4.23 Power

4.23.1 Introduction

Resource Issues
▶ Power generation dispatch
▶ Cost of power
▶ Power system reliability

TVA's operation of its power system focuses on providing reliable, low-cost power to its customers in the 201-county TVA Power Service Area. To provide for the total energy needs of its Power Service Area customers, TVA's generating resources include coal, nuclear, hydropower, oil, gas, pumped storage, and other renewable sources. TVA's management of the Tennessee River and its tributaries to provide flood control and navigation in accordance with the TVA Act, as well as other benefits, affects both hydropower and non-hydropower generation. Water discharged from the reservoirs for other purposes is released through the hydro turbines, if possible, and is scheduled during times of peak power demand to maximize its value. Coal and nuclear generating units also rely on the water released from the reservoirs to provide cooling water for their operation. The availability of adequate cooling water is a key element in TVA's ability to provide reliable power generation.

The construction and operation of TVA's integrated electric power and transmission systems are described in detail in TVA's Energy Vision 2020 Final EIS (December 1995). That document also discusses how TVA estimates future demand for energy from its system, what TVA's estimates for demand through 2020 are, and how TVA could meet those demands. In addition, the Final EIS analyzes the potential environmental impacts of TVA's current operations and alternative ways of meeting future demands.

To the extent that any changes in reservoir operations may alter the amount or timing of water releases, TVA's ability to provide reliable power generation may be affected. While hydropower generation is most directly affected by changes in reservoir operations, the changes may also affect the use or operation of TVA's coal and nuclear generating resources, and energy customers within the TVA Power Service Area may be affected. A substantial reduction in the availability of cooling water, particularly during periods of higher water temperatures in the Tennessee River and its tributaries, could negatively affect TVA's ability to generate energy at its coal and nuclear power plants. The effects on both hydropower and non-hydropower generation may cause an increase in the cost of power in the Power Service Area.

The key factors related to system-wide costs of power generation are:

- **Power Generation Dispatch—**changes in the availability of hydropower generation resources (the timing and amount of energy generated) and any offsetting increase or decrease in the use or "dispatch" of other generating resources; ancillary services; additional operating and maintenance costs for operating existing cooling towers for longer durations to reduce coal or nuclear plant derates; and derates or shutdowns of coal or nuclear generating units due to water temperature effects.

- **Power System Reliability—**availability of specific generating facilities to operate when required to provide generating reserves, system voltage support, and other system requirements as needed to ensure a reliable power supply.

Other factors that can affect power cost are:

- **Non-Generating Costs—**the costs of purchase, installation, and operations and maintenance of additional oxygenation equipment to maintain planned DO concentrations in selected tailwaters; additional capital costs for construction of new cooling towers, if necessary to reduce coal or nuclear plant derates; changes to the cost of shipping coal to fuel TVA's coal generating plants; and additional transmission costs.

To the extent that the changes may alter the amount and timing of TVA's use of either hydropower or non-hydropower generation, the mix of generating resources used to meet the power demand would be altered, changing the cost of power. Because power costs affect the cost of production and living in the Tennessee Valley, changes in power cost would affect the regional economy. For this study, the change in the cost of power was measured as a single value, a potential change in power rates. This potential rate change served as a basis of comparison of the alternatives. It also was used as an input for the regional economic model to estimate the indirect effects of potential changes in power costs on the regional economy. It should not be assumed, however, that the calculated change in the cost of power would be implemented as a rate change.

Changes in reservoir operations could directly affect power production in the TVA Power Service Area. As a result, the affected environment for power generation is bounded geographically by this 201-county area. All of TVA's power generation assets were included in the power generation studies.

4.23.2 Regulatory Programs and TVA Management Activities

Congressional acts and federal agencies that regulate or influence operation of TVA's power generation resources include:

- **TVA Act.** Section 9a of the TVA Act provides the legal context for the policies that guide the operation of TVA's dams and reservoirs today. Section 9a requires that the reservoir system be operated primarily to promote navigation and flood control and, to the extent consistent with these purposes, for power production.

- **Clean Air Act.** Power plant air emissions are controlled under the CAA and are addressed in Section 4.2, Air Resources.

- **Federal Energy Regulatory Commission.** The Federal Energy Regulatory Commission (FERC) regulates, among other things, the transmission and sale of wholesale electric power by public utilities under the Federal Power Act. Although TVA is not a public utility and thus is not subject to FERC's general regulatory jurisdiction, in certain cases FERC has jurisdiction to hear complaints against TVA concerning power transmission and related matters. TVA has chosen to voluntarily follow FERC rules and orders to the extent they are consistent with meeting TVA's obligations under the TVA Act.

- **North American Electric Reliability Council.** The North American Electric Reliability Council (NERC) is a voluntary, not-for-profit corporation formed in 1968 to further the reliable operation of the bulk electric system in North America. Among other things, NERC promotes cooperative efforts among various segments of the electric industry to develop voluntary standards, guidelines, and policies for both the operation and planning of the bulk electric system. NERC coordinates its work with its 10-member regional reliability councils and other organizations. TVA is a member of the Southeastern Electric Reliability Council (SERC), which is one of the 10 NERC regional councils.

- **Clean Water Act.** Under Section 316(a) of the CWA, which regulates cooling water intake structures, alternative thermal limits may be established based on a satisfactory demonstration that a balanced indigenous population of fish and shellfish is maintained in the receiving waterbody. With respect to TVA's coal and nuclear generating plants, CWA Section 316(a) is implemented by the authorized states, which issue NPDES permits that limit the thermal impact of the cooling water discharges. Each of TVA's coal and nuclear generating plants that discharge into the Tennessee River system has been issued and complies with an NPDES permit.

- **Nuclear Regulatory Commission License.** The Nuclear Regulatory Commission (NRC) licenses Sequoyah, Browns Ferry, and Watts Bar nuclear generation plants. To allow safe shutdown of the reactors in an emergency, the license limits the maximum temperature of each plant's essential raw cooling water, known as the ultimate heat sink. The Tennessee River is the ultimate heat sink for all three nuclear plants.

- **Homeland Security Act.** Consistent with this act, TVA is responsible for ensuring that the power supply system is protected from potential terrorist attacks.

4.23.3 Power Generation Dispatch

Existing Conditions

TVA operates its generating units to minimize power cost to the consumer, bringing generation on line as needed, and beginning with generating units with the lowest production costs. As demand increases, the next more costly unit is brought online until demand is met. The reverse is true as demand decreases. This economic dispatch of generating units is based on each unit's marginal cost of generating power. Fixed costs of a unit sitting idle include interest on funds used to construct the unit and provide its basic maintenance. When started up, additional costs are incurred for fuel, maintenance, and the economic value of emission allowances.

These additional costs are the marginal costs of generation. The largest factor in the marginal cost is usually fuel. Because hydropower generation's marginal costs are very low, it is a generation resource that is dispatched whenever it is most valuable. Any alternatives that affect the timing or amount of the availability of hydropower generation would increase the marginal power cost.

TVA must also consider the operating characteristics of each type of generating unit—hydropower, nuclear, fossil-fired (coal, oil, and gas) and pumped storage—when selecting which units to operate to meet the demand. Operating characteristics considered include the time required to start or stop a unit and whether a unit can be operated at less than full capacity (and if so, how quickly the load changes can be made). Hydropower generation's operational flexibility makes it a valuable generation source. Table 4.23-01 summarizes the various types of generating units in the power system, their key operating characteristics, and the use of each unit type (whether as base load or peaking).

Present Load

TVA balances the different operating costs and characteristics of its generating units to meet the power demand at the lowest cost. Figure 4.23-01 illustrates how the different types of generating units are dispatched to meet the power demand as it varies over a 24-hour period. Base load, the level of demand that occurs throughout the day, is provided largely by nuclear and coal units, units that are suited to continued running and have low marginal costs. Peaking power, the portion of the load that varies throughout the day, is generated by hydropower, pumped storage, purchased power, and combustion turbines, units that are suited to cycling their output up and down. Coal units are also used to provide peaking power, by increasing output to maximum capacity for short periods.

Although all of TVA's customers are affected by changes in the production cost of power regardless of the rate structure, approximately 15 to 20 percent of TVA's current demand is by customers who purchase power on a rate structure that varies hourly based on the marginal power cost. These customers are likely to be sensitive to changes in marginal power costs caused by changes in the availability of hydropower generation.

Present Supply

TVA currently has over 31,000 MW total winter net dependable generating capacity comprised of a combination of coal-fired, hydroelectric, nuclear, combustion turbine, and pumped storage hydropower plants. Table 4.23-02 shows the capacity mix and the percentage of annual generation supplied by each resource type for fiscal year 2002.

Table 4.23-01 Key Characteristics of the Power System Generation Resources

Generation Resource [1]	Operating Costs and Characteristics
Hydropower	The least marginal cost form of electricity Can be started and brought to full load more quickly and reliably than other sources of generation, making it ideal for peaking power[2] Can be made available almost instantaneously to cope with system emergencies or to provide system voltage regulation, enhancing power system reliability
Nuclear	Relatively low fuel costs, the next least-cost generation resource Principally operated as baseload[3] generating units because they cannot be brought online quickly nor can the output of energy be adjusted quickly
Coal	Next in cost are coal-fired units that vary in operating costs, depending on the installed technology at the various plants and type of coal used Best used to supply baseload generation but can be used for peaking at increased operating and maintenance costs
Pumped storage[4]	Uses excess baseload power to pump water to upper reservoir during off-peak periods, then generates to meet peak power requirements and other system needs, such as operating reserve Limited to only a set number of hours of operation at full output by the upper reservoir's storage volume Hours required to pump exceed hours of generation Net energy loss but net revenue producer
Combustion turbines (simple cycle)	Relatively high in cost to operate, burning natural gas or fuel oil—both high-cost fuel sources Lower efficiency compared to other types of generating resources Used sparingly to meet peak demands; rapid start-up relative to coal
Non-hydropower renewables	High-cost form of generation Various sources include wind, solar, and landfill gas generation Availability of wind and solar is intermittent; landfill gas is baseload

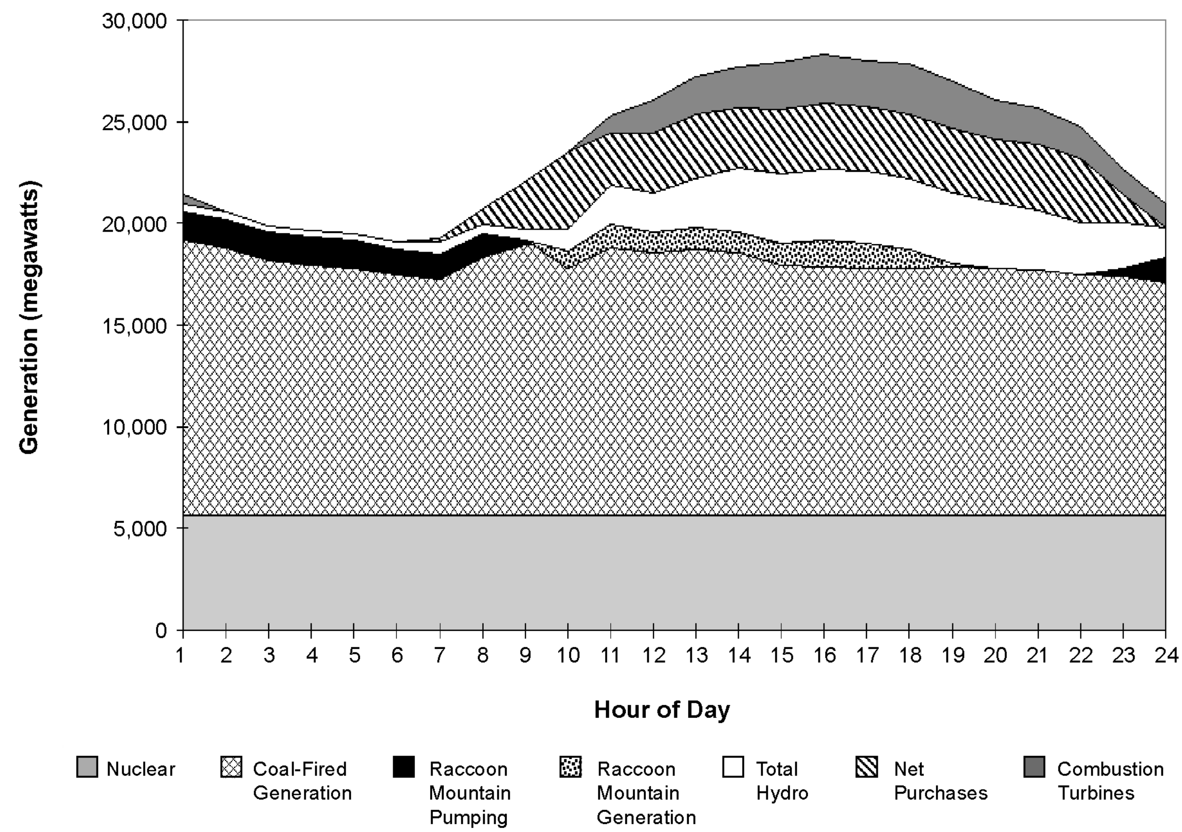
Notes:

1 Ranked in order from least to greatest marginal cost.

2 Peak power refers to supplying additional power quickly for those times when daily power demands are the highest.

3 Base load is the power that is provided around the clock to meet demand.

4 Raccoon Mountain Pumped Storage Project.



Source: TVA data 2003.

Figure 4.23-01 Typical Dispatch of TVA Generating Resources to Meet Daily Power Demand (July 11, 2000)

The nuclear and coal units total over 20,000 MW (or 65 percent of TVA's total capacity) and generated 140,000 MWhrs (or 85 percent of the annual energy) in 2002. In contrast, TVA's hydropower capacity comprised approximately 10 percent of TVA's total capacity and generated approximately 6.6 percent of the annual energy in 2002. This difference between percent capacity and percent energy indicates that the nuclear and coal units are run almost continuously to meet baseload demand while hydropower is operated less than continuously to meet peak demand.

Future Trends

Load Growth

As a part of its power planning process, TVA prepares long-term load forecasts. Load forecasts are developed for high, medium, and low growth rates to account for the uncertainties inherent in predicting future power needs. For the medium forecast performed in January 2003, the energy load was expected to grow 1.6 percent on an average annual basis from 2004 through 2022.

Table 4.23-02 Power Generation Resources

Generation Resource	Net Winter Dependable Capacity (MW)	Percent of Total Capacity	Annual Generation (Million KWhrs)	Percent of Total Energy
Coal	15,023	47.7	94,930	57.5
Nuclear	5,751	18.2	45,179	27.4
TVA hydropower	3,305	10.5	10,879	6.6
Purchased power[1]	440	1.4	10,424	6.3
Purchased hydropower[2]	731	2.3	3,175	1.9
Combustion turbines	4,643	14.7	1,190	0.7
Green power	-	-	18	-
Pumped storage[3]	1,624	5.2	-674	-0.4
Total	**31,517**		**165,121**	

Notes: Fiscal Year 2002 capacity and generation statistics.

[1] Red Hills (includes other purchases in generation).

[2] USACE Hydro Capacity and APGI's Tapoco Project.

[3] Raccoon Mountain Pumped Storage Project.

Source: TVA file data.

In addition to the energy load growth projected for 2022, a shift in demand among energy users is projected. Growth in industrial demand is expected to slow; commercial and residential demand is expected to increase as a percentage of the total load to be served. Because industrial demand is relatively constant over time and the residential/commercial demand varies daily, weekly, and seasonally, this shift would increase the percentage of peaking capacity needed in the generation mix by 2030.

While planning for the future load growth, TVA also is aware of the potential for deregulation of power generation markets in the Southeastern United States and nationally. In a deregulated market, TVA customers could purchase their power from other energy providers, increasing the uncertainty in the load forecast. In the medium forecast, TVA has assumed that the net effect of competition is that TVA will retain its current customers.

Supply Growth

In response to the long-term load forecast, power system capacity additions currently planned include improvements to the hydropower plants and the restart of Browns Ferry Unit 1 (see Section 3.3.1). For additional new generation, TVA's options as described in Energy Vision 2020 for meeting additional peaking generation needs include combustion turbines and power purchases. For meeting new base load generation needs, options include improvements to the existing hydropower system, construction of a combined-cycle plant, purchases from independent power producers, and combined cycle repowering of existing coal-fired plants. For the purpose of analyses for this EIS, all new generation except the Browns Ferry and hydropower improvements described above, was assumed to be gas-fired combined-cycle (base load) or gas-fired simple-cycle (peaking) as the current technology of choice for new capacity.

4.23.4 Power System Reliability

Existing Conditions

Power system reliability is the ability of the system to withstand high peak demands, extended drought periods, or sudden changes in the power system—such as generation or transmission equipment failures or large industrial plant shutdowns—and still provide uninterrupted power. To ensure power system reliability, TVA maintains extra standby generation capacity, known as a reserve margin. The amount of reserve margin is determined by balancing the cost of providing the additional capacity with the cost of power interruptions to TVA customers. Also, during critical power system situations, which include but are not limited to Power System Alerts and implementation of the ELCP, reservoir operations may temporarily deviate from normal system operating guidelines to meet power system needs. In such situations, water stored in the reservoirs may be used to the extent practicable to preserve the reliability of the TVA power system. The operating characteristics described in Table 4.23-01, such as its rapid start and stop capabilities, allow hydropower generation to play an important role in helping the power system withstand such system changes, enhancing its reliability.

One condition that TVA must address to ensure power system reliability is the effect of high Tennessee River water temperatures on operations of the power facilities. Each of TVA's coal and nuclear generating plants that discharge into the Tennessee River system has been issued and complies with an NPDES permit that limits the thermal impact of the cooling water discharge on the river. Historically, some coal and nuclear units have had to derate on occasion to comply with NPDES thermal limitations. In addition, each nuclear generating plant has as a condition of its NRC operating license, an upper limit on the temperature of the plant's ultimate heat sink. This limit ensures that, in the event of an emergency, adequate cooling water is available to safely shut down the nuclear reactor. The Tennessee River is the ultimate heat sink for each of TVA's nuclear plants; if its temperature exceeds the maximum temperature limit, one or more nuclear units must be shut down entirely. Shutdown of a single nuclear unit would represent a loss of over 1,100 MW of generating capacity. Since TVA's nuclear plants have been in operation, no nuclear plant shutdowns have occurred as a result of the ultimate heat sink temperature limitations of the NRC license.

Future Trends

The reserve margin proposed for the period through 2010 is 13 percent, declining to 12 percent for the period 2011 through 2030.

4.23.5 Coal and Nuclear Unit Derates

Existing Conditions

As a part of the process of converting fuel to electricity, many of TVA's plants withdraw water from the Tennessee River or its tributaries, use this water for cooling various plant systems, and then return the water to the river. During this process, the cooling water temperature rises. To protect the receiving water, the NPDES permit for each plant includes limits on the maximum discharge temperature and, in some cases, the instream temperature regime. To comply with these NPDES permits, TVA monitors water temperatures at each plant and manages water releases to assist in meeting permit requirements. If the quantity of water available for release is limited or its temperature is elevated (a condition that typically occurs in late summer months when rainfall and runoff is low and ambient temperatures are high), options to either alter river flows or derate the plants are evaluated. The most favorable option is implemented and can vary from day to day.

If the generating plant's output must be derated to meet thermal limitations due to constraints on available water releases, the energy must be provided by an alternate, and typically more expensive, generation source. Under extreme conditions, it is possible that the system load requirements would not be met and brownouts or blackouts could result. Under the existing reservoir operations policy, it is not uncommon for TVA to derate its coal-fired plants for some period of time each summer to meet NPDES permit requirements. Nuclear plants are derated only occasionally.

Future Trends

The changes to the power system that are expected to occur through 2030 that could affect derating coal-fired generation include the restart of Browns Ferry Nuclear Unit 1, expected as early as 2007. Restart and operation of Unit 1 would require construction of an additional cooling tower system and increasing intake flow rates by approximately 10 percent of the original Unit 3 flow, or about 50 percent from the present flow rate. The plant would be operated to ensure that the maximum cooling water discharge temperature and the temperature rise between intake and discharge remain within approved regulatory limits. Use of cooling towers would increase and, on infrequent occasions when the cooling towers are unable to meet thermal limits, the plant would be derated to remain in compliance with the established limits. This additional unit's cooling water discharge would increase the amount of heat that would need to be assimilated by the Tennessee River.

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