Chapter Six

Load Forecast and Need for Power

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TVA's need for power is based on an analysis of the ability of existing power facilities to meet customers' projected electricity needs. The need varies from season to season, day to day, and even minute to minute. TVA develops two types of forecasts—one for annual system peak load and one for annual system energy requirements.

One of the basic lessons of the 1970s was that it is extremely risky to plan on the basis of a single forecast. To deal with uncertainty in forecasting, TVA develops a range of forecasts—high, medium, and low.

TVA has determined its need for power to meet the medium load forecast to be 800 megawatts by 1998 and 16,500 megawatts by 2020. Based on the high load forecast, additional capacity will be needed by 1997, and the need for new power supply resources increases from that point on. Under the low load forecast, TVA will not need additional capacity during the forecast period for Energy Vision 2020.

The estimates include a reserve margin, or additional generating capacity for reliability of 15 percent average through 1997, 13 percent average for the years 1998 to 2010, and 12 percent average for the years 2011 to 2020.

This Chapter Includes:

Load Forecasting

- What Is Load Forecasting?
- Why Do Load Forecasting?
- The Results of TVA's Load Forecast
- Historical Perspective – Forecast Accuracy
- Elements of TVA's Load Forecast

Need For Power

- Where We Are Today – Current and Planned Capacity Additions
- Future Needs – Comparing Where We Are Today to the Load Forecast

Load Forecast and Need for Power

A projection of future power needs is basic to the integrated resource planning process. Astute business planning requires estimating future requirements, in this case, the demand for electricity. Planning also includes inventorying existing supply capabilities and determining what improvements, additions, or changes will be needed to meet future customer demands.

This chapter explains the findings of the Energy Vision 2020 load forecast analysis and how TVA estimates the need for power.

Forecasts serve as a guide to TVA power planners to ensure that the need for power will be met reliably and economically no matter what the future holds.

Load Forecasting

WHAT IS LOAD FORECASTING?

Load forecasting is simply what the name implies—it is a forecast, an estimate, or a prediction of how much electricity will be needed by the Valley's residences, companies, and other institutions in the future.

WHY DO LOAD FORECASTING?

The need for power in the Tennessee Valley varies from season to season, day to day, and even minute to minute. To ensure that an adequate supply of power is available to meet the demand, TVA must plan far into the future. Load forecasting is one of the planning processes used by TVA.

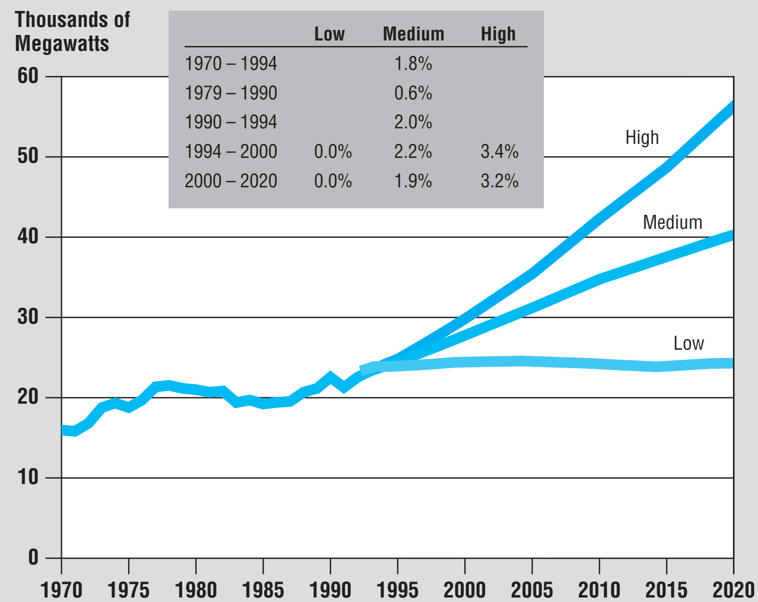
THE RESULTS OF TVA'S LOAD FORECAST

TVA develops two types of forecasts—one for annual system peak load and one for annual system energy requirements. The annual system peak load, measured in megawatts, is the highest load TVA needs to be prepared to serve each year. The annual system energy requirement, measured in kilowatt-hours, is the total electricity used during a year.

For each type of forecast—low, medium, and high—forecasts are developed to reflect the uncertain future. This range of forecasts serves as a guide to TVA power planners to ensure that the need for power will be met reliably and economically no matter what the future holds.

The range of long-term system peak load forecasts developed for Energy Vision 2020 is shown in *Figure 6-1*. For the medium forecast, peak loads are expected to increase 2.2 percent per year through 2000 and 1.9 percent per year from

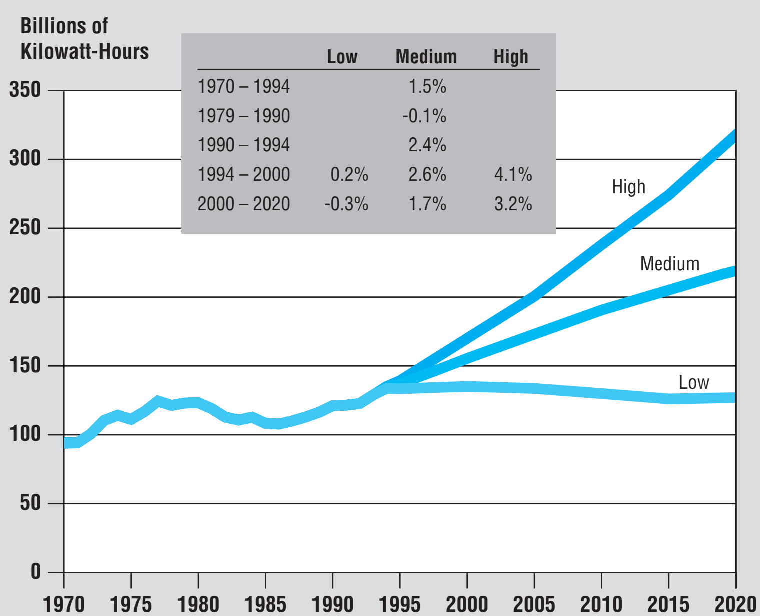
FIGURE 6-1. **Actual and Projected Growth of System Peak Needs**



	Low	Medium	High
1970 – 1994		1.8%	
1979 – 1990		0.6%	
1990 – 1994		2.0%	
1994 – 2000	0.0%	2.2%	3.4%
2000 – 2020	0.0%	1.9%	3.2%

A wide range of forecasts was developed to predict TVA's peak electricity needs each year.

FIGURE 6-2. **Actual and Projected Growth of Electricity Needs**



	Low	Medium	High
1970 – 1994		1.5%	
1979 – 1990		-0.1%	
1990 – 1994		2.4%	
1994 – 2000	0.2%	2.6%	4.1%
2000 – 2020	-0.3%	1.7%	3.2%

A wide range of forecasts was developed to predict the amount of electricity needed in each year.

2000 to 2020, with peak loads of 27,800 megawatts in 2000 and 40,300 megawatts in 2020. Recognizing the uncertainty in forecasting through the year 2020, TVA's high peak load forecast calls for an increase of approximately 3.3 percent per year with a peak load of 56,400 megawatts in 2020. The low peak load forecast calls for no increase in growth through 2020. The peak load for 1994 was 24,400 megawatts.

The system peak demand forecasts shown in *Figure 6-1* are derived from the energy requirement forecasts shown in *Figure 6-2*. These projections are based on state-of-the-art forecasting models that are accepted throughout the utility industry. These are explained later in this chapter.

The range of long-term forecasts for system energy requirements is shown in *Figure 6-2*. For the medium forecast, total system energy requirements are expected to increase 2.6 percent per year through the year 2000 and 1.7 percent per year from 2000-2020, with a demand for 155.5 billion kilowatt-hours of electricity in 2000 and 219.6 billion kilowatt-hours of electricity in 2020. In the high energy requirements forecast, demand for electricity grows at a rate of 4.1 percent a year through 2000 and 3.2 percent from 2000-2020, with a demand for 170 billion kilowatt-hours of electricity in 2000 and 317.5 billion kilowatt-hours of electricity in 2020. The annual growth rates for the low energy requirements forecast are 0.2 percent through 2000 and -0.3 percent from 2000-2020 with energy requirements of 135.1 billion kilowatt-hours of electricity for 2000 and 126.3 billion kilowatt-hours of electricity for 2020. The system energy requirements for 1994 were 133.4 billion kilowatt-hours.

HISTORICAL PERSPECTIVE – FORECAST ACCURACY

As stated earlier, forecasting future electricity needs is full of uncertainty. However, TVA's load forecast accuracy since 1985 has been within plus or minus 5 percent of actual loads over each five-year period. This is well within the industry standard of plus or minus 8 percent accuracy.

ELEMENTS OF TVA'S LOAD FORECAST

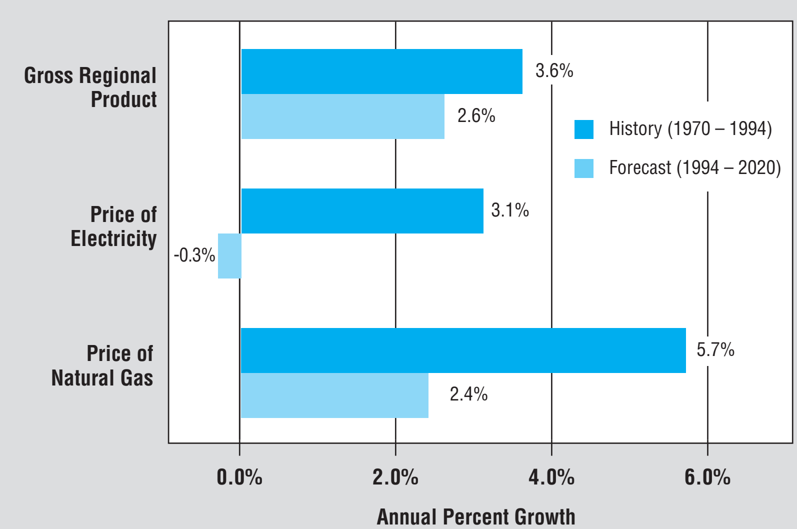
The load forecast is the basis for planning decisions, such as construction of power plants and implementation of demand-side management. Since the implementation of resource decisions can require many years and enormous financial obligation, state-of-the-art load forecasting is necessary. Key elements used to prepare a state-of-the-art forecast are:

- Best information about key variables
- Best methods that lead to best results

Best Information About Key Variables

TVA's forecast of electric energy requirements is driven by forecasts of four key variables that influence electricity use. These variables include (1) regional economic growth, (2) the price of electricity, (3) the price of alternative energy sources, and (4) TVA's competitive success. A summary of historical and forecast growth rates for the first three key variables is shown in *Figure 6-3*. In this figure, Gross Regional Product is shown as the measure of regional economic growth, and the price of natural gas is used to represent the price of alternative energy sources. The fourth variable, TVA's competitive success, is a new factor introduced into the forecast in response to rising competitiveness.

FIGURE 6-3. **Key Variables**



This chart compares historical and forecast rates of growth for these variables influencing electricity use, including regional economic growth as indicated here by Gross Regional Product, price of electricity, and price of alternative energy sources such as natural gas.

1. Regional Economic Growth

TVA produces its own forecasts of regional economic activity. These forecasts are derived from forecasts of the national economy. DRI/McGraw-Hill, an internationally recognized forecasting service, produced the forecast of the national economy. DRI/McGraw-Hill forecasts the national Gross Domestic Product to increase by 2 percent per year through 2020 compared to the historical average annual growth rate of 2.3 percent from 1979 to 1994. The TVA region is expected to continue to outperform the nation, primarily due to the continued strong performance of Valley manufacturing. (See Chapter 3, discussion of socioeconomic environment.) Gross Regional Product for the Tennessee Valley is forecast to grow 2.6 percent annually through 2020 compared to the historical average annual growth rate of 3.2 percent from 1979 to 1994.

2. Price of Electricity

TVA has not increased electric rates since 1987 and is committed to no rate increases through 1997.

TVA has not increased electric rates since 1987 and is committed to no rate increases through 1997. This has been achieved through a combination of efforts including controlling costs, refinancing debt, and efficiency improvements. Holding rates constant is expected to continue to have a positive impact on electricity sales. Simply put, increases in the price of electricity reduce sales—lower electric rates increase sales. The TVA wholesale price of electricity in real terms (that is, without including inflation) is expected to decline 0.3 percent per year through 2020.

3. Price of Alternative Energy Sources

The potential for consumers to substitute fossil fuels, primarily oil and natural gas, for electricity will depend on relative prices for a particular end use, such as heating, and on technology factors, such as new types of equipment becoming available. For example, the development of new types of home heating and cooling systems could make it enticing for consumers to use one energy source over another.

Natural gas has emerged as electricity's most important competitor in the market. Because of this, the price of natural gas compared to the price of electricity is the major factor in determining how successfully electricity competes. This affects how much electricity will be used and therefore is a factor in determining the load forecasts. Natural gas prices, without including inflation, are forecast to increase 2.4 percent per year through 2020.

4. TVA's Competitive Success

Competition is growing in the electric utility industry (See Chapter 1, discussion of competitive environment). Regulators are opening markets and allowing some customers to change energy providers. This increases the amount of uncertainty in the load forecast. In the medium forecast, the net effect of competition is that TVA will retain its current customers.

Market and regulatory changes impact TVA's high and low forecasts. If TVA operates at lower costs than the competition and legal requirements permit, TVA may have opportunities to gain customers from outside the existing service territory. This is termed "high competitive success." Likewise, if TVA is a higher cost producer than its competitors, it is likely to lose customers to competing electric utilities—described as "low competitive success." Both cases assume that deregulation of the electric industry continues.

In evaluating TVA's competitive success in the future, TVA analyzed competitive impacts for all sales. In other words, TVA looked at the total electric market rather than at specific customers. Results of surveys of distributors of TVA power and TVA's direct-served industries were used to identify the amount of load that appeared to be at high risk. TVA used this information in forecasting its performance in a low competitive success environment.

To estimate the potential for gain in wholesale markets, loads of municipal and cooperative distributors in neighboring regions were used to project TVA's performance in a high competitive success environment. Under high competitive success, approximately 5 percent of these loads are captured by TVA by the year 2015.

A more thorough discussion of the four key variables and the methods used to prepare the load forecast can be found in Volume 2, Technical Document 5, Load Forecast.

Best Methods That Lead to Best Results

TVA stays abreast of developments in load forecasting and continually incorporates new information into its forecasting process. State-of-the-art forecasting requires using the best methods available that lead to best results. The best methods include (1) using several advanced models, (2) building energy forecasts by class of customer and end use, and (3) producing a range of forecasts to deal with uncertainty.

1. Using Several Advanced Models

Advanced forecasting models and techniques are key tools used by TVA in developing its load forecast. These models allow for computer simulation of projected power needs based on a variety of considerations. These model and forecasting techniques have been incorporated to form a complete forecasting system from data collection to evaluation of forecast uncertainties.

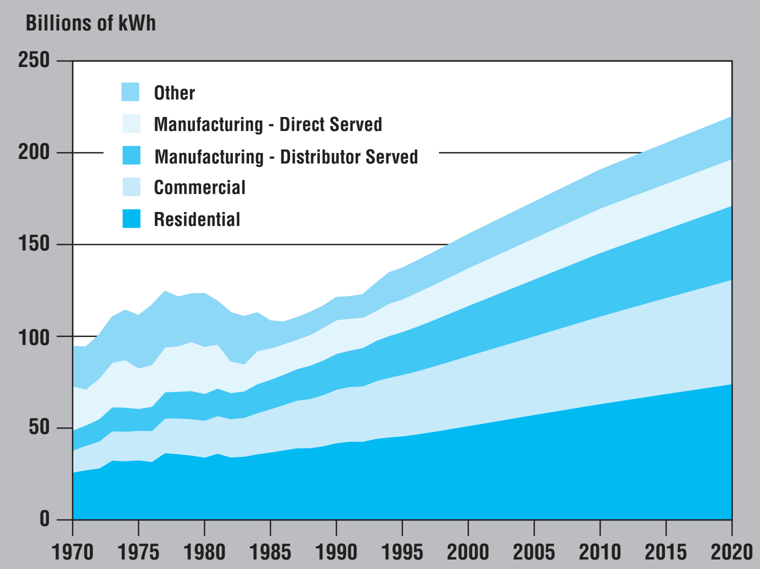
Three types of models are used:

- Econometric modeling is used extensively. An econometric model summarizes in equations estimated relationships between economic trends over a period of time.
- End-use models are used to measure how much energy will be consumed by given end uses such as residential air conditioners, office lighting, and industrial motors.
- Conditional demand and qualitative choice analysis is a combination of econometric and end-use modeling.

Best methods available include the following models that are used in the Energy Vision 2020 forecast:

- Residential Conditional Demand Model
- Residential Energy End-Use Planning System
- Electricity Forecasting Model
- Commercial Energy End-Use Model
- Industrial Energy End-Use Model
- Regional Economic Simulation Model
- Financial Model
- Hourly Electric Load Model

FIGURE 6-4. **Sales by Customer Class**



Annual Increase In Sales (%)

	Residential	Commercial	Manufacturing Distributor Served	Manufacturing Direct Served	Other
1970 - 94	2.4%	4.3%	3.1%	-1.5%	-1.7%
1979 - 90	1.6	3.6	2.2	-3.4	-6.7
1990 - 94	2.4	3.0	4.3	-2.3	4.6
1994 - 00	1.7	2.5	2.8	3.5	4.0
2000 - 20	1.9	2.0	2.0	1.1	1.2

Electricity sales are shown for the customer classes of residential, commercial, and manufacturing. Electricity sales for the manufacturing customer class are divided into sales to industrial customers served by distributors and sales to industries served directly by TVA. The other category includes outdoor lighting sales and power sales to other federal agencies.

More detailed information about the models and techniques used by TVA in preparing the load forecasts can be found in Volume 2, Technical Document 5, Load Forecast.

2. Building Energy Forecasts by Class of Customer and End Use

System energy requirements forecasts include several types of sales and also energy lost in transmission. TVA, through the 160 distributors of TVA power, serves three major groups or classes of electric customers: residential customers, commercial customers, and industrial or manufacturing customers. *Figure 6-4* shows the sales for these classes of customers. The energy forecast is developed by adding electricity sales to these groups, certain miscellaneous sales such as outdoor lighting, and sales to other federal agencies. The forecast also includes electric energy that is lost in transmitting and distributing power. These losses, which amount to approximately 7 percent of the electricity generated, occur because there is some natural resistance to electricity flow in power lines.

Residential. The residential forecasts are influenced by variations in six key factors: per capita income, population size, residential electric prices, residential natural gas prices, household types, and appliance efficiencies. In 1994, TVA's residential sales were 46.3 billion kilowatt-hours. In the medium forecast, residential sales are forecast to be 51.4 billion kilowatt-hours in 2000, and 74.3 billion kilowatt-hours in 2020. Growth rates are expected to be 1.8 percent per year through 2000 and 1.9 percent per year from 2000-2020.

Commercial. Electricity sales to commercial customers are driven by economic activity, the price of electricity, the price of natural gas, technology, and efficiency improvements. The 1994 commercial sales were 33.4 billion kilowatt-hours. In the medium forecast, commercial sales are expected to be 38.2 billion kilowatt-hours in 2000 and 56.9 billion kilowatt-hours in 2020. Growth rates are projected to be 2.3 percent per year through 2000 and 2 percent per year from 2000-2020.

Manufacturing. Manufacturing sales are influenced by economic activity, price of electricity, the price of natural gas, efficiency improvements, and the availability of new technologies. The manufacturing sector is especially important to TVA because the Valley economy is more dependent on manufacturing than is the economy of the United States as a whole. The TVA region has experienced faster growth in manufacturing than the United States. From 1979 to 1994, TVA region manufacturing output grew by an average of 4.2 percent per year, compared with an average of 1.8 percent per year for the nation as a whole.

The forecast of manufacturing sales is divided into two groups: sales to industrial customers served by distributors of TVA power and those industries served directly by TVA. (TVA directly serves 54 large industries due to their extremely high demand for power or unique operating characteristics that would make service by a power distributor difficult.)

Industrial sales by power distributors have increased steadily in the past and are expected to continue to increase. In the medium forecast, total electricity sales to industries served by power distributors are expected to increase from 23.1 billion kilowatt-hours in 1994 to 27.3 billion kilowatt-hours by 2000 and to 40.3 billion kilowatt-hours by 2020. Growth rates are expected to average 2.8 percent per year through 2000 and 2 percent per year from 2000-2020.

The forecast for industries served directly by TVA is developed on a company-by-company basis. In other words, direct-served customers are analyzed individually to develop a forecast for each company. These individual company forecasts are then added to determine the overall forecast for this group of customers. In the medium forecast, total electricity sales to directly served industries are expected to increase from 16.7 billion kilowatt-hours in 1994 to 20.5 billion kilowatt-hours by 2000 and to 25.4 billion kilowatt-hours by 2020. Growth rates are expected to be 3.5 percent per year through 2000 and 1.1 percent per year from 2000 to 2020.

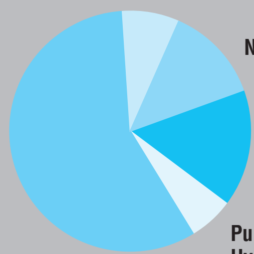
3. Producing a Range of Forecasts to Deal with Uncertainty

Growth in economic activity, population, and electricity sales in the future are all uncertain. TVA prepares the best medium forecast possible with the information available at the time of preparation. However, TVA's forecasters do not expect that the future will turn out to be exactly as forecast. High and low forecasts are prepared to show the degree of uncertainty that exists. TVA uses the range of forecasts to evaluate integrated resource planning options to determine how well they perform under different futures.

In the Energy Vision 2020 load forecast, TVA deals with uncertainty in two ways. First, as explained earlier, several models are used to generate the forecast. This provides the power planners with more than one forecast to analyze the relationship between electricity sales and the key variables.

Second, once the medium forecast is determined, the high and low levels of each key variable are quantified and models are used to determine the high and low sales levels. For the high load forecast, there are 9 out of 10 chances of the actual load being less than the forecast. For the low load forecast, there

FIGURE 6-5. **TVA's 1994 Generating Capacity Mix**



TVA's generating capacity mix and the percentage of power supplied by each source is shown.

is 1 out of 10 chances of the actual load being less than the forecast. This means that the high and low load forecasts are reasonable limits, or bounds, on the expected load in the future.

Additional information on TVA's load forecast can be found in Volume 2, Technical Document 5, Load Forecast.

Need For Power

WHERE WE ARE TODAY—CURRENT AND PLANNED CAPACITY ADDITIONS

TVA currently has 25,600 megawatts of generating capacity. Generating sources include coal-fired, hydroelectric, nuclear, and pumped-storage hydro plants, along with combustion turbines. (See Chapter 4 for a more detailed description of TVA's existing power system.)

Figure 6-5 shows TVA's generating capacity mix and the percentage of power supplied by each source.

Hydro and nuclear plants have the lowest operating costs and are used to the fullest extent possible by TVA. Coal-fired generating plants, the third lowest in cost, are used according to power system demand. Pumped-storage units are used to meet peak demand since energy output is limited by the size of the water reservoir. Combustion turbines or gas-fired plants are the most costly to operate and are typically used to meet peak demand only.

When assessing current generating resources, it is necessary to include not only those in operation, but also any planned additions or changes to the system. TVA already has under development additional supply-side resources of 2,400 megawatts as shown in *Figure 6-6*. These capacity additions consist largely of Watts Bar Nuclear Plant Unit 1 with 1,170 megawatts and Browns Ferry Nuclear Plant Unit 3 with 1,065 megawatts. Both plants are expected to be in operation in 1996. Other ongoing or expected power system capacity changes include improvements to hydroelectric facilities. However, reductions in generating capacity at some of TVA's coal-fired plants due to steam sales and the installation of pollution control equipment are also expected to occur during this period.

On the demand side, TVA has in excess of 2,500 megawatts of interruptible power contracts with industrial customers. These contracts allow TVA to interrupt power to these industrial customers during periods of peak loads or high demands on the power system. In other words, TVA has the right to turn off or turn down power to some industries so that others can use the power when power supplies are not adequate to serve everyone.

This interruptible power is used as part of TVA's available capacity; however, not all of

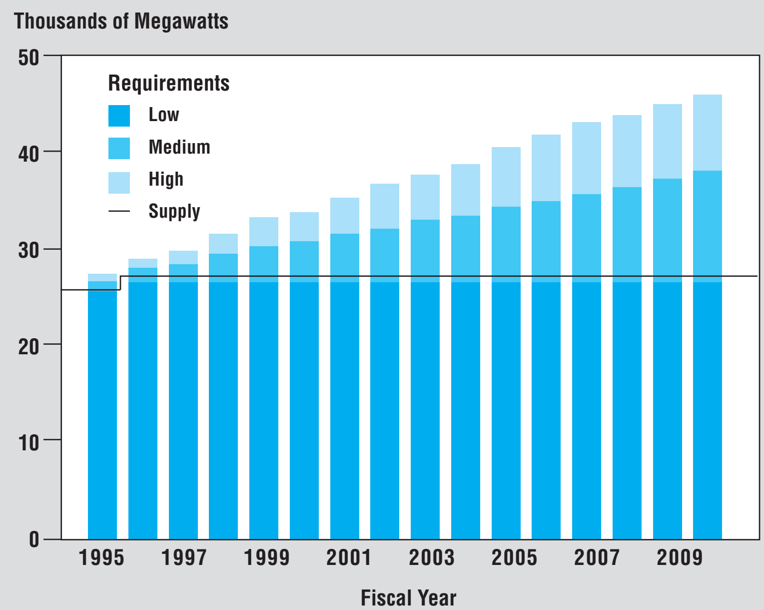
FIGURE 6-6. **Current and Planned Capacity**

	Current Capacity in 1994	Planned Capacity Additions from 1994 – 2005	Total Capacity in 2005
Conventional Hydro	4,044	360	4,404
Pumped-Storage Hydro	1,532		1,532
Coal	14,743	(153)	14,590
Combustion Turbines	1,952		1,952
Nuclear	3,282	2,235	5,517
Total	25,553	2,442	27,995

TVA's current capacity measured in megawatts is shown for each generating power source. TVA already has underway additional supply-side resources as shown by the planned capacity additions.

the contracted power is available for interruption due to variations in contracts. Approximately 1,700 megawatts of the 2,500 megawatts of industrial load is available for interruption during peak periods through 2002. After 2002, the availability of interruptible power is expected to drop to 1,500 megawatts through 2020.

FIGURE 6-7. **Long-Term Capacity Requirements and Supply**



The expected capacity surplus or deficit for low, medium, and high projections are shown through the year 2010. The low, medium, and high capacity requirements are shown by the different colors on the vertical bars. These capacity requirements include both TVA's annual peak load forecasts plus reserve margins. Supply, which includes both TVA's current system capacity and planned additions to capacity, is indicated by the solid line. The difference between the solid line and the requirements shows the deficit or surplus which defines the need for power.

FUTURE NEEDS—COMPARING WHERE WE ARE TODAY TO THE LOAD FORECAST

The low, medium, and high load forecasts developed for Energy Vision 2020 are compared to current generating capacity to provide a picture of future power needs. Comparing existing capability to the load forecasts predicts when and how much additional resources will be needed at any given time.

The future need for power is illustrated graphically in *Figure 6-7*, which shows the expected capacity surplus or deficit for low, medium, and high load projections through 2010. Supply, indicated by the solid line, is defined by TVA's current system capacity and planned additions to capacity. Capacity requirements represent the annual peak load forecasts plus reserve margins.

System Demand and Supply Requirements

The medium load forecast developed for Energy Vision 2020 indicates that TVA will need about 800 megawatts of additional generating capacity by 1998. The need for power is based on projections of peak demand—the maximum amount of electricity used at any given time.

This need for power is in addition to the completion or return to service of Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3, available interruptible power, and improvements to TVA's existing generating system.

In the longer term, TVA estimates the need for additional generating capacity will increase to 6,250 megawatts by 2005 and up to 16,500 megawatts in 2020. Resource options identified during Energy Vision 2020 will be used to meet these future needs for power.

Additional information about these resource options can be found in Chapter 7, Supply-Side Options; Chapter 8, Customer Service Options; and Chapter 9, Resource Integration/Alternative Strategy Comparisons.

Based on the high load forecast, additional capacity will be needed by 1997, and the need for new power supply resources increases from that point forward. Under the low load forecast, TVA will not need additional capacity during the forecast period for Energy Vision 2020.

Reserve Requirements

As explained earlier, electric utilities plan and operate their systems to be able to meet the maximum need for energy or the peak load forecast. However, emergencies can occur that prevent certain energy resources from operating—generating units could break down—or maintenance of a resource may require that a unit be off-line when unexpected demands arise. Therefore, capacity is also needed to provide a reserve margin sufficient to ensure power system reliability.

Reserve margin is simply additional power supply that can be called upon in an emergency. The amount of reserve power that may be needed is determined by studying the costs of providing an "acceptable" level of system reliability (the higher the reliability, the higher the cost), the performance of the TVA power system, and the performance of other power systems that TVA may rely upon for power purchases when necessary.

System reliability is determined by the ability of the system to withstand sudden equipment failures on generation or transmission facilities and by changes in load caused by temperature variations or customer equipment failures. Poor reliability can result in interruptions of electric service—people lose their electricity.

Practically speaking, it is not possible to have a power system that is 100 percent reliable. There is always some possibility that an equipment failure or an unforeseen event will cause a power interruption or outage to a customer. Reliability can be improved by adding extra capacity, but this increases the cost to the customer. However, power interruptions also cost the customer, in terms of lost production from manufacturing plants or as a discomfort from the loss of air conditioning on a hot summer day.

Optimum reliability balances the cost of adding new capacity with the cost of outages. This optimum reliability translates into a reserve margin, or additional generating capacity, for TVA of 15 percent average through 1997, 13 percent average for the years 1998 to 2010, and 12 percent average for the years 2011 to 2020. This decline in reserve margin is due to improved availability of generating resources.

The reserve margin proposed by TVA is in alignment with reserve margins established by other entities in the utility industry. Among members of the North American Electric Reliability Council, of which TVA is a member, forecast reserve margins range from 13.5 percent to 22.3 percent for 1995 and projections of 11.9 percent to 18.5 percent for the year 2000.

Conclusion

TVA has determined its need for power to be 800 megawatts by 1998 and 16,500 megawatts by 2020 based on the medium load forecast. To meet this future need, TVA has examined a broad range of options including both supply-side and customer service options. These options will be discussed in the following two chapters. Uncertainty in the load forecasts requires the development of plans that are flexible. Resource options must be available to meet a wide range of customer needs, but at the same time must not produce either a costly surplus of capacity or a shortage of capacity. This need for flexibility is analyzed in Chapter 9, Resource Integration/Alternative Strategy Comparisons.