APPENDIX B

LOAD FORECASTING METHODS

B-1. General.

a. A model is a mathematical description of how the complex elements of a real-life situation or problem might interplay at some future date. In projecting electricity demand, a modeler uses data on electricity prices, income, population, the economy, and the growth rates for each and then varies the mix according to varying sets of assumptions. Different assumptions produce different outcomes. The relationships between electricity demand and the multitude of factors that influence or affect electricity demand are expressed in mathematical equations called functions. A model is a collection of functions. A function, in turn, is made up of variables - those factors which change or can be changed. Independent variables are those factors which influence the demand for electricity, and the dependent variable is electricity demand itself. In other words, the demand for electricity depends on population, income, prices, etc. Finally, elasticities describe how much the dependent variable (electricity demand) changes in response to small changes in the independent variables. Elasticities are what the modeler uses to measure consumer behavior.

b. Energy planners often speak of scenarios - hypothetical pictures of the future based on different assumptions about economic or political events. They make different projections for each scenario. For example, a low-growth scenario might assume high energy prices and slow population growth, while a high-growth scenario would assume the opposite. These scenarios allow planners to see how electricity demand might change if the different assumed economic and political events actually occur. All of the forecasting methods are capable of looking at different scenarios and do so by changing their basic assumptions.

B-2. Types of Models.

a. Introduction. The three types of electricity demand forecasting methods (or models) are: trend analysis, end-use analysis, and econometrics. Each of the three forecasting methods uses a different approach to determine electricity demand during a specific year in a particular place. Each forecasting method is distinctive in its handling of the four basic forecast ingredients: (a) the mathematical expressions of the relationship between electricity demand and

the factors which influence or affect it - the functions; (b) the factors which actually influence electricity demand (population, income, prices, etc.) - the independent variables; (c) electricity demand itself - the dependent variable; and (d) how much electricity demand changes in response to population, income, price, etc., changes - the elasticities.

b. Trend Analysis.

(1) Trend analysis (trending) extends past growth rates of electricity demand into the future, using techniques that range from hand-drawn straight lines to complex computer-produced curves. These extensions constitute the forecast. Trend analysis focuses on past changes or movements in electricity demand and uses them to predict future changes in electricity demand. Usually, there is not much explanation of why demand acts as it does, in the past or in the future. Trending is frequently modified by informed judgement, wherein utility forecasters modify their forecasts based on their knowledge of future developments which might make future electricity demand behave differently than it has in the past.

(2) The advantage of trend analysis is that it is simple, quick and inexpensive to perform. It is useful when there is not enough data to use more sophisticated methods or when time and funding do not allow for a more elaborate approach.

(3) The disadvantage of a trend forecast is that it produces only one result - future electricity demand. It does not help analyze why electricity demand behaves the way it does, and it provides no means to accurately measure how changes in energy prices or government policies (for instance) influence electricity demand. Because the assumptions used to make the forecast (informed judgements) are usually not spelled out, there is often no way to measure the impact of a change in one of the assumptions. Another shortcoming of trend analysis is that it relies on past patterns of electricity demand to project future patterns of electricity demand. This simplified view of electrical energy could lead to inaccurate forecasts in times of change, especially when new concepts such as conservation and load management must be included in the analysis.

c. End-Use Analysis.

(1) The basic idea of end-use analysis is that the demand for electricity depends on what it is used for (the end-use). For instance, by studying historical data to find out how much electricity is used for individual electrical appliances in homes, then multiplying that number by the projected number of appliances in each home and multiplying again by the projected number of homes, an estimate of how

much electricity will be needed to run all household appliances in a geographical area during any particular year in the future can be determined. Using similar techniques for electricity used in business and industry, then adding up the totals for residential, commercial, and industrial sectors, a total forecast of electricity demand can be derived. The advantages of end-use analysis is that it identifies exactly where electricity goes, how much is used for each purpose, and the potential for additional conservation for each end-use. End-use analysis provides specific information on how energy requirements can be reduced over time from conservation measures such as improved insulation levels, increased use of storm windows, building code changes, or improved appliance efficiencies. An end-use model also breaks down electricity into residential, commercial and industrial demands. Such a model can be used to forecast load changes caused by changes within one sector (residential, for example) and load changes resulting indirectly from changes in the other two sectors. Commercial sector end-use models currently being developed have the capability of making energy demand forecasts by end-uses as specific as type of business and type of building. This is a major improvement over projecting only sector-wide energy consumption and using economic and demographic data for large geographical areas.

(2) The disadvantage of end-use analysis is that most end-use models assume a constant relationship between electricity and end-use (electricity per appliance, or electricity used per dollar of industrial output). This might hold true over a few years, but over a 10- or 20-year period, energy savings technology or energy prices will undoubtedly change, and the relationships will not remain constant. End-use analysis also requires extensive data, since all relationships between electric load and all the many end-uses must be calculated as precisely as possible. Data on the existing stock of energy-consuming capital (buildings, machinery, etc.) in many cases is very limited. Also, if the data needed for end-use analysis is not current, it may not accurately reflect either present or future conditions, and this can affect the accuracy of the forecast. Finally, end-use analysis, without an econometric component (discussed next), does not take price changes (elasticity of demand) in electricity or other competing fuels into consideration.

d. Econometrics.

(1) Econometrics uses economics, mathematics, and statistics to forecast electricity demand. Econometrics is a combination of trend analysis and end-use analysis, but it does not make the trend-analyst's assumption that future electricity demand can be projected based on past demand. Moreover, unlike many end-use models, econometrics can allow for variations in the relationship between electricity input and end-use.

(2) Econometrics uses complex mathematical equations to show past relationships between electricity demand and the factors which influence that demand. For instance, an equation can show how electricity demand in the past reacted to population growth, price changes, etc. For each influencing factor, the equation can show whether the factor caused an increase or decrease in electricity demand, as well as the size (in percent) of the increase or decrease. For price changes, the equation can also show how long it took consumers to respond to the changes. The equation is then tested and fine tuned to make sure that it is as reliable a representation as possible of the past relationships. Once this is done, projected values of demand-influencing factors (population, income, prices) are put into the equation to make the forecast. A similar procedure is followed for all of the equations in the model.

(3) The advantages of econometrics are that it provides detailed information on future levels of electricity demand, why future electricity demand increases or decreases, and how electricity demand is affected by all the various factors discussed in this section. In addition, it provides separate load forecasts for residential, commercial, and industrial sectors. Because the econometric model is defined in terms of a multitude of factors (policy factors, price factors, end-use factors), it is flexible and useful for analyzing load growth under different scenarios.

(4) A disadvantage of econometric forecasting is that in order for an econometric forecast to be accurate, the changes in electricity demand caused by changes in the factors influencing that demand must remain the same in the forecast period as in the past. This assumption (which is called constant elasticities) may be hard to justify, especially where very large electricity price changes (as opposed to small, gradual changes) make consumers more sensitive to electricity prices.

(5) Also, the econometric load forecast can only be as accurate as the forecasts of factors which influence demand. Because the future is not known, projections of very important demand-influencing factors such as electricity, natural gas, or oil prices over a 10- or 20-year period are, at best, educated guesses. Finally, many of the demand-influencing factors which may be treated and projected individually in the mathematical equations could actually depend on each other, and it is difficult to determine the nature of these interrelationships. For example, higher industrial electricity rates may decrease industrial employment, and projecting both of them to increase at the same time may be incorrect. A model which treats projected industrial electricity rates and industrial employment separately would not show this fact.

(6) Econometric models work best when forecasting at national, regional, or state levels. For smaller geographical areas, meeting the extensive data needs of the model can be a problem. This is because most utilities have oddly shaped service areas for which there is no published economic or demographic data.

B-3. Forecasting Accuracy. The only way to determine the accuracy of any load forecast is to wait until the forecast year has ended and then compare the actual load to the forecast load. Even though the whole idea of forecasts is accuracy, nothing was said in the comparison of the three forecasting methods about which method produces the most accurate forecasts. The only thing certain about any long-range forecast is that it can never be absolutely precise. Forecasting accuracy depends on the quality and quantity of the historical data used, the validity of the forecaster's basic assumptions, and the accuracy of the forecasts of the demand-influencing factors (population, income, price, etc.). None of these is ever perfect. Consequently, regional load forecasts are reviewed continually, and some are revised yearly. Even so, there is simply no assurance that electricity demand will be exactly as forecast, no matter what method is used or who makes the forecast.