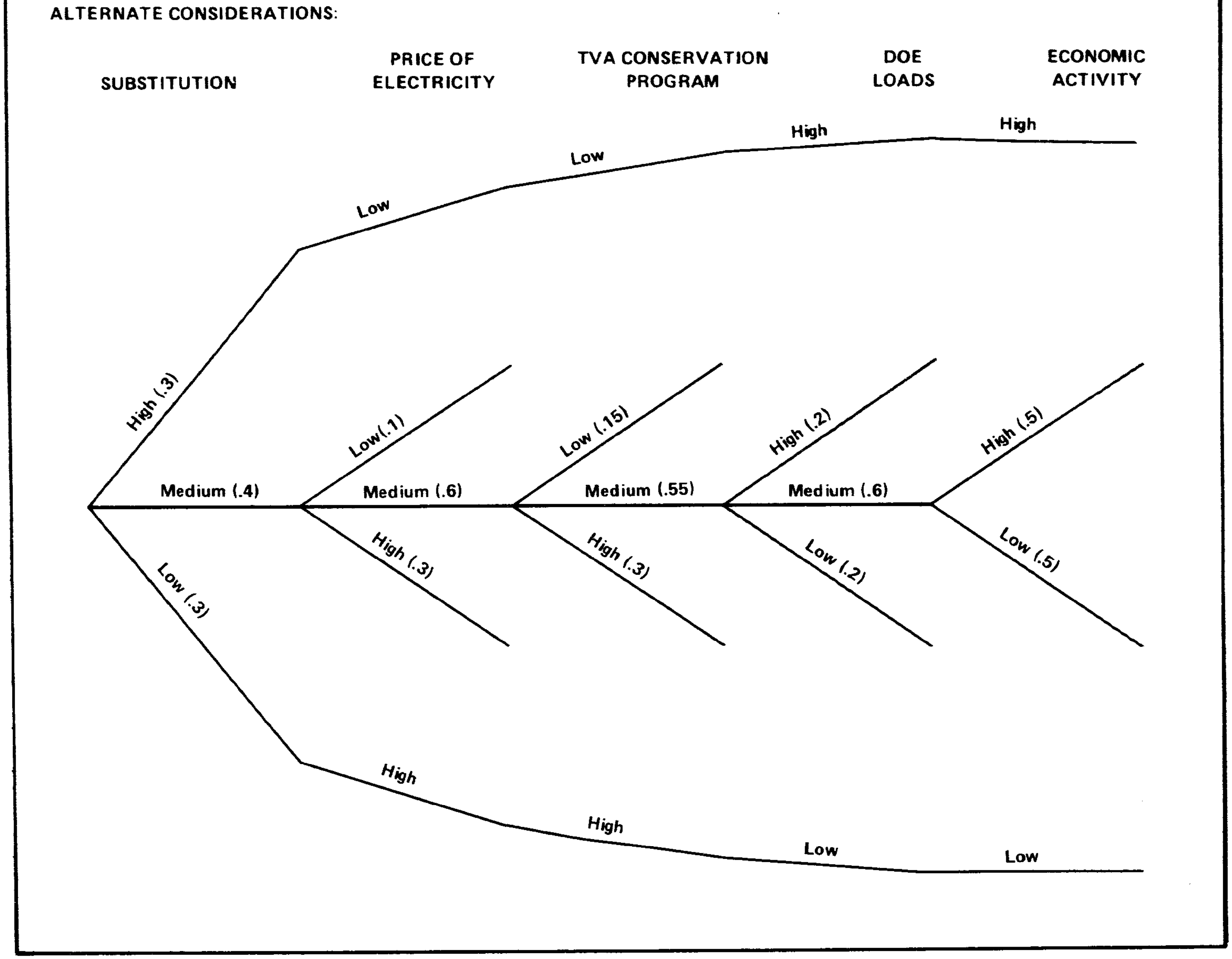
This uncertainty is characterized by assigning a range of probabilities to outcomes of the five variables. A 50-percent chance is given to TVA's achieving high economic growth, and a 50-percent chance is assigned to lower growth. Other variables are assigned high, medium, or low outcome levels, and associated probabilities, as shown in figure 4. Higher probabilities indicate more certainty about a outcome; lower probabilities indicate greater certainty that the outcome is unlikely.

Several of the forecasts employed this technique. For example, BPA's July 1982 forecast of electricity loads in the Pacific Northwest is shown is figure 5. Total regional electricity load is represented by the solid line which reflects BPA's baseline forecast of 1.7 percent annual growth over the next 20 years. Forecasting uncertainty is expressed by high and low ranges of input values that result in a high growth projection of 2.4 percent annually and a low growth projection of 0.9 percent per year. According to a BPA spokesman, judgment was used in assigning values and assuming conditions that would result in a reasonable range of loads.

The 1982 10-year local forecast of American Electric Power (AEP), a large investor-owned utility, also recognized the uncertainty of forecasting by expressing ranges of demand in addition to AEP's base-line forecast. AEP evaluated two additional scenarios--one based on optimistic growth and another on pessimistic growth. As they stated in their plan, these differing assumptions about the future performance of the economy can make a considerable difference in forecasts of electricity demand. The pessimistic set of assumptions, for example, produced an average

FIGURE 4

Alternate Load Forecasts

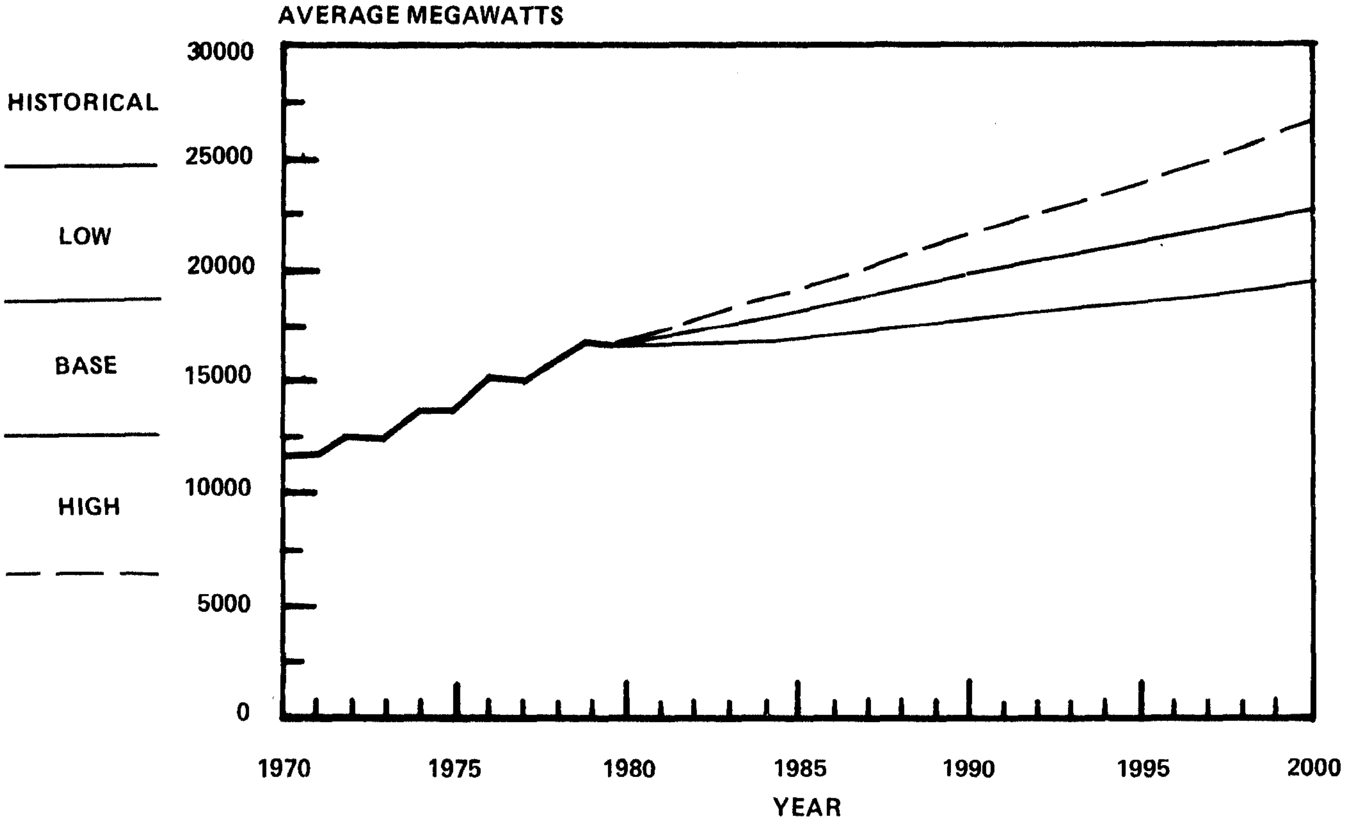


Source: Tennessee Valley Authority, "Perspectives On Forecasting", Jan. 1982.

FIGURE 5

FORECASTS OF ELECTRICITY LOADS FOR THE PACIFIC NORTHWEST
PROJECTED TO YEAR 2000

(In Average Megawatts)



Source: Bonneville Power Administration Forecasts of Electricity Consumption In The Pacific Northwest, 1980-2000: (July, 1982).

annual growth rate of 2.2 percent, compared to the baseline forecast of 3.1 percent. The optimistic scenario yielded a growth rate of 4.3 percent. Although forecasting ranges of electricity demand helps reflect the uncertainty of forecasting, it does not eliminate the problems associated with forecasting error.

Resource planning

Historically, utilities have built large central-station generating plants to meet projected loads. Because these plants have long development leadtimes, it has been necessary to forecast loads 10 years or more into the future and spend funds to develop the resources many years before they were actually needed. During the lengthy construction period the utility was vulnerable to many things that might have an effect on the cost of and need for the plant. As discussed earlier, this could cost the utility's ratepayers and stockholders billions of dollars. To avoid this situation and mitigate the uncertainties associated with long-term forecasts, some utilities are turning to shorter leadtime resources and other strategies.

The most notable example of this approach to strategic resource planning is the power plan developed and adopted by the NPPC. Established by the Congress in Section 4 of the 1980 Pacific Northwest Electric Power Planning and Conservation Act (16 U.S.C. 839), the NPPC is charged with developing a power plan for the Pacific Northwest. In putting together the first plan the NPPC, which by law must give priority to conservation resources, developed an "options" approach for developing resources to meet their projected loads. Under this approach, resources would undergo a preliminary development process, but this would stop at a required level of funding. At this point the resource would be "put on the shelf" until needed. This approach with its emphasis on conservation and renewable resources takes advantage of their shorter development leadtimes and lower costs without precluding the development of conventional generation. In addition to setting out a formal planning process, the act also requires the State and the public at large to participate in the planning process. It is anticipated that this participation will enhance the success of the resource development process.

Since the act is only 2 years old and the first plan was just adopted in April 1983, it is too early to judge the success of the act in providing the Pacific Northwest adequate, cost-effective resources. Whether the options approach is workable and will provide the flexibility necessary to mitigate the uncertainties associated with load forecasting is uncertain.

CHAPTER 3

KEY ASSUMPTIONS

We identified four controversial assumptions that drive load forecasts. These assumptions deal with

- the price elasticity of demand,
- the correlation between economic growth and growth in electricity consumption,
- the impacts of switchovers from alternate fuels, and
- the impacts of conservation and new technologies.

A major problem facing forecasters in making the assumption of how each of these factors will influence future demand is deciding how to allocate responsibility for changes in historical consumption patterns since the mid-1970's to each factor. The frequently subjective nature of this process and projecting what impact each factor will have on future loads form the basis of the debate and controversy.

PRICE ELASTICITY OF DEMAND

The general economic theory behind price elasticity holds that as a product or service's price increases, demand for the product or service will decrease. If a small price increase causes a dramatic decline in demand, this is categorized as being highly elastic. Conversely, if a large price increase results in a minimal change in demand, the relationship is categorized as inelastic. For electricity the rate increases of the 1970's and 1980's and the concurrent declines in load growth and in some regions actual declines in consumption have verified that the demand for power is related to its price. This fact was previously obfuscated by stable electricity prices. The precise relationship and at what level of consumption demand will become increasingly inelastic is still not clear.

The assumption that the forecaster makes on future price elasticity can make a major difference in the final load projections. For example, in 1982 the Bonneville Power Administration issued its first regional forecast for the Pacific Northwest. In the industrial sector (excluding Bonneville's direct service industrial loads)[1] the forecast assumed a price elasticity of 1.0; that is, for every percent rise in electricity prices there would

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[1] Bonneville supplies power directly to 17 large industrial customers. These loads are contractually set and are not forecast per se.

be an equal decline in electricity consumption. Subsequently a National Economic Research Associates (NERA) review of the forecast requested by the Bonneville administrator took issue with this assumption, suggesting a 0.5 price elasticity was more consistent with the econometric literature on the subject; i.e., for every percent rise in price, consumption would fall one-half of one percent. The effect of this difference in assumption results in about a 90-MW swing in projected load growth between 1982 and 1983.

Price elasticity may also vary from region to region and utility to utility depending on historical price levels and consumption patterns. Areas with historically low rates and high levels of electricity use may have a higher elasticity than regions with the opposite characteristics. This phenomenon has been evidenced in both the TVA and BPA service areas where the introduction of higher priced power into a low cost base has resulted in major consumer cutbacks.

ELECTRICITY/ECONOMY RELATIONSHIP

In recent years another key debate in energy circles has been how the level of future economic growth will affect the level of electricity use. From 1947 to 1973 the statistical correlation between economic growth (as measured in changes in the Gross National Product or GNP) and electricity load growth was close--98 percent of the time the two growth curves were parallel. The 2 percent variation is due to weather fluctuation and random error. What the relationship has been since 1973 and what it will be in the future form the basis of debate over a critical forecasting assumption.

Traditional utility forecasters maintain that since 1973 economic growth has resulted in a higher level of electricity load growth than would have been expected based on historical trends. From their view, this has been the result of a shift from the use of fuels such as oil and natural gas to electricity due to electricity's

--end-use flexibility,

--availability,

--environmental benefits,

--minimum user capital investment, and

--price improvement relative to other fuels.

Some forecasters believe that this trend will continue into the foreseeable future. Consequently, they believe that future demand for electricity is primarily dependent on economic growth and inadequate power supplies would jeopardize future economic growth.

This view is now being seriously challenged, however, by other utility forecasters who maintain that conservation (covered in the next section) and shifts in the Nation's industrial mix will allow the economy a faster economic growth than electricity loads, in effect "decoupling" the historical relationship. As the United States and world economies evolve, some forecasters see the United States losing a portion of its aging, energy-intensive heavy industry and shifting more to a high technology and service-oriented economy, which requires less energy. A similar shift is occurring in other highly industrialized countries such as Japan. The results of this shift in electricity terms may be dramatic. Based on the premise of decoupling, both BPA and TVA forecast a higher level of economic growth than the national average with a much lower level of load growth.

FUEL SWITCHING

With few exceptions, other fuels can be substituted for many uses of electricity. Consequently, the relative price and availability of substitutes can directly influence the level of electricity demand. In the residential sector, for example, homeowners may change from oil heat to an electric heat pump to avoid higher and unpredictable oil prices. The same holds for natural gas. Deciding the magnitude and timing of these shifts is difficult for forecasters because of the human variables involved and the uncertainties in predicting the future price of electricity and other energy forms. The capital costs involved must also be considered to evaluate what payback or savings threshold would make consumers switch.

Lack of data on the end uses of electricity frequently hampers forecasters in this area. Appliance saturation (particularly for space and water heaters) and industrial equipment inventories are key to assuming what the magnitude of switchovers will be. Yet this information is costly to collect and maintain, and consequently it is not available to many utility load forecasters. To exacerbate the situation the rate uncertainty of the 1970's also caused consumers to shift from electricity to other fuel forms including solar and other renewable resources.

CONSERVATION

Many of the same factors that make fuel switchovers difficult to quantify also hamper forecasters in predicting the impacts of conservation on future loads. Most utilities have not comprehensively surveyed their customers to develop an end-use data base or to assess the conservation potential within their system. Without this information forecasters must rely on their own estimate as to what degree consumers will conserve in response to predicted higher prices. Conservation undertaken as a result of specific programs, i.e., weatherization, is somewhat easier to quantify, but accuracy is still dependent on the forecaster's knowledge in terms of "what's out there." The effectiveness of conservation programs is also dependent on either the consumer's interest in voluntarily adopting the measures or the Government's interest in making participation mandatory. Both of these items are difficult to predict at the time a load forecast is developed.

New technologies and more efficient equipment may also change demand patterns in the future. In addition to less energy-intensive industry, the new plants that are being built take advantage of techniques to improve their efficiency.

COMMENTS BY PANEL OF EXPERTS AND OUR EVALUATION

All the panel members commented on the economy/electricity relationship. For example, one panel member stated that all of the recent forecasts, including end-use forecasts, have been too high because they fail to reflect the growing trend of less electricity use per dollar of Gross National Product (GNP). He went on to state that the combined effect of more efficient buildings and machines and an economy that contains a less energy-intensive mix than in the past is not reflected in most load forecasts. Another panel member's comments, however, reflect the position that there has been a very high correlation between electricity and GNP in the past and once the economy picks back up, the load growth for electricity will follow.

This divergence of opinion among panel members only serves to highlight the theme of our report--that there is a great deal of uncertainty associated with load forecasting and the methods used. The economy/electrical growth issue appears to be the most prevalent area of disagreement among individuals knowledgeable of load forecasting. Because of the disagreement, we plan to cover the topic in future work related to the overall issue of supply and demand of electricity.

CHAPTER 4

HOW CONSERVATION AND DISPERSED GENERATION ARE FACTORED INTO FORECASTS

The fundamental economic and social changes electric utilities faced in the 1970's brought with them a wide range of energy conservation measures and dispersed generation technologies such as wind power and cogeneration. With the exception of price-induced conservation and Government efficiency standards, conservation programs and dispersed generation are frequently not perceived as forecasting variables but rather as resource options that are available to utilities to reduce their need for more traditional powerplants. Recognizing this demand versus supply distinction, this chapter discusses how these resources are either included in the forecast or related to it.

HOW ELECTRIC UTILITIES CONSIDER CONSERVATION IN THEIR FORECASTS

Some utilities factor conservation impacts directly into their forecasts, treating it as a separate variable. Generally, utilities with in-house conservation programs are most likely to factor conservation into their forecasts as an independent variable or include it implicitly through price elasticity or appliance data. However, utilities for the most part are not factoring conservation directly into their forecasts because they believe that conservation will have only a marginal effect on their service area or that the impacts are reflected in other variables included in their forecasting methodologies.

UTILITIES THAT INCLUDE CONSERVATION IN THE FORECASTS

The utilities that include conservation in their forecasts are those in States with legislatively mandated conservation goals, such as Florida, California, and the Pacific Northwest. Utilities in these States have been involved mostly in sponsoring conservation programs, quantifying their energy savings, and accounting for them in their forecasts.

Florida utilities

In Florida, the Energy Efficiency and Conservation Act enacted in 1980 established goals for the State. To implement the act, the Florida Public Service Commission has stipulated that the growth rate for each utility's peak demand for 1981-89 should not exceed 72.25 percent of customer growth and that growth in energy[1] should not exceed 75 percent of customer growth. To meet

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[1] Energy is the average power produced over a stated interval of time. It is expressed in kilowatt-hours, megawatt-hours, average kilowatts, or average megawatts.

these goals, Florida utilities have instituted aggressive conservation programs.

In Florida, one utility we talked to stated that it accounts for conservation in its forecast three different ways. First, it accounts for price-induced conservation in its econometric model in its price elasticity variable. Second, it captures the impacts of appliance efficiency standards through the appliance data in its end-use model. Third, it captures the impacts of its in-house conservation programs by quantifying them and subtracting them from its base forecast.

To quantify the savings of its in-house conservation programs, the utility estimates the saturation levels of each of its programs. For its heat pump program, for example, the utility surveys how many new housing units will be built over a specific period of time and projects the saturation levels of heat pumps for these units as well as for existing housing, calculating that energy usage for heating should be reduced by 50 to 60 percent. After estimating the impacts of its conservation programs, the utility deducts the total expected energy savings from its base forecast. This occurs as one of the final steps in the forecasting process, after the models have been run and the forecasts combined.

Two other Florida utilities also factor conservation into their forecasts in a similar manner. These utilities use both econometric and end-use models which capture price-induced conservation and the impacts of appliance efficiency standards. In addition, they also estimate the effects of their own conservation programs and deduct them from their base forecast.

California utilities

California has been the Nation's leading innovator in energy conservation programs. The State Energy Commission has established conservation standards for construction of new buildings and mandatory maximum efficiency standards for new household appliances which are among the most comprehensive in the country. Under California law, the California Energy Commission is required to establish a "common forecast methodology" for utilities to follow in preparing forecasts. Utilities are required to explicitly account for conservation programs in their forecasts and to explain the quantification techniques used. The Commission has developed end-use models utilities can use to quantify the impacts of conservation.

Methods for quantifying the impacts of conservation vary among California utilities. All of the major utilities use both econometric and end-use models. Most utilities use a variation of the end-use model that the Energy Commission developed to quantify the impacts of conservation. In addition, some utilities, like those in Florida, quantify the impacts of their in-house conservation programs separately as aggregate savings and subtract them from their base forecast.

One utility we spoke with uses a variation of the Commission's end-use model to quantify Federal and State government efficiency standards. Utility-sponsored conservation programs are calculated separately and estimated yearly savings are subtracted from the initial projections.

Another utility we spoke with accounts for conservation in its forecast in a similar manner. It uses an econometric model which includes conservation impacts as one of its key variables. It also uses an end-model based on the California Energy Commission model which captures the impacts on demand of Government efficiency standards. Further, it calculates the impacts of its in-house conservation programs and subtracts them from its base forecast.

Like the Florida utilities, these California utilities account for the impact of conservation in three ways--in their econometric models as a reaction to price, in their end-use models as a response to Government standards, and in response to in-house conservation programs.

TVA and BPA

Both TVA and BPA are involved in promoting energy conservation and are implementing extensive residential and commercial conservation programs. Conservation is expected to have a significant impact on future electricity sales and load growth in these Federal entities' service areas. TVA and BPA factor conservation in their forecasts in a slightly different way than the Florida and California utilities. Rather than deducting the estimates savings of their in-house conservation programs from their base forecasts, TVA and BPA factor conservation directly into their forecasts as an independent variable.

TVA uses a sophisticated set of models to produce its forecast including several econometric and end-use variables that affect the forecast. The models incorporate five key variables that affect the forecast. One of these variables is the impact of conservation. TVA considers the impacts of its conservation programs as the amount of conservation it would obtain over and above that obtained solely as a result of increases in the price of electricity. TVA obtains an estimate of the impact of its conservation programs on future load growth based on a market analysis of the cost effectiveness of each program as compared to available alternative energy supply options. TVA is forecasting that its conservation programs will reduce electricity usage by 13 to 20 percent in the residential sector and 8 to 15 percent in the commercial and industrial sector over and above the price-induced conservation already included in the forecast.

Like TVA, BPA factors conservation in its forecast in two ways. It captures the effects of price-induced conservation in its price elasticity variable and it captures the effects of existing BPA, private utility and Government conservation programs in a separate conservation variable. Conservation programs that have yet to be initiated or budgeted by BPA utilities, Government agencies, or the Northwest Power Planning Council are not included in the forecast. They will be included as part of a separate conservation assessment that will be used in the overall policy decisions of BPA.

DIFFICULTIES MEASURING IMPACTS OF CONSERVATION

According to an California Energy Commission official, quantification of energy savings from conservation programs is an art that is in its infancy. At present, conservation measurement is not a precise or rigorous science because forecasters have little experience with it and there is little historical data on which to base projections. Although the impacts of price-induced conservation and building and appliance efficiency standards can be factored into forecasts through econometric and end-use models, the impacts of utility-sponsored conservation programs are difficult to quantify. Measuring the impacts of conservation programs is currently a very subjective practice.

Utilities generally calculate the impacts of conservation program in any of several ways. Utilities examine the penetration rates of the various programs, they do customer surveys, do bill comparisons before and after energy audits and bill comparisons between homes with and without audits and conservation programs, and/or monitor energy usage of homes with conservation programs through special meters. Measuring conservation programs' impacts in these ways, however, is fraught with potential problems. There are six main problems in measuring the effects of conservation programs:

--<u>Doublecounting</u> - It is difficult to differentiate between conservation due to price and conservation resulting from a utility's conservation programs. A utility that accounts for price-induced conservation in its econometric model and also deducts an estimate of savings from its in-house conservation programs from its base forecast may be doublecounting the conservation savings.

--<u>Portfolio effects</u> - If a utility customer has several different conservation measures in the home, the total conservation savings will be less that the savings of each individual program. Utilities may miscalculate the conservation savings in these homes.

--<u>Self-selection</u> - Utilities may have difficulty obtaining conservation savings data for an "average" household because the kind of people who volunteer for conservation test programs may be "different" from the average customer.

--<u>Rebound</u> - Consumers with conservation measures in the home may raise their thermostats, thereby negating any conservation savings. It is difficult to net out this rebound in energy consumption from estimates of conservation.

--<u>Aggregation</u> - Diversity across customers in appliance holdings may make it difficult to extrapolate results from a sample of customers to the service area population.

--<u>Long-term uncertainty</u> - Conservation programs are so new that it is difficult to project their saturation rates over the long term. It is difficult for utilities to determine how many conservation programs will be on line in the 1990's and beyond.

Utilities generally are unable to avoid many of these problems in factoring the impacts of conservation into their forecasts. The danger of doublecounting conservation savings seems to be particularly severe. It is extremely difficult for utilities to determine the impacts of price-induced conservation versus those of utility conservation programs. As the California Energy Commission points out, no demonstration of consistency between price and programs savings has been sufficiently documented to remove doubts about doublecounting. Some utilities, such as Florida Power and Light, attempt to calculate the doublecounting, rebound, and portfolio effects present in their conservation estimates and substract them from the total expected savings. In general, however, the problems quantifying conservation cause most utility estimates of conservation savings to be subjective and generally weak. According to the California Energy Commission, the current uncertainty associated with conservation savings estimates is "excessively large." Thus, although some utilities attempt to factor the impacts of conservation programs into their forecasts, their estimates of these programs are not necessarily accurate.

HOW DISPERSED GENERATION IS FACTORED INTO FORECASTS

Another factor influencing future electric utility loads is dispersed electric generation. Dispersed generation includes customer-generated electricity from wind or other alternative technologies as well as cogeneration. Cogeneration is the sequential production of both electricity and useful thermal energy from the same energy source. Since a cogeneration plant produces both thermal and electric energy, it saves from 10 to 30 percent of the fuel that would otherwise be used if two separate plants were involved. Many industries have recently became more involved in cogeneration programs. Cogeneration is generally a much more important factor in a utility's service area than alternative forms of electric generation since it almost always involves greater electricity savings.

Dispersed generation is only factored into a utility's forecast when it is significant in size. Utilities without a significant amount of wind generation in their service area, for example, would not factor this dispersed generation into their forecast at all. Similarly, utilities with little industry in their service area would have little cogeneration and thus would not factor it in.

When dispersed generation is included in a utility's forecast, it is included in different ways. Some utilities, like the two we spoke with in Florida, include dispersed generation (cogeneration, in these utilities' case) in the same category as their conservation programs and deduct it from their base forecasts along with the expected conservation savings. Other utilities do not subtract cogeneration from their forecasts, treating it as a resource instead. Alternate forms of electric generation are usually not considered in a utility's forecast because their impacts on electricity demand are both marginal and difficult to measure. TVA, however, does include passive and active solar generation explicity in its forecast as part of its conservation variable.

Unlike the impacts of conservation programs and alternative forms of electric generation, the amount of energy saved from cogeneration is relatively easy for utilities specifying the amount of electricity their programs will save. The effects of cogeneration are more difficult to measure over the long term, however, because the contracts are for 1 to 2 years, and thus it is difficult to calculate their future impacts. Industry may not know if it can continue to generate power for long periods of time; therefore, cogeneration contracts are of short duration.

COMMENTS BY PANEL OF EXPERTS AND OUR EVALUATION

Several panel members also had comments concerning conservation. One member stated that a fundamental error in most forecasts was utilities do not factor in conservation because they believe it will have only a small impact on demand. He suggests that utilities should use conservation and load managment as an active program that constitutes a source of supply. Another member stated that in terms of total numbers utilities do not factor conservation into their forecasts but this is not true for utilities that have most of the generating capacity.

We recognize that how much conservation is achieved is difficult to measure. This is particularly true, as brought out in our report, because of the lack of data being collected on the effects of conservation. Again, this serves to point up the fact that the assumptions used are critical to the forecasting process.

UTILITIES, ASSOCIATIONS, AND INTEREST GROUPS CONTACTED

Private utilities

American Electric Power Corporation
Baltimore Gas and Electric Company
Florida Power Corporation
Florida Power and Light Company
Pacific Gas and Electric Company
Pacific Power and Light
Potomac Electric Power Company
Seattle City Light
Southern California Edison Company
Tampa Electric Company

Federal utilities

Bonneville Power Administration
Tennessee Valley Authority

Utility associations

American Public Power Association
Edison Electric Institute
Electric Power Research Institute
North American Electric Reliability Council

Interest groups

Environmental Defense Fund
Natural Resources Defense Council

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U.S. General Accounting Office, "Electric Energy Options Hold Great Promise for the Tennessee Valley Authority" (EMD-78-91, Nov. 29, 1978).

U.S. General Accounting Office, "New England Can Reduce Its Oil Dependence Through Conservation and Renewable Resource Development" (EMD-81-58, June 11, 1981).

REVIEW PANEL

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KNOXVILLE, TENNESSEE 37902

OFFICE OF THE BOARD OF DIRECTORS

MAY 27 1983

Mr. J. Dexter Peach
Director
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

I have indicated some comments in the margin but I really have only one fundamental criticism of this report.

The report fails to drive home the most important lesson utility executives are learning the hard way, mainly that all of the recent forecasts including end-use forecasts have been too high, because they fail to reflect the growing trend of less energy and less electricity per dollar of GNP. The combined effect of more efficient buildings and machines and an economy that contains a less energy intensive mix than in the past is not reflected in most load forecasts. Utilities with a responsibility for "keeping the lights on" are naturally reluctant to run the risk of underestimating. As a result, the estimates continue to reflect past data more than recent trends.

Primarily the point I am making is a problem of omission from the report; but, at pages 35 and 36 by reciting what I consider largely theoretical problems of overestimating conservation impacts, the report is actually misleading by failing to state that the overestimation problems are dwarfed by the much more real problem of underestimation.

I would suggest that the report should at least allude to the option of utilities using as a basis of their power plant construction program a more modest rate of growth than their present projections and use conservation and load management as an active program that constitute a source of supply that can assure that the more modest rate of growth is not exceeded. Such an approach I think may be feasible and provides at least one way out of the current dilemma.

Sincerely,

S. David Freeman
Director

GAO Note: The conservation material referenced is located on pages 26 and 27 of the final report.

AES APPLIED ENERGY SERVICES, INC.

May 20, 1983

Mr. J. Dexter Peach
Director
Resources, Community, and Economic
  Development Division
United States General Accounting Office
Washington, D.C. 20548

Dear ~~Mr. Peach~~ Dexter:

The report does a good job in describing the different analytical techniques taken by utilities in load forecasting. However, the report does not address what we here have found to be the key issues regarding load forecasting models:

1) What is the track record of the utilities' load forecasting techniques?

2) What can be done to improve them?

The accuracy of industry and government load forecasts has been terrible. For the last 10 years, forecasts of peak demand and consumption have been consistently high. The North American Electric Reliability Council (NERC), the industry's own forecasting overseer, documented them nicely in their last report (see the attached Figure). During the 1973 to 1982 period, electricity consumption actually grew at an average of 2.2 percent per year, while the average of all utilities' 10-year projections was 6 percent per year. These projections cost ratepayers billions of dollars in expenses for unused capacity.

While part of the reason for the error in the forecasts lies with faulty assumptions (for example, GNP growth was also almost always overestimated in this period), the techniques themselves entered some bias in the forecasts. During this period, most utilities used trend or econometric techniques to forecast demand. These techniques rely on historical trends, and tend to forecast futures similar in behavior to history. Since demand grew at 7 percent per year over most of their history, it is not surprising that utility forecasts were in this range in the 1970's.

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To avoid this bias, many utilities are shifting to end-use forecasts. As an early pioneer in this approach, we know that end-use models are no panacea -- they are expensive, have large data requirements, and are subject to the same limitations of all forecasting methods (the output is only as good as the input assumptions). But, they have consistently avoided the forecaster bias shown in the Figure, if carefully implemented.

I believe GAO should add to its report a section on forecasting accuracy, and suggestions as to what should be done to improve it.

Sincerely,

Roger

Roger W. Sant
President

/shw

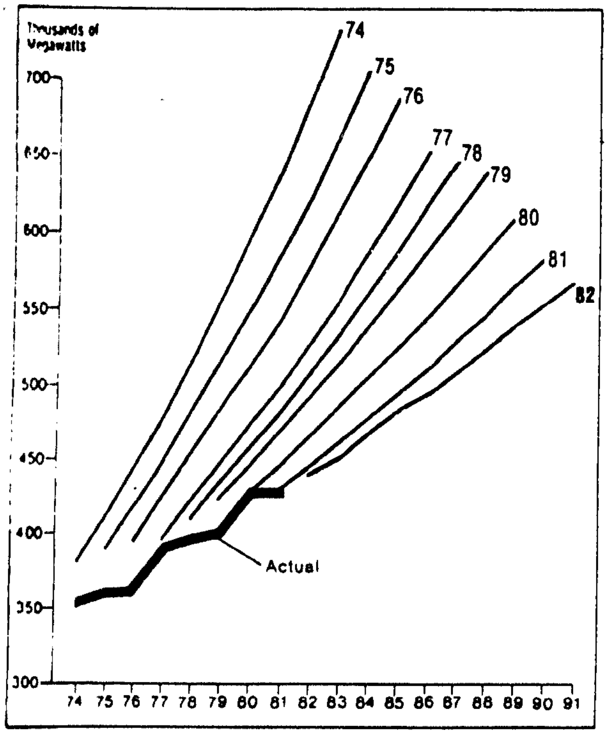
Enclosure

Highlights

CONTIGUOUS U.S.	1982	1991	1982-1991
Projected Summer Peak Demand (MW)	438,086	569,140	—
Summer/Winter Peak Demand Ratios	108.5%	107.0%	—
Summer Peak Demand Average Annual Growth Rate	—	—	3.0%
Net Electrical Energy Requirements (10^6 kWh)	2,385,202	3,180,947	—
Annual Load Factors	62.2%	63.8%	—
Net Energy Average Annual Growth Rate	—	—	3.3%
Scheduled New Coal-fired Generating Units	—	—	174 (91GW)
Scheduled New Nuclear Generating Units	—	—	61 (66GW)
Scheduled Oil-To-Coal Unit Conversions	—	—	67 (10GW)

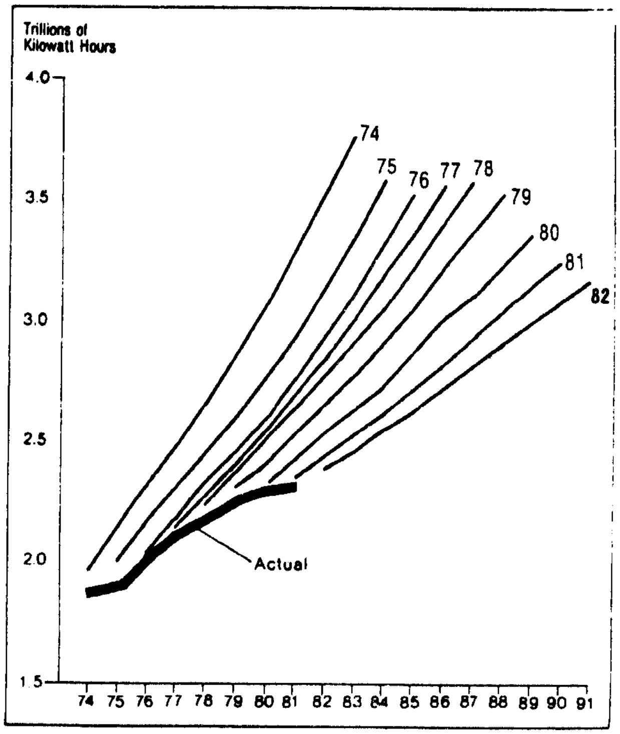
Projected ten-year growth continues to slow...

Summer Peak Demand Projections
Comparison of Annual Ten-Year Forecasts
(Contiguous U.S.)



average annual
growth rate (%)
projecting ten years
1974 — 7.6
1975 — 6.9
1976 — 6.4
1977 — 5.7
1978 — 5.2
1979 — 4.7
1980 — 4.0
1981 — 3.4
1982 — 3.0

Net Energy Projections
Comparison of Annual Ten-Year Forecasts
(Contiguous U.S.)



average annual
growth rate (%)
projecting ten years
1974 — 7.5
1975 — 6.7
1976 — 6.3
1977 — 5.8
1978 — 5.3
1979 — 4.8
1980 — 4.1
1981 — 3.7
1982 — 3.3

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