Demand Forecasting for Electricity

Prediction is a very difficult art, especially when it involves the future
-Neils Bohr (Nobel Laureate Physicist)

Introduction

Forecasting demand is both a science and an art. Econometric methods of forecasting, in the context of energy demand forecasting, can be described as 'the science and art of specification, estimation, testing and evaluation of models of economic processes' that drive the demand for fuels. The need and relevance of forecasting demand for an electric utility has become a much-discussed issue in the recent past. This has led to the development of various new tools and methods for forecasting in the last two decades. In the past, straight-line extrapolations of historical energy consumption trends served well. However, with the onset of inflation and rapidly rising energy prices, emergence of alternative fuels and technologies (in energy supply and end-use), changes in lifestyles, institutional changes etc, it has become imperative to use modeling techniques which capture the effect of factors such as prices, income, population, technology and other economic, demographic, policy and technological variables.

Need for good predictions

There is an urgent need for precision in the demand forecasts. In the past, the world over, an underestimate was usually attended to by setting up turbine generator plants fired by cheap oil or gas, since they could be set up in a short period of time with relatively small investment. On the other hand, overestimates were corrected by demand growth. The underlying notion here was that in the worst case, there would be an excess capacity, which would be absorbed soon. In the Indian context, the demands were usually overestimated, notwithstanding which, the capacities fell short of the actual demands on a year to year basis.

The presence of economies of scale, lesser focus on environmental concerns, predictability of regulation and a favorable public image, all made the process of forecasting demand much simpler. In contrast, today an underestimate could lead to undercapacity, which would result in poor quality of service including localized brownouts, or even blackouts. An overestimate could lead to the authorization of a plant that may not be needed for several years. Many utilities do not earn enough to be able to cover such a cost without offsetting revenues. Moreover, in view of the ongoing reform process, with associated unbundling of electricity supply services, tariff reforms and rising role of the private sector, a realistic assessment of demand assumes ever-greater importance. These are required not merely for ensuring optimal phasing of investments, a long term consideration, but also rationalizing pricing structures and designing demand side management programs, which are in the nature of short- or medium-term needs.

The gestation period for power plants, which are set up to meet consumer demand, typically varies between 7 to12 years in the case of thermal and hydro plants and 3 to 5 years for gas-based plants. As a result, utilities must forecast demand for the long run (10 to 20 years), make plans to construct facilities and begin development well before the indices of forecast growth reverse or slowdown. In manufacturing institutions and electric utilities there are a number of factors that drive the forecast, including market share. The forecast further drives various plans and decisions on investment, construction and conservation. Since electric utilities are basically dedicated to the objective of serving consumer demands, in general the consumer can place a reasonable demand on the system in terms of quantity of power. With some built-in reserve capacity, the utilities may have to configure a system to respond to these to the extent possible. In the process of making predictions, forecaster bears in mind the feedback effects of pricing and other policy changes, and therefore, participates in the process of designing ways and means to meet consumer demands.

Short-term demand forecasting also plays a role in the process of regulation. A precise estimate of demand is important for the purpose of setting tariffs. A detailed consumer category-wise consumption forecast helps in the determination of a just and reasonable tariff structure wherein no consumer pays less than the cost incurred by the utility for supplying the power. Also, the utility can then plan the power purchase requirements so as to meet the demand while maintaining the merit order dispatch to achieve optimization in the use of their resources.

The nature of the forecasts has also changed over the years. It is not enough to just predict the peak demand and the total energy use, say on an annual basis. Since the whole objective of demand-side management is to alter the system load shape, a load shape forecasting capability within the system is most desirable. The various methods of implementing demand-side management are time of use pricing, use of curtailable/interruptible rates, imposition of penalties for usage beyond a predetermined level, and real time pricing. A time-of-day tariff structure to manage peaks and troughs in electricity demand, an hour-by-hour load shape forecast has become an essential prerequisite. Further, the end-use components of the load shape must also be known in order to plan the other demand-side management activities to achieve maximum conservation, while avoiding undue demand restrictions.

Another use for demand forecasting models is the assessment of the impact that a new technology might have on the energy consumption. This helps planners to evaluate the cost effectiveness of investing in the new technology and the strategy for its propagation . The use of a straightforward engineering end-use approach that focuses only physical factors can miss the emergence of new end uses, as well as other effects such as the impact of rising energy prices as a stimulus to energy efficiency. Also the process of projecting the demand would require estimating market penetration of various devices, while accounting for fuel substitution, average capacity and efficiency factors in the future, as well as average utilization rates. The demand forecasts are also done for each consumer category and voltage level. Charging the commercial, industrial and large consumers a higher charge, which is used to subsidize social reform programs, optimizes revenues while keeping social objectives in mind. The forecast plays an important role in identifying the categories which “can pay” and those that should be subsidized.

To deal with all of the above many forecasting techniques have been developed, ranging from very simple extrapolation methods to more complex time-series techniques, extensive accounting frameworks and optimization methods, or even hybrid models that use a combination of these for purposes of prediction.

Existing methods

There is an array of methods that are available today for forecasting demand. An appropriate method is chosen based on the nature of the data available and the desired nature and level of detail of the forecasts. An approach often used is to employ more than one method and then to compare the forecasts to arrive at a more accurate forecast. The forecaster may use a combination of techniques that give him aggregate annual forecasts and those that predict hour-by hour demand for electricity in individual sectors. This helps greatly in tariff setting and designing demand-side management programs. In this section, we take up a discussion on the methods commonly referred to in literature on energy forecasting. Most of these could be used for both long- and short-term forecasting.

Trend method

This method falls under the category of the non-causal models of demand forecasting that do not explain how the values of the variable being projected are determined. Here, we express the variable to be predicted purely as a function of time, rather than by relating it to other economic, demographic, policy and technological variables. This function of time is obtained as the function that best explains the available data, and is observed to be most suitable for short-term projections.

This method has been used by the 16th Electric Power Survey (EPS) of the Central Electricity Authority to forecast the consumption of most consumer categories except HT Industries. The Base Paper of the EPS, detailing the methodological issues, states that in the domestic, commercial and miscellaneous categories, the observed time series in the number of consumers and consumption per capita have been projected into the future, with adjustments for increase in appliance ownership. It is only for the HT industries that an end-use method is used. It also mentions that adjustments have been made to account for unmet demands due to the presence of power cuts, though the specific assumptions have not been elaborated upon. Thus, unrestricted demands were worked out for the future.

The trend method has the advantage of its simplicity and ease of use. However, the main disadvantage of this approach lies in the fact that it ignores possible interaction of the variable under study with other economic factors. For example, the role of incomes, prices, population growth and urbanization, policy changes etc., are all ignored by the method. The underlying notion of trend analysis is that time is the factor determining the value of the variable under study, or in other words, the pattern of the variable in the past will continue into the future . Therefore, it does not offer any scope to internalize the changes in factors such as the effects of government policy (pricing or others), underlying institutional structure, regulatory regimes, demographic trends, aggregate and per capita growth in incomes, technological developments etc. However, this method is important as it provides a preliminary estimate of the forecasted value of the variable. It may well serve as a useful cross check in the case of short-term forecasts.

End-use method

The end-use approach attempts to capture the impact of energy usage patterns of various devices and systems. The end-use models for electricity demand focus on its various uses in the residential, commercial, agriculture and industrial sectors of the economy. For example, in the residential sector electricity is used for cooking, air conditioning, refrigeration, lighting, and in agriculture for lift irrigation. The end-use method is based on the premise that energy is required for the service that it delivers and not as a final good. The following relation defines the end use methodology for a sector:

$$E = S \times N \times P \times H$$

E = energy consumption of an appliance in kWh
S = penetration level in terms of number of such appliances per customer
N = number of customers
P = power required by the appliance in kW
H = hours of appliance use.

This, when summed over different end-uses in a sector, gives the aggregate energy demand. This method takes into account improvements in efficiency of energy use, utilization rates, inter-fuel substitution etc., in a sector as these are captured in the power required by an appliance, P. In the process the approach implicitly captures the price, income and other economic and policy effects as well.

For instance, the Planning Commission had used a combination of the trend and end-use methods to forecast the energy requirement in the various sectors. The results from trend and regression analysis were compared with those obtained from the end use model to arrive at the best forecasts. Also, detailed sectoral analysis was carried out, especially for the transport and domestic sectors. To estimate the end-use model the Planning Commission used, a spreadsheet based integrated energy demand model called DEFENDUS (Development of End Use Energy Scenarios). In the household sector, the estimates for energy requirement for lighting were derived from the kerosene requirement norms and for cooking and space heating were derived from the useful energy per person per. The agricultural demand was assessed on the basis of the stock of tractors and pump sets used while the commercial demand was assumed to follow on lines similar to the one followed for the household sector.

The end-use approach is most effective when new technologies and fuels have to be introduced and when there is lack of adequate time-series data on trends in consumption and other variables. However, the approach demands a high level of detail on each of the end-uses. One criticism raised against the method is that it may lead to a mechanical forecasting of demands, without adequate regard for behavioral responses of consumers. Also, it also does not give regard to the variations in the consumption patterns due to demographic, socio-economic, or cultural factors. A feature of this method is that the data is collected with a picture of the end result in mind. For example, a study of the agriculture sector may require a look at the area under each of the major crops, cultivation practices and water requirement per unit area irrigated (including percentage rain-fed) for these crops, etc. However, if one were to look at the agricultural sector as a whole, the degree of detail required might not be as intensive. Therefore, the degree of detail required in the data depends on the desired nature of the forecasts.

Econometric approach

This approach combines economic theory with statistical methods to produce a system of equations for forecasting energy demand. Taking time-series[1] or cross-sectional/pooled data[2], causal relationships[3] could be established between electricity demand and other economic variables. The dependant variable, in our case, demand for electricity, is expressed as a function of various economic factors. These variables could be population, income per capita or value added or output (in industry or commercial sectors), price of power, price(s) of alternative fuels (that could be used as substitutes), proxies for penetration of appliances/equipment (capture technology effect in case of industries) etc. Thus, one would have:

$$ED = f\ (Y, Pi, Pj, POP, T)$$

where,

ED = electricity demand
Y = output or income
Pi = own price
Pj = price of related fuels
POP = population
T = technology

Several functional forms and combinations of these and other variables may have to be tried till the basic assumptions of the model are met and the relationship is found statistically significant. For example, the demand for energy in specific sectors could be explained as a function of the variables indicated in the right hand side of the following equations:

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[1] Detailed data over the last, some 25 to 30 years.
[2] Detailed data pooled over different regions/states/individuals and time as well.
[3] Functional forms where a cause-and-effect relationship is established between variables. For example, changes in Income cause a change in consumption and/or vice versa.

Residential ED = f (Y per capita, POP, Pi, Pj)
Industrial ED = g (Y of power intensive industries, GFKF or I, index of T, index of GP)
where,
GFKF = gross fixed capital formation
I = investment
GP = government policy, and
f and g represent functional forms.

Inserting forecasts of the independent variables into the equation would yield the projections of electricity demand. The sign and the coefficients of each variable, thus estimated, would indicate the direction and strength of each of the right-hand-side variable in explaining the demand in a sector.

The Planning Commission had used a variant of this approach wherein they assumed that the growth rates of GDP are as per the Revised Draft Ninth Five-Year Plan (6.5% for the 9th plan, 7.7% for the 10th plan and 8.0% for the 11th plan periods). The average growth rate over the 15-year period thus works out to be 7.4% per year. Regression estimates were arrived at after relating the energy consumption in the past with the GDP. The same method was used to forecast demand for petroleum products. For the household sector, the industrial and the petroleum products sectors, private final consumption expenditure, value added of mining and manufacturing were used as independent variables for regression.

The econometric methods require a consistent set of information over a reasonably long duration. This requirement forms a pre-requisite for establishing both short-term and long-term relationships between the variables involved. Thus, for instance, if one were interested in knowing the price elasticity of demand, it is hard to arrive at any meaningful estimates, given the long period of administered tariffs and supply bottlenecks. However, the price effect will have an important role to play in the years to come. In such a case, one may have to broaden the set of explanatory variables apart from relying on more rigorous econometric techniques to get around the problem. Another criticism of this method is that during the process of forecasting it is incorrect to assume a particular growth rate for the explanatory variables. Further, the approach fails to incorporate or capture, in any way, the role of certain policy measures/ economic shocks that might otherwise result in a change in the behavior of the variable being explained. This would have to be built into the model, maybe in the form of structural changes.

Fuel share model: A variant of econometric models, the category of fuel share models consider a two-step approach for estimating energy demands. First, the total energy consumption by a sector is estimated, which is then used in the determination of fuel shares, defined as ratios of individual fuels consumed to the total energy consumption by the sector. Emphasizing the dependence of fuel shares on relative fuel prices brings the focus on inter-fuel substitution.

A drawback of this method is its failure to recognize the interdependence between prices and quantity. The estimating equations assume that fuel prices are determined independently of both total energy consumption and the distribution of consumption by fuels. The sequential estimation procedure also assumes that total energy consumption is independent of fuel shares. Thus, all fuel supplies must be perfectly elastic and price elasticities are meaningful only if total energy demand remains fixed in response to a change in relative prices. Also the aggregate energy quantities and prices are weighted averages of individual fuels expressed in common heat units, which is acceptable only if all fuels are substitutable in different applications. The weights are unaffected by relative prices making the aggregation procedure inconsistent with the premise that fuel shares shift in response to relative fuel prices.

All the models built using this approach have predicted that electricity demand is highly price-responsive. Also, energy prices are important in determining both total energy consumption and the fuel choice while income is more important in determining total energy demand than the fuel choice. Thus the expectations based on demand theory that relative fuel prices, not income, affect fuel choices, while both determine the energy consumption levels. The strength of these relationships, however, is still to be established beyond doubt.

Time series methods

A time series is defined to be an ordered set of data values of a certain variable. Time series models are, essentially, econometric models where the only explanatory variables used are lagged values of the variable to be explained and predicted. The intuition underlying time-series processes is that the future behavior of variables is related to its past values, both actual and predicted, with some adaptation/adjustment built-in to take care of how past realizations deviated from those expected. Thus, the essential prerequisite for a time series forecasting technique is data for the last 20 to30 time periods. The difference between econometric models based on time series data and time series models lies in the explanatory variables used. It is worthwhile to highlight here that in an econometric model, the explanatory variables (such as incomes, prices, population etc.) are used as causal factors while in the case of time series models only lagged (or previous) values of the same variable are used in the prediction.

In general, the most valuable applications of time series come from developing short-term forecasts, for example monthly models of demand for three years or less. Econometric models are usually preferred for long term forecasts. Another advantage of time series models is their structural simplicity. They do not require collection of data on multiple variables. Observations on the variable under study are completely sufficient. A disadvantage of these models, however, is that they do not describe a cause-and-effect relationship. Thus, a time series does not provide insights into why changes occurred in the variable.

Often in analysis of time series data, either by using econometric methods or time series models, there do exist technical problems wherein more than one of the variables is highly correlated with another (multi-collinearity), or with its own past values (auto-correlation). This sort of a behavior between variables that are being used to arrive at any forecasts demands careful treatment prior to any further analysis. These, along with other similar methodological options, need a careful assessment while working out forecasts of demand for any sector.

Co-integration: Essentially a variant of the time-series approach, this method attempts to overcome some of the limitations of the simple econometric forecasts wherein we prescribe a growth rate to the explanatory economic factors. The underlying concept here is that the overall pattern or relationship between any set of variables is likely to persist into the future as well. It is observed that some economic variables tend to behave in a similar fashion in the long run. That is to say that there is an implicit time-trend in the pattern of variables. In such a case, it is often found that these factors have significant causal effects[4] on each other. A practical example here is that of the number of water pumps installed and the rate of fall in the water table. Clearly, an increase in the number of pumps installed would deplete the water table faster which in turn leads to the installation of a larger number of (possibly, more powerful) pumps. Another example often cited is that of per capita GDP and per capita consumption. It is seen that with an increase in the per capita GDP, there is an increase in the per capita consumption. This in turn leads to an increase in the

[4] Wherein a cause-and-effect relationship is established between variables. For example changes in Income cause a change in consumption and/or vice versa.

per capita GDP. Thus, in the long run, per capita GDP and per capita consumption tend to follow the same pattern. In such a case we say that the two series are co-integrated. The long run (common) equation capturing the relationship between the variables involved is called the co-integrating vector. Various software packages have now been developed that can establish such relationships with a fair degree of simplicity and then utilize them for arriving at future projections.

If any two series are co-integrated, the process of building the model differs slightly from that in the case of a simple econometric model. We use a system of equations to build the model as against just one equation, as in the case of a simple econometric or time series model. In addition we also include an additional term called, the "error correction term" to account for the long run effects, while the short run effects are captured by the co-integrating vector.

The advantage of this technique is that one does not need to prescribe the growth rates of any of the variables that are co-integrated with one another. The system of equations internally generates the forecasted values of the variables involved, based on the long-run pattern established in the past. In addition, introducing shocks into the system could capture the effect of policy implications. The major disadvantage of this approach is the need for a consistent time-series spanning at least 30 time-period as a pre-requisite. In the Indian context the lack of such a database makes the use of co-integration techniques often difficult.

Suggested hybrid approaches

In light of prevailing conditions in the Indian power sector, it might be advisable to utilize a combination of the techniques discussed above to suit our requirements.

Combining econometric and time series models

It is common to use a combination of econometric and time series models to achieve greater precision in the forecasts. This has the advantage of establishing causal relationships as in an econometric model along with the dependency relationship. Various functional forms such as linear, quadratic, log-linear, translog, etc are used to capture the possible trends that may be evident in the data. The functional form of the model is arrived at after a trial and error process. A model is built using the available data, truncating the last few observations. The procedure for testing the model entails making predictions for the last few time periods for which actual data are available and were truncated.

The functional form where the forecasts have least deviations from the data available is chosen.

Integration of econometric and end-use approach

A bulk of empirical literature suggests a hybrid of end-use and econometric method for forecasting. This would allow integration of physical and behavioral factors in a common framework: while the econometric relationships would internalize the influence of price, income and policy effects, the end-use approach will provide an accounting plane for aggregating end-use and sectoral energy demands projected into the future. The accounting framework accommodates new end-uses, alternative fuel mixes, penetration of appliances and technologies, growth pattern of physical or value of output, population and its distribution amongst income class. The integrated approach will provide a better grasp of many diverse influences that shape the demand for energy into the future.

Predicting the shape of the load curve

This can be classified into three techniques: disaggregation, aggregation and econometric methods. Each type can use various principles of engineering estimation and econometrics in their execution.

Disaggregation basically refers to starting with a known shape, decomposing it into components to the extent necessary, making modifications for demand side management and recombining to provide an estimate of the load shape after measures towards demand side management have been undertaken. The initial load shape is estimated using econometric or regression methods. This technique is quite useful in making early estimates of load shape impacts. The level of detail in the decomposition, possible concerns regarding accuracy and its response to weather are, however, shortfalls of this method.

Aggregation, as opposed to disaggregation, is based on the principle of building up or aggregating the load shape to enable structuring a load shape and to explicitly include consideration of demand side management programs or initiatives as a part of the process. A computer model called Electric Load Curve Synthesis (ELCS) was developed and used by the Public Service Electric and Gas Company, USA to predict load shape for up to a 30-year period. The underlying aim was to predict the load shape changes caused both by demand side management and by other load shape changes. The basic concept used in ELCS was to allow an examination of the existing electric load shape, apply appropriate forecasted non-demand side management and then demand side management impacts and then to examine the resulting revised load shape. This is then used to determine the financial impact upon the utility with greater accuracy than was possible in the past. This method has the ability to investigate the diversified load curves of various end-use appliances. Also it can separate the system load-curve by rate, revenue component, and/or class of business, and determine the impact on any of the major components of the system load curve on an hourly basis resulting from a change in any major end-use component.

Forecasting new technologies

The forecasting process has to take into account the effect of new technologies that may be in use in the future on the usage, efficiency and losses of electricity. These, along with the direct effect of the new technology, have a significant impact on the demand for electricity. Since there is no historical data available, classical techniques are not applicable here. We require a high degree of complex technical input into the decision process here. Based on the data available, the forecaster has to choose between a subjective and an objective model. Subjective models do not specify processes and the data is analyzed informally using judgement and experience as against objective methods where the process to analyze the data is clearly specified.

The Electric Power Research Institute (EPRI), USA has logically divided forecasting methods into three branching pairs: judgmental and model-based, extrapolation and causal and static and dynamic.

Judgmental forecasting methods are mental processes that people use to make predictions. They can be simple or complex and may use quantitative or qualitative data as inputs. This method relies on the experience and perceptions of the forecaster and is easily implemented at a low cost. They are useful when little or no historical data is available, when the past does not significantly affect the future, or when explanation and sensitivity analysis are not required.

A popular approach is that of historical analogies. This approach assumes that similar technologies exist that have preceded a new technology and that the analyst can use the historical penetration of the previous product to gauge the success of the present product. The underlying assumption, in the absence of which this method is not justifiable, is that the earlier product or technology had a similar economic/market environment during its introductory stage as does the current product.

Model-based methods use well-specified algorithms to process and analyze data. These algorithms are repeatable and can be based on quantitative or qualitative input data. We include extrapolation and causal methods in this category.

Extrapolation methods are numerical algorithms that help forecasters find patterns in time-series observations of a quantitative variable. These are popular for short-range forecasting. This method is based on the assumption of continuity and projects historical patterns into the future. Thus, we require data only on the variable being forecasted for a sufficient historical time-series.

Causal methods rely on the assumption that a stable, systematic structure accounts for changes that the forecast variable will undergo in the future. These models can be simple, such as the single-independent-variable linear equation specification, or complex using nonlinear, simultaneous equations, each with several independent variables. These methods may be static or dynamic or a blend of the two. A static forecast is used to forecast into the near future and uses actual data for the variables in the past or the present. On the other hand, a dynamic forecast can be used to make long term projections since it uses the forecasted values to predict later in the future.

Econometric techniques, as mentioned earlier, involve prescribing a relationship between hourly load and major variables such as energy prices, income levels, and appliance saturation rates. These relationships are organized into the form of equations, parameters are estimated based on historic data, and then the equations are used to forecast.

Issues of data

Given the fast changing power scenario in the country, a move to better forecasting methods cannot be undermined. Indeed, while one would face problems with availability of information, initiating work with better methods would provide the impetus for collection and collation of the information that would form the backbone of any useful exercise. For example, the Indian Market Demographic Surveys conducted by the National Council of Applied Economic Research (NCAER) provides a time-series on income distribution of population, appliance ownership by income class, region, profession and the rate of depreciation, all of which will be critical in determining residential electricity demand. This could be broadened in scope. Similarly, the household expenditure surveys of the CSO could be adapted to meet the demand of energy demand forecasts. Specifically, the effective use of end-use methods would require that extensive primary-level surveys be carried out to build and consolidate a reliable database on end-uses of energy in the different sectors.

It is also noteworthy that the time series data available in India is admittedly unreliable. In particular, the data on agricultural consumption, being unmetered, is recorded as residual consumption. With the deregulation, it is now evident that this category absorbs a degree of the technical and non-technical power losses of the utility to keep these at acceptable levels. A greater transparency in documentation of sectoral consumption is clearly impending, especially to provide a boost to private sector initiative in generation and sales of electricity. Another issue that needs to come into the limelight is that of unmet demand for energy. Studies to collect and assimilate data on the unrestricted demand for power, giving due recognition to non-utility power generation (e.g. small-scale captive generation by industries, use of generators for residential and commercial use) are critical. The data on this is scant, to say the least.

It is worth mentioning that all the forecasting methods available today are highly data intensive. The accuracy of the forecast increases with the size of the database used to arrive at the model. However, there is a practical limit to the quantity of data that is cost effective to gather and manipulate in terms of additional information gained by the utility planner. Studies are on, the world over, to develop new techniques that would reduce the amount of data required for a given level of accuracy to be achieved in the forecast.

Unless a beginning is made now, it would not be possible to keep up with the demands placed by a fast changing economic scenario for power. In the same fashion, the data collected by the state-level statistical departments could also be utilized and tuned in future to serve the purpose of energy forecasting exercises.

Reform process and demand estimation

With the ongoing reform process, a renewed interest has been generated in deriving precise demand estimates. However, as matters stand, in spite of the several uses and advantages of good demand forecasting methods that have been studied and applied by experts the world over, a bulk have yet to gain a level of recognition in India. As is admitted by many a Regulatory Commission, the estimates of electricity demand made by the electricity boards are often found to lack the expected degree of accuracy and rigor. The current practice to estimate demand is to use compounded annual growth rates (CAGR) or at best a simple trend analysis. These methods, however, only forecasts demand met and not actual demand besides ignoring the effect of changes in incomes, prices, consumer tastes and quality of supply. There is, nonetheless, concern about the cost and feasibility of modeling electricity demand in a purely econometric setting among the utilities in India. With the advent of competition in the power sector, the consequences of a poor forecast of demand make it worthwhile to take up even fairly expensive but accurate demand forecasting exercises.

One major handicap in the context of the Indian power sector is the non-availability of precise and detailed data. Agricultural consumption in the country is unmetered and therefore, the consumption data is at best a guestimate of the actual value. Thus, the projected value also is a guestimate. This has a bearing on the estimate of the transmission and distribution losses. It is often alleged that the estimates of agricultural consumption are deliberately inflated with the dual purpose of obtaining higher subsidies and artificially keeping the levels of loss low.

Awareness regarding the importance of demand forecasting has been increasing in the very recent past. The need for the use of rigorous methods has been recognized by the Uttar Pradesh Electricity Regulatory Commission in their publication, Power Diary. The tariff order passed by the Commission also highlights the need for data collection on various essential variables to enable introduction of further refinements in the future, thus making the reform process faster and more effective.

The Haryana Electricity Regulatory Commission has issued guidelines making it mandatory for the licensee to submit to the Commission a forecast of future demand in the respective areas of supply of each licensee for a period of 10 years. The licensee is also required to furnish details of the data, and assumptions on which it is based along with a justification for its choice of forecasting methodology. The Commission reserves the powers to specify, from time to time, particular matters that should be dealt with in the load forecasts. These may include demand-side management programs and anticipated increase in end-use efficiency, category-wise loads, losses (technical and non-technical), seasonal and time-of-day changes in load shape, benchmarking load growth, and other related issues.

In the case of Andhra Pradesh, the quality of data was an issue taken up by various people in their objections. Only 41% of the total electricity generated is metered and billed. This leads to inefficiencies in the usage of electricity in the state. The uncertainty surrounding the estimate of the agricultural consumption (being unmetered), which in turn has a bearing on the identification of transmission and distribution losses was also questioned with objectors producing calculations showing that the demand estimates were either over- or under-estimates. The licensee here relied on various methods to arrive at estimates of agricultural consumption over the years. For the year 2000-01, the licensee has estimated monthly consumption pattern aggregating to 9800 MUs. This was supported by short term forecast of energy sales, energy requirements and peak demand which projected to 9420 MUs sales while on the other hand estimating consumption of 9900 MUs on the basis of the agricultural consumption pattern in Kuppan Rural Electric Co-operative Society. There was no apparent consistency in the methods used to project the agricultural consumption. Thus, the Commission directed the licensee to institute a year long sample study during 2000-01 to determine the energy consumption by the agricultural pumpsets covering all the Mandals and ½% of the pumpsets in the State apart from the study taken up by APTRANSCO with funding by the World Bank. The licensee has also been directed to carry out a census of agricultural pumpsets within six months of the issue of the order.

In Orissa, the role of regulators has been clearly defined by the Electricity Regulatory Commission Act, 1998. The Regulatory Commission is envisaged to plays a key role in tariff filing. The Commission has been empowered under Section 22 (1)(a), and Section 22(2)(c) to regulate the electricity sector in the State. Thus, the Commission may advise the licensee to take up demand forecasting exercises to ensure a just and reasonable tariff structure. Planning strategies for conservation, load distribution and implementation of other such demand side management programs will also be aided by a detailed demand forecast. Besides, a long-term demand forecast would assist the Commission to evaluate the need and feasibility of investment in building future capacity, keeping in mind the long gestation periods of plants and rapidly changing technologies in the power sector.

Conclusions

In view of the fast changing power scenario in India, the need for development and use of more sophisticated and relevant tools and methods for estimating demands has emerged like was never the case before. Time and again, the importance accorded to these exercises by governmental and non-governmental organization has remained rhetorical and never really got translated into the action in the true sense. Clearly, it is time that a pro-active approach is adopted to initiate work with better methods, which would also provide the much-needed impetus for data collection and feed effectively into the electricity reforms processes.

Specifically, drawing upon the discussions presented in the foregoing sections of the paper, we would like to recommend the following:

1. In respect of the annual forecasts, on account of excessive reliance on simple extrapolation of past rates of growth or trend, power forecasting in India is not up to the mark, both in terms of rigor and precision. With prevailing conditions in the Indian power sector, it is advisable to make a beginning with the use of simple time-series or econometric methods and/or utilize more extensive end-use approaches for purpose of forecasting, to say the least. With independent regulation, pricing and related policy reforms will have an ever increasing bearing on demands. Thus, given the data constraints, it might be preferable to depend on a combination of the techniques discussed above to suit individual requirements.
2. With renewed focus on demand side management and role of new technologies, the need for determining the shape of the load curve and predicting the impact of new technologies has gained additional importance. Thus, new methods will have to be deployed to estimate the demand variations across hours, weeks, months and even regions.
3. For the future, we suggest that after requisite consultations with all stakeholders, homogeneous standards be laid down for data collection and reporting. Thus, we should strive toward the development of a repository of data/information for each state and as the grid gets more connected there would be comparable databases across the country so that analysis for a group of states or a region or the country as a whole can be seamlessly put together. For instance, if there is a generation project covering, say four states, it is important to have a consistent set of data for all the states to estimate their joint requirements.
4. In the past, it was mandatory for the industry to report to the government its plans and programs of production and management for the future. The government records served as a useful and updated database for the forecaster. However, in the delicensed regime in the industry, the task of the forecaster is made more challenging since now he not only has to strive for instituting good estimation techniques but also access data on these units from other sources.
5. In an effort to develop an extensive database, which would enable the effective use of the techniques discussed above, collaboration and co-operation among the various government departments such as the CEA, Planning Commission, Census Department, etc. would be an advantage. Increased interaction between these departments is therefore suggested to achieve increased efficiency in demand forecasting.

References

1. Analyzing demand behavior: a study of energy elasticities. Douglas R. Bohi (1981) John Hopkins University Press, Baltimore.
2. Demand forecasting for electric utilities. C.W. Gellings, PE (1991) The Fairmont Press, Inc.
3. Power Diary. Uttar Pradesh Electricity Regulatory Commission. Lucknow. August 2000.
4. A Base paper on demand projection. Central Electricity Authority, Ministry of Power, Government of India. New Delhi. December 1999.
5. Note on the “Base paper on demand projections”. Submitted by TERI to the CEA.