Energy Vision 2020

VOLUME ONE

Integrated Resource Plan
Environmental Impact Statement

TVA

Energy Vision 2020

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Integrated Resource Plan Environmental Impact Statement

Tennessee Valley Authority
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Energy Vision 2020—An Integrated Resource Plan and Programmatic Environmental Impact Statement

( ) Draft (**X**) Final Environmental Impact Statement

Responsible Federal Agency: Tennessee Valley Authority (TVA)

Proposed Action: In Energy Vision 2020 TVA has identified and proposes to select a long-range strategy that will enable TVA to meet the additional needs of its customers for electricity from 1996 to 2020. TVA has identified a portfolio of energy resource options from seven alternative strategies that best meet TVA's evaluation criteria regarding costs, rates, environmental impacts, debt, and economic development while meeting customer energy needs. The plan is designed to be flexible to protect TVA and its customers from the uncertainties that the electric utility industry and TVA will face in the future.

Existing TVA generating plants would continue to be the backbone of its power supply system for the planning period (1996-2020). Additional needs would be met by the following actions:

Long-Term Actions: TVA's portfolio of new generation (supply-side) options includes combustion turbines, power purchases, and "call" options for peaking power to meet peaking power requirements for 1996-2005. Compressed air energy storage would be added to the portfolio to meet additional peaking power needs in the 2006-2020 timeframe.

Nine options could supply base-load power for 1996-2005. These include call options on base-load power, improvements to the existing hydro system, siting and engineering for a combined cycle plant, purchases from independent power producers, combined cycle repowering of existing coal-fired plants, renewables (landfill methane, refuse-derived fuel, and coalbed methane), conversion of Bellefonte Nuclear Plant to a coal gasification with coproducts facility, and an additional coal-fired unit at Shawnee Fossil Plant. Base-load power for 2005-2020 could be supplied by wind turbines, a coal refinery, cascaded humidified advanced turbine (CHAT), an integrated gasification combined cycle plant (IGCC), and integrated gasification with CHAT.

TVA would also use demand-side management (DSM) and beneficial electrification options to meet customer and TVA system requirements. Demand-side management options include energy efficiency improvements, residential new construction programs, and commercial and industrial DSM finance plans. Beneficial electrification includes residential heating, air conditioning, and water heater programs; commercial cooking programs; and industrial electrotechnology programs.

Short-Term Actions: The primary focus for the short-term is flexibility. TVA would buy "call" options, including base load in 2001-2002 and peaking for winter and summer in 1998-2002. TVA would not complete by itself three nuclear units (Bellefonte Units 1 & 2, Watts Bar Unit 2), or restart Browns Ferry Unit 1. TVA would convert the Bellefonte Nuclear Plant to a combined cycle plant utilizing natural gas or gasified coal as the primary fuel. Additional evaluation would then be done to determine the best approach for further development at Bellefonte. DSM programs would be expanded to save up to 2,200 megawatts by 2010. Research and development actions would be taken by TVA to support the timely development of other supply-side and customer service options defined in the long-term plan.

Jurisdictions Affected by Proposed Action: Primarily the TVA power service area that includes almost all of the state of Tennessee and parts of Alabama, Kentucky, Georgia, Mississippi, North Carolina, and Virginia.

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Technical documents that provide more in-depth information on specific areas of interest are found in Volume 2 of this set:

- Technical Document 1, Comprehensive Affected Environment
- Technical Document 2, Environmental Consequences
- Technical Document 3, Existing Power System
- Technical Document 4, Evaluation Criteria
- Technical Document 5, Load Forecast
- Technical Document 6, Supply-Side Options
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Responses to public comments on the draft Energy Vision 2020 published on July 26, 1995, are found in Volume 3 of this set.

Energy Vision 2020 — Summary

Purpose of and Need for Action

Energy Vision 2020 is TVA's roadmap for meeting the energy needs of its customers during the next 25 years with economical and environmentally sound energy choices. These are important challenges for TVA, which is the largest single producer of electricity in the United States. With a generating capacity of 28,000 megawatts, TVA provides wholesale power to 160 distributors and directly serves 60 large industrial and federal customers. In partnership with the distributors, the TVA power system serves 7.7 million people in an 80,000-square-mile area that covers parts of seven southeastern states.

TVA is expecting important changes in the relationships between utilities and their customers. Consumer, legislative, and utility actions across the nation are changing the electric utility industry from a regulated monopoly to a competitive marketplace. TVA is at the forefront of this change and welcomes the opportunity for growth and improved service and responsiveness to the needs of its current and new customers. By identifying the best energy choices for current and future consumers, Energy Vision 2020 will guide TVA as it enters this competitive marketplace.

Moreover, Energy Vision 2020 goes beyond the issue of how TVA can provide competitively priced power. The plan also considers economic development and the environment as part of TVA's mandate to be a leader in total resource development. Innovative approaches to meeting the demand for energy through new technologies and business arrangements are the means by which TVA can provide competitively priced power, opportunities for economic growth, and a quality environment rich in natural resources.

The TVA Board has already taken several strategic actions in part based on information and analyses performed in conjunction with Energy Vision 2020. These are:

- Reversed TVA policy on nuclear plant construction.
- Placed an internal limit on new capital debt and announced a debt reduction program.
- Kept TVA's electric rates steady for a ninth consecutive year.
- Introduced TVA to the global energy market through international bond offerings.
- Commissioned a major study to identify strategic actions that will strengthen TVA's position in an open marketplace.

The result of these efforts is that TVA's self-supporting power system is financially strong. TVA's electric power production and operating costs are competitive with utilities in the regional market. The same is true for the electric prices paid by consumers in the TVA service area.

Energy Vision 2020 provides the TVA Board with a flexible energy supply plan that will help guide the strategic actions necessary for TVA to serve its customers efficiently, and to compete and succeed in the electric utility marketplace of the future.

Launched in the winter of 1994, Energy Vision 2020 includes an unprecedented effort by TVA to involve the public in TVA's energy planning process. Environmental, consumer, and energy industry representatives were appointed to a citizen group to provide input on the formulation of the plan, and public meetings were held throughout the TVA service area to gather public comments and suggestions. Interviews were also conducted with elected officials and opinion leaders. The open process produced a stronger partnership with the more than 7.7 million people who use the electricity produced by TVA.

Energy Vision 2020 identified a viable mix of conservation programs and options for power plant operations that will be used to responsibly and economically provide energy for sustainable economic growth. For all resource options, the environmental consequences and economic impacts were considered as part of TVA's effort to encourage sustainable economic growth in the region. Strong public support for various options, such as demand-side management, also was considered.

Overall the key recommendations of Energy Vision 2020 are:

- Invest in up to 3,000 megawatts of flexible purchases of power
- Convert Bellefonte to an alternative fuel source such as natural gas or coal
- Implement up to 1,450 megawatts of energy efficiency and load management
- Research and develop renewable energy resources—wind, biomass, solar photovoltaics

Additional recommendations, which the TVA Board of Directors has asked the staff to include, are:

- Begin additional flexible demand-side management programs with a potential of 750 megawatts
- Investigate the development of a flexible wind project, a biomass refinery, and a combined garbage and biomass energy facility

Because TVA has a unique mission to supply electric power and encourage sustainable economic development in its service region, Energy Vision 2020 has the flexibility to shift priorities as the marketplace evolves and changes influence the viability of power supply options. When changes in energy options are necessary, TVA will remain focused on making economical and environmentally sound energy choices.

ENERGY VISION 2020

The purpose of TVA's Energy Vision 2020 is to identify, with extensive public involvement, long- and short-term actions TVA can take to provide flexible, competitive energy choices. TVA has used the best industry practices in integrated resource planning, which include looking at a broad range of sup-

ply-side and customer service options, using multiple evaluation criteria, considering future uncertainties, and seeking public input. Energy Vision 2020 also includes a programmatic environmental impact statement on the proposed alternative strategies.

Through Energy Vision 2020, TVA developed a comprehensive evaluation system that reflects TVA's goals and objectives, as well as the concerns and values of the public. The evaluation criteria that were used to compare energy resource strategies include:

- Long-Run Cost and Value Criteria
- Short- and Mid-Term Rates
- Reliability
- Environment
- Economic Development
- Financial Requirements
- Risk Management
- Equity Among Rate Classes

These criteria and associated measures became the quantitative basis for ranking supply-side and customer service options. They were later used in the multi-attribute trade-off analysis to evaluate and improve TVA's strategies. Using the multi-attribute trade-off analysis allowed TVA's planners to improve strategies to mitigate potential adverse impacts on the evaluation criteria.

NEED FOR ADDITIONAL POWER

TVA's existing power system currently provides 25,600 megawatts of dependable generating capacity, consisting of 57 percent coal plants, 16 percent hydro facilities, 13 percent nuclear, 8 percent combustion turbines, and 6 percent pumped storage-hydro. TVA will add two nuclear units in (Watts Bar Unit 1 and Browns Ferry Unit 3) in 1996, which will bring the total generating capacity to 28,000 megawatts.

TVA's existing coal-fired plants will continue to provide the largest part of TVA's generating supply during the Energy Vision 2020 planning period. Although the 1990 Clean Air Act Amendments imposed significant requirements on utilities, TVA has taken the necessary actions to meet or exceed these requirements. TVA operates 16,000 miles of transmission lines, which carry power from 42 generating sites to 750 wholesale delivery points. TVA also connects with 13 neighboring utilities at 57 different locations.

In 1994, TVA sold 123 billion kilowatt-hours of electricity—84 percent was sold to distributors at wholesale rates, with the balance retailed to directly served industrial and federal customers. The total revenue from these sales was 5.4 billion dollars.

The need for additional power is based on an analysis of the ability of TVA's existing power facilities to meet the projected electricity needs of its customers in the future. The need for power varies from season to season, day to day, and even minute to minute. Thus, TVA developed two types of power needs forecasts—one for annual system peak load (the maximum single-event demand)

and one for annual system energy requirements. To deal with uncertainty in forecasting, TVA developed a range of forecasts—high, medium, and low.

TVA has determined that in order to meet the medium load forecast it will need an additional 800 megawatts by 1998 and an additional 16,500 megawatts by 2020. Based on the high load forecast, additional capacity will be needed by 1997 and will continue to increase after that. Under the low load forecast, TVA will not need additional capacity during the period 1996 out through 2020.

Alternative Strategies

TVA created an extensive list of generating options to meet new peaking, intermediate, base-load, and storage power supply needs through the year 2020. These included traditional technologies (i.e., coal plants, combustion turbines), as well as potential renewable and advanced combustion facilities. In addition, TVA identified options that would give TVA greater flexibility in its planning. These included purchasing competitively priced power from other suppliers (i.e., independent power producers, cogenerators), buying options on future power delivery, and entering business partnering arrangements. Overall, TVA characterized and considered over 100 supply-side resource options based on their performance, cost, and environmental impacts.

Energy Vision 2020 also considered the actions that end-use customers can take on their side of the electric meter to obtain energy efficiencies and improve their productivity and quality of life. Customer service options also include load management actions that reduce TVA's need for power during periods of high demand.

TVA considered over 60 customer service options, which included traditional demand-side management (i.e., energy efficiency and load management), self-generation, beneficial electrification, and rate options. TVA has included the existing and emerging technology and electric rate options into a variety of program packages to meet the changing needs of its customers and the TVA power system.

KEY STRATEGY ALTERNATIVES

The resource integration phase of Energy Vision 2020 identified over 2,000 strategies using various mixes of supply-side and customer service options. From an extensive series of evaluations, seven strategies emerged that offer low cost, lower debt, and improved environmental and economic development performance. These strategies also provide hedges against the key uncertainties, namely load growth, natural gas prices, possible environmental regulations for air and water, and nuclear performance. The seven strategies, along with a "No Action" or reference strategy, are summarized in *Figure S-1*.

PREFERRED ALTERNATIVE

Energy Vision 2020's long-term plan is a portfolio of options drawn from the seven key strategy alternatives. These options were chosen because they are

projected to best meet TVA's objectives and to be the most robust and flexible given the key uncertainties mentioned above. This preferred combination or bundle of options is described in *Figure S-2*.

Initial steps that could be taken to implement this long-term plan are described in *Figure S-3*. The short-term action plan (1996-2002) relies heavily on the flexible supply-side options of purchased power and "call" options to purchase power.

FIGURE S-1. **Key Alternative Strategies**

	Strategies							
	D	J	M	O	Q	R	S	T
SUPPLY-SIDE OPTIONS								
Bellefonte Conversion IGCC w/ Coproduction		•		•	•	•	•	•
Combustion Turbines	•	•	•	•	•	•	•	•
IPP Combined Cycle	•	•		•	•	•	•	•
IPP Coal	•							
Purchasing Peaking Capacity					•	•		
TVA Flexible Base Capacity Option					•	•		
TVA Flexible Peaking Capacity Option					•			
TVA Combined Cycle	•					•		
Repower Coal Units w/ Gas Combined Cycle								•
Pulverized Coal			•					•
Pulverized Coal w/ Scrubbers			•					
Clean Coal Technologies	•	•	•	•	•	•	•	•
Landfill & Coalbed Methane		•	•	•	•	•	•	•
Hydro Modernization		•	•	•	•	•	•	•
Wind								•
Compressed Air Energy Storage								•
CUSTOMER SERVICE OPTIONS								
DSM Block 1 (Low Price Options)	•	•	•	•	•	•	•	•
DSM Block 2 (Low Cost Options)				•				
Low-Level Beneficial Electrification						•	•	
Off-System Sales			•		•	•	•	
ENVIRONMENTAL CONTROLS (SO_2)								
Gas Repowering of Selected Fossil Units								•
Add Scrubbers to Selected Fossil Units	•	•	•	•	•	•	•	
Switch to Lower Sulfur Coal	•	•	•	•	•	•	•	•
ENVIRONMENTAL CONTROLS (CO_2)								
Cost Added for Dispatch of Emitting Units								•
Biomass (waste wood) Cofiring (0.3%)		•	•	•	•	•	•	•

Strategies

- D Reference/"No Action"
- J Bellefonte Coproduct/Renewables/IPPs
- M DSM/Off-System Sales
- O Bellefonte Coproduct/More DSM/Off-System Sales
- Q Flexibility w/External Options
- R Flexibility w/Internal Options
- S Low Cost & Rates, Improved Environment
- T Bellefonte Coproduct/Repowering/DSM

FIGURE S-2. Long-Term Plan

This long-term plan is defined to meet key objectives. The plan is organized by supply-side options for the short term (1996 – 2005) and the long term (2006 – 2020), customer service options and actions which hedge key uncertainties.

Develop a preferred portfolio of resource options for the long term from key strategies. Objectives of the portfolio are:

1. Balance costs, rates, environment, debt, and economic development.
2. Provide a robust set of resource options or flexibility to adapt to uncertain load growth, future market prices, changes in environmental regulations, and changes in market regulations to manage risk.

Strategies

- J – Bellefonte Coproduct, Renewables, IPPs
- M – Combined DSM and Off-System Sales
- O – Bellefonte Coproduct, More DSM, More Off-System Sales
- Q – Flexible Strategy with External Options
- R – Flexible Strategy with Internal Options
- S – Low Cost, Low Rates, Improved Environment
- T – Low-Cost Renewables, Low-Price DSM, Repowering, Bellefonte Coproduct Partnership

Options		1996 –2005	2006 –2020
Supply	Peaking	• Combustion turbines, purchases of peak power, and call options on peaking power	• Compressed air energy storage (CAES)
	Base Load	• Call options on base-load power • Improvements to existing hydro system • Combined cycle with pre-siting and engineering • Purchases from independent power producers with and without cogeneration • Combined cycle repowering of coal-fired plants • Renewables—landfill methane and refuse-derived fuel • Coalbed methane • Bellefonte coal gasification and coproducts with partners • Additional coal unit at Shawnee • Improvements in existing system • Nuclear partnership	• Wind turbines • Coal refinery • Cascaded humidified advanced turbine (CHAT) • Integrated gasification combined cycle (IGCC) • Integrated gasification with CHAT (IGCHAT)
Customer Service		• DSM—low price and cost (examples of programs)	• Residential new construction • Commercial and industrial comprehensive finance • Industrial motors
		• Beneficial Electrification (examples of programs)	• Residential heating, air conditioning, and water heating • Commercial cooking • Industrial electrotechnologies
		• Flexible DSM and Beneficial Electrification	
Environmental		• Pursue a flexible strategy of fuel switches, scrubbers • Global climate challenge—improvements to existing system, biomass cofiring	

RESOURCE ALTERNATIVES TO MANAGE RISK

Uncertainty	Options
• Load Growth	• Call options on purchases from external suppliers • Flexible internal supply options • Small modular options—landfill methane, coalbed methane, and distributed resource alternatives • Flexible DSM options
• Natural Gas Prices/Coproduct Prices	• Integrated gasification combined cycle (IGCC) • Integrated gasification cascaded humidified advanced turbine (IGCHAT) • Bellefonte coal gasification with a chemical coproduct
• Environmental Regulation—Air, Water, CO_2 Regulation	• Renewables—wind, landfill methane, biomass • Coalbed methane • Aggressive DSM and beneficial electrification • Natural gas-based resource alternatives

Affected Environment

The study area for Energy Vision 2020 includes the TVA power service area and the Tennessee River watershed. It covers 58 million acres within the 201-county jurisdictions of seven states. The location of a TVA power plant outside the primary study area on the Green River in Kentucky, is also included.

The assessment region for air quality is larger than this study area. There are pollutant emissions originating outside the region, pollutants leaving the area, and pollutant effects such as haze, ozone, and acidic precipitation that TVA recognized as regional issues.

Since Energy Vision 2020 is a regional, strategy-level analysis, the assessments of potential effects were made at a programmatic level, rather than on a site-specific basis.

SOCIOECONOMIC ENVIRONMENT

The population in the power service area was 7.7 million in 1994. The region had an economy of $146 billion in total personal income, 3.6 million people in total non-farm employment, and $175 billion in gross product sales. The region is considerably rural, and the economy depends much more on manufacturing than the nation does as a whole. A large manufacturing base, however, has helped the Tennessee Valley outperform the U.S. economy in recent years.

After the year 2000, the region's growth is projected to slow, as newer manufacturing industries reach maturity. The region's service sector is expected to remain somewhat underdeveloped relative to the nation's. Thus, with the slowing down of manufacturing growth, the whole regional economy is expected to proceed at a slower tempo.

PHYSICAL ENVIRONMENT

Natural resources include regional air, water, and land resources. Overall, regional air and water quality are good and have been steadily improving. Land resources are adequate for siting energy supply facilities.

Regional Air Resources

Good air quality is necessary in order to protect human health and natural resources. Regional compliance with the Federal National Ambient Air Quality Standards serves as a key indicator of how well human health and the environment are protected. These standards set limits on the emissions of six pollutants to protect human health and the environment. Following the enactment of the Clean Air Act of 1970, the overall air quality in the study area has improved as indicated by a decrease of areas that are in non-attainment with the National Ambient Air Quality Standards.

Sulfur Dioxide

For the purpose of Energy Vision 2020, sulfur dioxide (SO_2) is one of the more important pollutants because it produces sulfates that contribute to acidic deposits and fine particles, which can impact natural resources and impair visibility. TVA electric generation accounts for 76 percent of the sulfur dioxide emissions pro-

FIGURE S-3. Short-Term Action Plan

Short-Term Actions—Supply-Side	Milestones
Purchase Call Options	
• Base-Load Coverage - 2001 – 2002	Implement up to 3,000 MW
• Winter and Summer Peaking Coverage - 1998 – 2002	
Hydro Modernization Projects	
• Invest in hydro modernization projects between 1996 – 2007	Achieve 150 MW
Bellefonte Nuclear Plant Conversion to Combined Cycle Plant	
• Converting the Bellefonte Nuclear Plant to a combined cycle plant utilizing natural gas or gasified coal as the primary fuel has been identified as one of the most viable alternatives. Such an alternative provides the opportunity to utilize a substantial portion of the Bellefonte non-nuclear plant equipment. However, there is a degree of uncertainty and market risk associated with this alternative which requires further in-depth engineering and financial examination. Accordingly, TVA will use an outside, independent team of technical and financial experts to assess and develop the Bellefonte conversion strategy more fully over the next 18 to 24 months. During the course of the study, TVA will also pursue the evaluation and development of a demonstration gasification plant with the Department of Energy. In the meantime, the Bellefonte plant and Watts Bar Nuclear Plant Unit 2 will continue in a deferred status. TVA will continue to be receptive should outside entities propose an acceptable financial arrangement to complete these units as nuclear facilities in partnership with TVA.	18 – 24 month study
• Browns Ferry Nuclear Plant Unit 1 will continue in its inoperative status.	
Renewables	
• Implement cost-effective biomass cofiring	
- Cofiring precommercial demonstration runs at existing TVA coal-fired plants	1996
- Initiate first commercial wood waste cofiring project operation	1997
• Investigate biomass energy facilities	1996 – 97
• Implement a flexible wind project	1996 – 97
• Determine coalbed methane resources feasibility	1996 – 97
• Inventory sites suitable for landfill methane	1996
• Initiate 25-kW landfill methane fuel cells pilot	1997 – 98
Additional Capacity Development	
• Acquire three sites and develop preliminary engineering modules suitable for coproduction, combined cycle, combustion turbines, cascaded humidified advanced turbines, and compressed air energy storage	1996 – 1998
• Investigate cogeneration and other unique energy supply arrangements	1996
Implement a Flexible Phase II Acid Rain Strategy	
• Strategy/Plan Definition	1996
• Initiate early implementation options	1996 – 97

FIGURE S-3. **Short-Term Action Plan** *CONTINUED*

Short-Term Actions—Customer Services	Milestones
DEMAND-SIDE SAVINGS	Up to 650 MW - 2002, Up to 2,200 MW - 2010
Residential	
Full Scale Programs	Revisions in Place
• Heat Pump Leasing / Financing	1996–97
• Ground Source Heat Pump Leasing	1996–97
• New Homes Program	1996–97
• Manufactured Housing - New Construction	1996–97
• Residential Self-Audit	Launch 1996–97
• Load Management	Revisions in Place
- Air Conditioners	1996–97
- Water Heaters	1996–97
Flexible Residential Demand-Side Programs for Selected Market Segments	Launch Phase 1
• Efficiency Products Catalog - Mail Order	1997
• Lighting Products Retail Component	1997
• Low Income Program - Site Visit	1997
• Student Self-Audit - Schools Environmental	1997
• Heat Pump Water Heater Initiative	1997
Commercial and Industrial	
Full Scale Programs	Launch 1996–97
• Commercial and Industrial Energy Services	1996–97
- Comprehensive Measures Financing	1996–97
- Commercial New Construction	1996–97
- Commercial Lighting	1996–97
- Commercial Appliances	1996–97
- Industrial Process Energy Efficiency	1996–97
- Industrial High Efficiency Motors	1996–97
• Commercial Cool Storage	1996–97
Flexible Commercial and Industrial Programs	Launch Phase 1
• Commercial Group Load Curtailment	1997
• Commercial Rooftop Cool Storage Program	1997
BENEFICIAL ELECTRIFICATION	
Residential	
• HVAC and Water Heating applications to improve consumer value	1996–97
• Initiate Flexible Security Lighting and Lawn Mower Programs	Launch 1997
Commercial and Industrial	
• Commercial Space Conditioning and Water Heating	Launch 1996–97
• Commercial Cooking and Security Lighting	Launch 1996–97
• Industrial Electrification Programs for Processing Heating, Food Processing, and Environmental Technologies	Launch 1996–97
• Flexible Industrial Electrification Options for Curing & Drying applications and Textile processes	Launch Phase 1 - 1997
General Research and Development	
• Develop telecommunication supported demand-side management programs	Launch 1996
• End-use renewables, market transformation, load management new technologies, targeted distributed generation, photovoltaics, electric vehicles	Launch 1996–97

duced by human activity within the region or roughly one-quarter of the total sulfur dioxide emissions in the region. Since 1976, concentrations of this pollutant have been reduced 40 percent in the TVA study area; TVA's sulfur dioxide emissions have been reduced approximately 70 percent since 1976.

TVA's contribution to regional visibility impairment is primarily associated with fine sulfate particles. TVA sulfur dioxide emissions have a relatively small contribution to visibility impairment in the Great Smoky Mountains National Park because sulfate production from sulfur dioxide in the atmosphere is slow. Areas further downwind from TVA sources are more likely to benefit from TVA emission reductions than will southern Appalachia.

The Environmental Protection Agency is considering a new standard for short-term exposure to sulfur dioxide because short-duration high concentration exposures can cause short-term problems for some sensitive individuals.

Nitrogen Oxides

Nitrogen oxides (NO_X) emissions contribute to the formation of acid rain and ozone. Nitrogen oxides emissions from TVA power plants accounted for 36 percent of total human-produced nitrogen oxides in the study area. Emissions from TVA facilities will be reduced as TVA installs pollution control equipment to meet the 1990 Clean Air Act Amendments. However, overall nitrogen oxides emissions in the region may not decline due to expected increases in motor vehicle nitrogen oxides emissions.

Ozone

Ozone is produced in the presence of sunlight from the primary emissions of nitrogen oxides and volatile organic compounds. Human health impacts are most severe when ozone concentrations are high. At sufficient concentrations, ozone can also harm vegetation and some building materials. Nashville, Tennessee is the only metropolitan area in the TVA Region classified as a non-attainment area for the ozone standard. Adverse resource impacts have been noted in the Class I parks and wilderness areas, but the significance of these impacts is not well understood and is undergoing extensive analysis through the Southern Appalachian Mountain Initiative (see Cooperative Research and Assessment Programs in Volume 2, Technical Document 1, Comprehensive Affective Environment).

The Environmental Protection Agency is considering revisions to the standards to better address impacts from extended exposures to ozone and cumulative impacts on crops and forests. In addition, it is investigating the effects of inter-regional transport of ozone or ozone precursors on ozone attainment in the Northeast U.S. and other urban areas. Reductions in allowable nitrogen oxides emissions may be needed to help reduce ozone levels. This has important implications for TVA because coal-fired plants are a source of nitrogen oxides emissions.

Water Quality

Water quality is critical to protecting, preserving, and restoring finite water resources. These resources include aquatic ecosystems and aquatic life, recreation, and domestic and industrial water supplies. Discharges from sewage treatment facilities, industrial plants, and coal-fired and nuclear power plants are regulated by state agencies and the Environmental Protection Agency.

Coal-fired and nuclear power plants use water to produce steam and for cooling purposes, and release heated water into surface water (e.g., rivers). TVA plants meet the temperature requirements stated on their permits, either by plant design or by limiting operations to be in compliance.

Another water quality issue is non-point source pollutants—run-off from agriculture, urban uses, and mined land—that results in stream or lake pollution. Pollutant concentrations in the air, and subsequently in rain, can also affect surface water and aquatic habitats. The potential concentrations of toxic substances from the mining of coal and coal-fired plant operations can also be a water quality issue and affect future resource decisions.

Another water quality concern is low dissolved oxygen levels in stream reaches below TVA dams. Damming the rivers and releasing oxygen-consuming pollutants are the principal causes of low-dissolved oxygen levels in the TVA reservoir system. TVA has initiated a program to improve dissolved oxygen levels in water discharged from its dams. TVA addresses this problem further in its 1990 environmental impact statement, *Tennessee River and Reservoir System Operation and Planning Review.*

Land Use

Land use includes management of the natural ecosystem, agriculture, forestry, urban and industrial use, and recreational use. Minimizing impacts on soil, groundwater, wildlife, sensitive or threatened ecosystems, threatened and endangered species, cultural resources, and terrestrial environments, such as wetlands and forests, is important in order to support and preserve these uses.

TVA affects land resources through site selection for power plants, transmission lines, fuel procurement, air emissions, radioactive waste management, and solid waste management. Most land resource impacts are site-specific in nature, and therefore are not addressed in detail in this document. Subsequent site-specific reviews will consider such impacts. The amount of land taken up by the final seven selected and "No Action" strategies is identified.

Wastes

Wastes are also an environmental concern. Combustion of pulverized coal in power plant boilers produces solid wastes such as fly ash and bottom ash. Depending on quality and market conditions, these wastes can be sold and used to make several commercial products (e.g., blocks, paving). TVA sold almost 20 percent of the nearly 6 million tons of ash it produced in 1994.

Nuclear waste is an issue that was raised by the public and is addressed in Energy Vision 2020. Almost all (99 percent) of high-level waste from commercial nuclear plants is used fuel that has released most of its energy. After removal from the reactor, spent fuel is initially stored at nuclear plant sites in steel-lined concrete vaults filled with water, or in dry, above-ground concrete or steel containers. Spent fuel has been stored safely since the 1950s.

TVA plans to continue to store spent nuclear fuel on-site at plant locations where generated until the Department of Energy accepts physical custody by shipment off-site to a designated location. Current spent fuel storage capacity is sufficient at Sequoyah Nuclear Plant until 2003, at Browns Ferry Nuclear Plant until 2007, at Watts Bar Nuclear Plant until 2009, and at Bellefonte Nuclear Plant until at least 2020. TVA plans to continue to use the Barnwell facility for low-level waste disposal until the Southeast Compact Commission's North Carolina facility is completed. Should either or both of these facilities close unexpectly, low-level radioactive waste will be stored in on-site facilities at the TVA nuclear plants.

Environmental Consequences

One of the most important conclusions to be drawn from TVA's Energy Vision 2020 evaluation is that TVA's existing coal-fired units are responsible for most of TVA's contribution to the identified environmental impacts. TVA's contribution to many environmental problems, however, has been substantially reduced over the years and is being reduced still further.

Energy Vision 2020 focuses primarily on what additional energy resource options, if any, should be added to TVA's system in the future. TVA's final strategies were compared to the "No Action" alternative—Reference Strategy D—for several key environmental measures.

AIR QUALITY IMPACTS

In addition to quantifying (measuring) the emissions of the most important pollutants, TVA developed quantitative approaches to measure four important air-related impacts and integrate them with other criteria: They include:

- Human Health Through Inhalation
- Visibility Impairment
- Forest and Crop Productivity
- Materials Damage

A number of conclusions can be derived from Energy Vision 2020's assessment of potential air resource impacts:

- Although coal usage is projected to increase under all of TVA's alternative strategies, sulfur dioxide and nitrogen dioxides emissions are expected to decrease compared to 1995 levels.
- Sulfur dioxide emissions are projected to decrease from 1995 levels by 40-50 percent in 2005 and 51-57 percent in 2020, depending on the strategy.

- Nitrogen oxides emissions are projected to decrease by 10-20 percent by 2000, then increase but still remain some 4-16 percent below 1995 levels.
- For all alternative strategies, absolute decreases in TVA's contributions to human health impacts, visibility impairment, forest and crop productivity, and materials degradation are expected.
- TVA's contribution to ozone-related impacts is expected to be reduced under all strategies, but TVA's reductions are likely to be offset by emission increases elsewhere in the region. (Mobile source emissions are projected to increase substantially.)
- Among the final strategies, only Strategy D (the reference strategy) and Strategy T (including low-cost renewables) show a noticeable difference in air resource impacts. The reference or "No Action" strategy uses the most coal and has greater impacts for most environmental categories. Strategy T repowers several existing coal-fired units and uses the most natural gas and renewable resources. This results in a reduction in TVA's contribution to most environmental impacts ranging from 9 to 13 percent. However, land resource impacts increase.
- Greenhouse gas emissions are expected to increase in total during the planning period but compared to the expected increase associated with the reference strategy would be reduced by 7-13 percent. Although total emissions would increase, greenhouse gas emissions (as reflected by equivalent carbon dioxide emissions) per kilowatt-hour actually decline. This means that the TVA system would be producing electricity in a more environmentally efficient way.

POTENTIAL WATER RESOURCE IMPACTS

Three water-quality impacts were considered:

- Human health by ingestion
- Water supply and waste assimilation
- Fish, aquatic life, and aquatic biodiversity

A number of conclusions can be derived from Energy Vision 2020's assessment of potential water resource impacts.

There are only slight differences among TVA's final seven strategies and reference strategy for most water resource impacts. Since less coal is burned under Strategy T (low-cost renewables), it shows the best performance for water resource quality.

The effects of damming rivers and operating the existing hydroelectric units is responsible for the more important water resource impacts. However, since no new dams are proposed in the final strategies or the reference strategy, this impact is the same across all strategies.

Increasing the capacity of TVA's existing hydroelectric plants is environmentally beneficial. This produces new capacity without constructing new plants and allows the use of new turbine designs, which add oxygen into the water as it flows through the turbine. This increases dissolved oxygen and helps combat the low dissolved oxygen problem that exists today below a number of TVA dams.

Because TVA's existing coal-fired plants contribute to water pollution, cost-effective repowering of selected less-efficient coal-fired units provides some of the best options for maintaining water quality.

Repowering or adding capacity at any existing facility is preferable from a water resource impact perspective because it lessens the risk of impacts to those resources.

POTENTIAL LAND RESOURCE IMPACTS

Although land use impacts tend to be site-specific, certain conclusions or observations can be made at this programmatic level of review based on the generic attributes of various energy resource options.

Resource options that involve expansions at existing plants or the repowering of existing units have little or no land resource impacts.

From the standpoint of land consumption, Strategy T uses the most land. This is due primarily to the extensive acreage that is needed to support coalbed methane recovery systems and wind turbines.

The 2,000 megawatts of wind energy capacity in Strategy T is estimated to require 50,000 acres of land at high elevations where the wind resource tends to be found in or close to the TVA region. Wind turbines are also visually prominent and would have some of the most important aesthetic impacts among the various resource options.

All of TVA's final proposed strategies, including the reference strategy, expand TVA's use of coal. Coal mining and coal combustion waste disposal are two indirect land uses that have undesirable land resource impacts. Total coal use rises about 35 percent in most of the final proposed strategies compared to current coal use. Only Strategy T is noticeably different, using about 12 percent less coal than the reference or "No Action" strategy.

There is sufficient land in the TVA region to allow energy resource options to be put in place without impacting sensitive land resources such as wetlands or endangered species. Land resources should not be a constraint on putting any of the energy resource options identified in TVA's final proposed strategies in place, with the possible exception of wind turbines.

Chapter One

Overview and Objectives

Chapter One: Overview and Objectives

TVA is the largest producer of public power in the United States. With a generating capacity of 28,000 megawatts, TVA provides wholesale power to 160 distributors, and it directly sells power to over 60 large industrial and federal customers. Together with the distributors, TVA's power system serves nearly 8 million people in a 7-state region that covers some 80,000 square miles.

Like other utilities, TVA is expecting important changes in the relationship between utilities and their customers. Consumer, legislative, and utility actions across the nation are changing the electric utility industry from a regulated monopoly to a more competitive marketplace. TVA is at the forefront of this change and welcomes the opportunity for growth with improved, responsive services to best meet the needs of its current and new customers.

TVA's integrated resource plan--Energy Vision 2020--will guide TVA in entering this competitive marketplace by identifying the best energy resource choices for the current and future generation of consumers.

Energy Vision 2020 goes beyond simply providing for competitively priced power. The plan, built with extensive public involvement, also considers economic development and the environment as part of TVA's mandate to be a leader in total resource development. Innovative approaches to meeting the demand for energy through new technologies and business arrangements are among the means TVA will use to achieve its goals: competitively priced power, opportunities for economic growth, and a quality environment rich in natural resources.

In the process of developing Energy Vision 2020, several issues developed that are important to TVA and its customers. These include TVA's debt; competition, including the legislative restrictions on TVA sales (e.g., the fence); electric rates; privatization of TVA; and TVA's nuclear program, including the consequences of completion of Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3. Each of these issues is addressed in Energy Vision 2020.

This Chapter Includes:

- Introduction to Energy Vision 2020
- A Brief Description of TVA
- Purpose of and Need for Integrated Resource Planning
- Energy Vision 2020 Objectives
- The Changing Electric Utility Industry
- Public Participation in Energy Vision 2020

Overview and Objectives

Introduction to Energy Vision 2020

Energy Vision 2020 is TVA's roadmap for meeting the energy needs of its customers during the next 25 years with economical and environmentally sound energy choices. These are important challenges for TVA, which is the largest single producer of electricity in the United States. With a generating capacity of 28,000 megawatts, TVA provides wholesale power to 160 distributors and directly serves 60 large industrial and federal customers. In partnership with the distributors, the TVA power system serves 7.7 million people in an 80,000-square-mile area that covers parts of seven southeastern states.

Today, TVA is looking ahead to the 21st century, to answer the questions necessary to best serve the future needs of Valley residents: How much electricity will the Tennessee Valley need in coming years? What is the most economical and environmentally acceptable way to provide that energy?

TVA is expecting important changes in the relationships between utilities and their customers. Consumer, legislative, and utility actions across the nation are changing the electric utility industry from a regulated monopoly to a competitive marketplace. TVA is at the forefront of this change and welcomes the opportunity for growth and improved service and responsiveness to the needs of its current and new customers. By identifying the best energy choices for current and future consumers, Energy Vision 2020 will guide TVA as it enters this competitive marketplace.

Moreover, Energy Vision 2020 goes beyond the issue of how TVA can provide competitively priced power. The plan also considers economic development and the environment as part of TVA's mandate to be a leader in total resource development. Innovative approaches to meeting the demand for energy through new technologies and business arrangements are the means by which TVA can provide competitively priced power, opportunities for economic growth, and a quality environment rich in natural resources.

The TVA Board has already taken several strategic actions in part based on information and analyses performed in conjunction with Energy Vision 2020. These are:

- Reversed TVA policy on nuclear plant construction.
- Placed an internal limit on new capital debt and announced a debt reduction program.
- Kept TVA's electric rates steady for a ninth consecutive year.
- Introduced TVA to the global energy market through international bond offerings.
- Commissioned a major study to identify strategic actions that will strengthen TVA's position in an open marketplace.

The result of these efforts is that TVA's self-supporting power system is financially strong. TVA's electric power production and operating costs are com-

petitive with utilities in the regional market. The same is true for the electric prices paid by consumers in the TVA service area.

Energy Vision 2020 provides the TVA Board with a flexible energy supply plan that will help guide the strategic actions necessary for TVA to serve its customers efficiently, and to compete and succeed in the electric utility marketplace of the future.

Launched in the winter of 1994, Energy Vision 2020 includes an unprecedented effort by TVA to involve the public in TVA's energy planning process. Environmental, consumer, and energy industry representatives were appointed to a citizen group to provide input on the formulation of the plan, and public meetings were held throughout the TVA service area to gather public comments and suggestions. Interviews were also conducted with elected officials and opinion leaders. The open process produced a stronger partnership with the more than 7.7 million people who use the electricity produced by TVA.

Energy Vision 2020 identified a viable mix of conservation programs and options for power plant operations that will be used to responsibly and economically provide energy for sustainable economic growth. For all resource options, the environmental consequences and economic impacts were considered as part of TVA's effort to encourage sustainable economic growth in the region. Strong public support for various options, such as demand-side management, also was considered.

Overall the key recommendations of Energy Vision 2020 are:

- Invest in up to 3,000 megawatts of flexible purchases of power
- Convert Bellefonte to an alternative fuel source such as natural gas or coal
- Implement up to 1,450 megawatts of energy efficiency and load management
- Research and develop renewable energy resources—wind, biomass, solar photovoltaics

Additional recommendations, which the TVA Board of Directors has asked the staff to include, are:

- Begin additional flexible demand-side management programs with a potential of 750 megawatts
- Investigate the development of a flexible wind project, a biomass refinery, and a combined garbage and biomass energy facility

Because TVA has a unique mission to supply electric power and encourage sustainable economic development in its service region, Energy Vision 2020 has the flexibility to shift priorities as the marketplace evolves and changes influence the viability of power supply options. When changes in energy options are necessary, TVA will remain focused on making economical and environmentally sound energy choices.

A Brief Description of TVA

The Tennessee Valley Authority (TVA) was established by an act of Congress in 1933 as a federal corporation to develop the natural resources of the Tennessee Valley region and to improve the lives of the region's population, which was being ravaged by the Great Depression, flooding along the Tennessee River, and erosion of the region's natural resources. From its beginning, TVA's challenge has been to look at economic development and natural resource issues in a comprehensive fashion. TVA has also been expected to demonstrate the unique strengths of "a corporation clothed with the power of government but possessed of the flexibility and initiative of a private enterprise." TVA is managed by a three-member Board of Directors appointed by the President.

BUILDING A POWER SYSTEM

By harnessing the destructive potential of the Tennessee River, TVA created a major tool for improving the quality of life in the Tennessee Valley region—abundant and inexpensive electricity. In 1933, only 3 out of 100 farms in the area had electric lights. During its early years, TVA met the demand for power through its series of hydroelectric dams and completed 12 hydroelectric dams during World War II to provide a massive supply of electricity to meet critical wartime industries' demand, such as aluminum production.

By the early 1950s, however, TVA discovered that demand was quickly outstripping the capacity of its dams and its Watts Bar Fossil Plant, which was completed in 1945. During the next 20 years, TVA built 11 large coal-fired generating plants to meet the region's growing needs. TVA advanced technology by building the largest, first-of-a-kind coal-fired units in the world. The decade of the 1960s brought even greater growth to the region. To meet this anticipated need for more power, TVA expanded its generating resources through an ambitious program of nuclear plant construction.

Despite this growth program, TVA's electric rates remained among the lowest in the nation throughout the 1960s. However, the 1970s brought unprecedented change to the entire utility industry's ability to control costs and rates charged to customers. The change was slow at first—starting with the oil embargo in 1973—and then accelerated during the late 1970s. Coal costs and the costs of constructing nuclear units skyrocketed, forcing TVA and most other electric utilities to increase their rates.

As energy costs across the nation continued to climb in the late 1970s and early 1980s, TVA introduced programs to encourage customers to reduce their demand for electricity. These programs, focusing on energy conservation and reducing peak electric loads, worked in concert with TVA's existing generating resources to meet consumer energy needs.

TODAY'S POWER SYSTEM

Today, TVA is one of the largest producers of electricity in the United States, generating 4 to 5 percent of all the electricity in the nation. TVA's power system serves almost 8 million people in a 7-state region encompassing some 80,000 square miles *(Figure 1-1)*.

With a generating capacity of 28,000 megawatts, TVA's electricity is distributed to homes and businesses through a network of 160 power distributors, including municipally owned utilities and electric cooperatives. In addition, TVA sells power directly to about 60 large industrial customers and government installations.

TVA's power system includes 5 nuclear generating units, 12 coal-fired plants (1 mothballed), 29 hydroelectric dams, 48 combustion turbine units, and 1 pumped-storage facility. The system is linked by approximately 16,000 miles of transmission lines throughout the 7-state region. TVA's electric system is self-financed, as are other electric utility systems.

Today, TVA is looking ahead to the 21st century, to answer the questions necessary to best serve the future needs of Valley residents: How much electricity will the Tennessee Valley need in coming years? What is the most economical and environmentally acceptable way to provide that power?

One way TVA is answering these questions is by developing this integrated resource plan, called Energy Vision 2020. This integrated resource plan identifies resources to meet the electricity and energy service needs of TVA's customers during the next 25 years, through the year 2020.

FIGURE 1-1. **TVA's Power System**

TVA's power system covers some 80,000 square miles in a 7-state region.

Purpose of and Need for Integrated Resource Planning

As with any business, it makes good sense for TVA to do long-range planning. Integrated resource planning helps electric utilities choose the best resource options to generate electricity and other options to meet customer expectations for energy services. Increasing competition, changing technologies, and environmental concerns are among the many issues utilities must consider when developing their plans.

The size of TVA's power system and its influence on the Tennessee Valley's economy make integrated

resource planning especially important. The decisions TVA makes will significantly affect the quality of life for millions of residents, as well as the competitive success of businesses and industries in the Valley.

The National Energy Policy Act of 1992 established requirements that TVA must meet in performing least-cost planning. The focus of a least-cost plan is to provide energy services to customers at the lowest total cost over the long run. TVA's integrated resource planning process, however, goes well beyond conventional least-cost planning. Energy Vision 2020 evaluates the effects of resource options on the Tennessee Valley's environment and its economy, as well as on TVA's future prices of electric energy and future level of debt.

This Act also requires TVA to provide distributors of TVA power an opportunity to participate in the integrated resource planning process. Furthermore, the public must have an opportunity to comment before TVA selects major new energy resources. Thus, Energy Vision 2020 reflects the results of customer participation and extensive public involvement, including the preparation of an environmental impact statement under the National Environmental Policy Act.

TVA has integrated the components of a programmatic environmental impact statement into the overall integrated resource planning process and preferred plan. A programmatic level environmental impact statement was developed as opposed to a project or site-specific environmental impact statement because of the broad strategic nature of integrated resource planning.

TVA used the National Environmental Policy Act guidelines and integrated an environmental impact statement into Energy Vision 2020 in several ways. First, TVA used multi-attribute trade-off analysis, which is recognized as an effective way of quantitatively comparing resource planning issues.

Second, TVA has involved the public extensively in determining the scope of the analysis for Energy Vision 2020. TVA also obtained wide response on its draft energy resource plan. In developing the public participation process, TVA began with the National Environmental Policy Act guidelines, but TVA's public involvement process goes well beyond the minimum requirements of this Act.

Incorporating a programmatic environmental impact statement into Energy Vision 2020 provides TVA with a broad analytical foundation to assist in the development of project-specific environmental reviews. Appropriate project-specific reviews will be conducted for energy resource options that TVA may eventually put in place under its selected strategy.

Energy Vision 2020 Objectives

The ultimate objective of Energy Vision 2020 is to develop a resource plan that will enhance TVA's competitiveness in a manner that meets or exceeds its customers' expectations. This objective is consistent with TVA's four broad strategic goals set by the TVA Board of Directors in 1995: being customer driven, environmentally responsible, growth oriented, and employee sensitive. The Board also established a new vision for TVA that calls for the corporation

to be the recognized world leader in providing energy and related services, independently and in alliances with others, for society's global needs.

Competitiveness, as defined in Energy Vision 2020, goes beyond being the lowest-cost electricity producer. It also means that TVA must be competitive in the quality and value of its electric services delivered to its customers. Competitiveness is also measured in terms of TVA's contribution to economic development in the region and the region's environmental quality.

TVA modified the typical integrated resource planning process to better address the implications of an increasingly competitive environment. TVA also incorporated many more opportunities for public involvement that included regular meetings with a group of stakeholders who worked closely with TVA in reviewing and developing the plan. (Stakeholders are customers, consumers, members of government, and any others who may have an interest in, or be affected by, a utility's resource decisions.)

The Changing Electric Utility Industry

Consumer, legislative, and utility actions are changing the electric utility industry from a regulated monopoly to a more competitive industry. Similar changes have taken place in the airline, natural gas, and telecommunications industries over the past decade. In Energy Vision 2020, TVA considers four key elements of this changing structure:

1. The characteristics of a more competitive environment
2. TVA's current position in the market
3. The uncertainty in future power markets
4. Planning alternative energy resources for the future market

THE COMPETITIVE CHANGES IN THE ELECTRIC UTILITY INDUSTRY

The initial step toward fostering competition in the electric utility industry is focused on changing the ground rules on access to the national grid of independent transmission systems that connects utilities with their customers and with each other. The proposed change would provide what is referred to in the industry as "open access."

Historically, TVA and regulated electric utilities have had well-defined, protected markets or service areas. Such markets also brought the responsibility of meeting the demands for electricity within utility service areas. Utilities have had primary control over their transmission systems, choosing whose power they purchase for resale to their customers, whose power they will transport (or "wheel") through their service area, and how much they will charge for such "wheeling" services.

Open access is defined by the provisions of the National Energy Policy Act of 1992 and by the proposed implementing regulations currently under review by the Federal Energy Regulatory Commission. The initial thrust of the proposed open access provisions is to provide wholesale customers and suppliers access to virtually any part of the nation's transmission system. It is believed

that under open access, competing utilities will be able to make better use of existing generating facilities, bring more cost-effective options to the market, and provide electric utilities and their customers with lower cost electricity.

Implementation of wholesale open access is unfolding throughout the nation. Utilities that own transmission systems are starting to restructure their rates and service agreements to allow open access, while protecting the best interests of their existing customers. Utilities with and without transmission facilities are searching for opportunities to make short- and long-term power supply arrangements with the lowest-cost suppliers to meet their existing and future customer electricity service requirements.

The Potential Impacts on TVA

To understand the potential impacts of open access on TVA, it is important to understand the "fence." In 1959, Congress amended the TVA Act to allow TVA to use power revenues to finance future expansion of its generation and transmission facilities. Although the amendment passed, there was significant resistance from investor-owned electric utilities that feared the competitive threat of TVA. To resolve this concern, Congress limited TVA's market to its existing service area at that time and restricted TVA's power exchange arrangements to 13 other utilities. These restrictions are generally known as the "fence."

The authors of the National Energy Policy Act of 1992 recognized that the intent of the wholesale access provisions could have a uniquely negative impact on TVA and its customers. TVA sells approximately 80 percent of the power it generates to wholesale customers (e.g., municipal utilities and cooperatives), compared to an average of 3 to 4 percent for other U.S. electric utilities. Because of this and TVA's limited ability to sell power outside its existing service area, the National Energy Policy Act of 1992 gave special protection to TVA through an arrangement called an "anti-cherry picking" amendment.

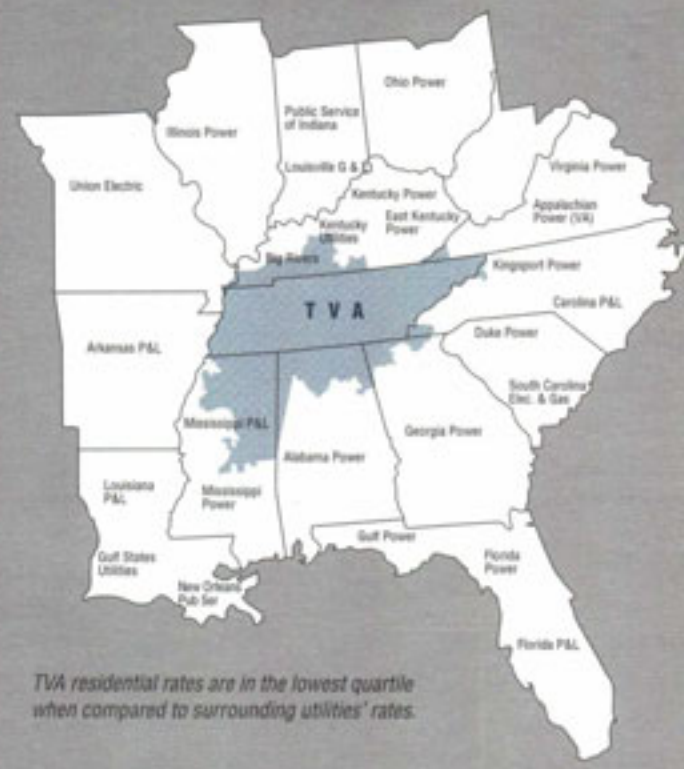
The anti-cherry picking provision exempts TVA from being required to transport power from another utility to TVA's wholesale customers. This reduces the risk of other power suppliers "cherry-picking" selected wholesale customers, who are relatively inexpensive to serve, and leaving TVA's remaining distributors and directly served customers with the large financial burden of supporting an underutilized power system.

TVA also recognizes that many of its customers may want the choice of shopping for energy services in a competitive marketplace. TVA has recently completed a study of the potential ramifications of eliminating the fence. This study, "The Ties That Bind: TVA in a Competitive Electric Market", has concluded that the fence provisions should be changed in two phases. Phase 1 would allow TVA to conduct all conventional types of wholesale business with utilities bordering TVA and beyond. During Phase 1, TVA would not be allowed unbalanced access to traditional non-profit wholesale customers of neighboring utilities with which TVA's relationship has been severely restricted since 1959 and which cannot serve in the TVA territory under the TVA Act. Phase 2 would remove the fence entirely, giving TVA's current wholesale cus-

FIGURE 1-2. **1993 Residential Rate Comparison**

Kentucky Utilities	4.4 ¢/kWh
Kentucky Power	4.9
Kingsport Power	5.1
Appalachian Power (VA)	5.7
Public Service of Indiana	5.8
TVA	**5.9**
Louisville Gas & Electric	6.0
Mississippi Power	6.2
Ohio Power	6.3
East Kentucky Power	6.4 [1]
Gulf Power	6.6
Big Rivers	6.9
South Carolina Elec & Gas	7.1
Alabama Power	7.2
Duke Power	7.3
Union Electric	7.5
Georgia Power	7.8
Louisiana P&L	7.8
Florida Power	7.9
New Orleans Pub Ser	7.9
Florida P&L	8.1
Gulf States Utilities	8.2
Carolina P&L	8.3
Virginia Power	8.6
Mississippi P&L	8.6
Arkansas P&L	9.3
Illinois Power	10.2

[1] Using South Kentucky REC Corp. as representative of East Kentucky Power Coop



TVA residential rates are in the lowest quartile when compared to surrounding utilities' rates.

Source: DOE 826, REA Forms 7 & 12, and TVA Electric Sales Statistics

tomers in the Valley free market access and, at the same time, permitting TVA to seek markets outside the Valley on the same basis that competitors could enter the Valley to provide service.

TVA's Competitive Position in the Market

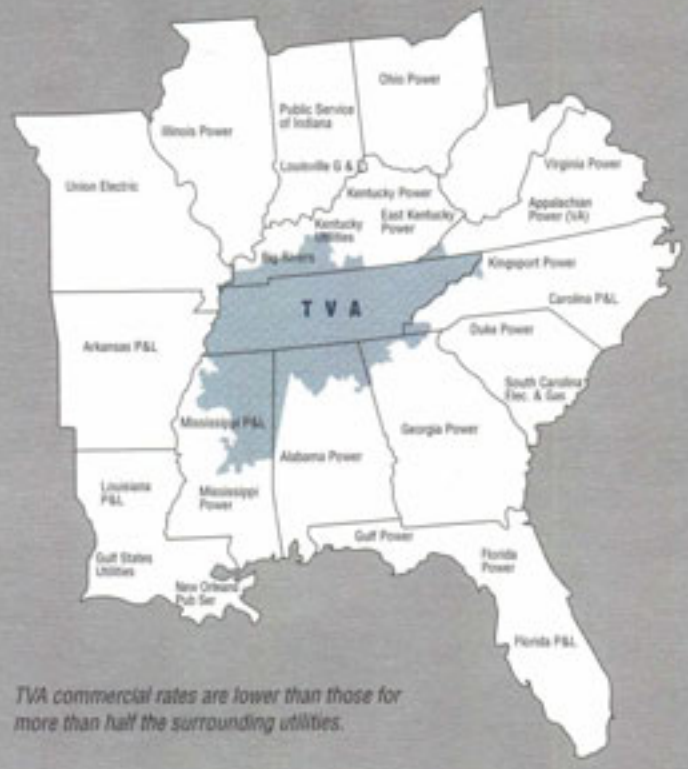
The 1995 report "The Ties that Bind" found that TVA's electric power production and operating costs are in the lower end of the range of utilities in the huge regional market. TVA's electric rates are very competitive with those of other utilities. Comparisons of TVA's rates with surrounding utilities' rates for residential, commercial, and industrial customers are shown in *Figures 1-2, 1-3,* and *1-4.*

Overall, TVA is ranked 30 in a comparison of 130 utilities in the nation from the standpoint of lowest average rates. On a regional basis, TVA's residential electric rates are lower than most surrounding utilities' residential rates. Of the 27 Southeastern utilities listed in *Figure 1-2,* TVA's residential rates rank as the sixth lowest. Likewise, TVA's commercial and industrial rates are below the median level of other utilities' rates, as shown in *Figures 1-3* and *1-4.* TVA's rates compare even more favorably on a national basis. The inte-

FIGURE 1-3. **1993 Commercial Rate Comparison**

Kentucky Utilities	4.3 ¢/kWh
Public Service of Indiana	4.6
Kingsport Power	5.1
Kentucky Power	5.2
Appalachian Power (VA)	5.3
Ohio Power	5.5
Louisville Gas & Electric	5.6
Gulf Power	5.6
South Carolina Elec. & Gas	5.6
Florida Power	5.8
TVA	**5.9**
Mississippi Power	6.0
Duke Power	6.0
Virginia Power	6.2
Union Electric	6.3
Florida P&L	6.8
East Kentucky Power	6.8 [1]
Big Rivers	6.9
Carolina P&L	6.9
Alabama Power	6.9
Gulf States Utilities	7.3
Georgia Power	7.4
Arkansas P&L	7.6
Louisiana P&L	7.8
Illinois Power	8.3
New Orleans Pub Ser	8.4
Mississippi P&L	8.6

[1] Using South Kentucky REC Corp. as representative of East Kentucky Power Coop



TVA commercial rates are lower than those for more than half the surrounding utilities.

Source: DOE 826, REA Forms 7 & 12, and TVA Electric Sales Statistics

grated resource plan proposed in this report is intended to improve TVA's competitive position with regard to rates in the future.

THE UNCERTAINTY IN FUTURE POWER MARKETS

As regulatory changes occur, the impacts on different parts of TVA's business will probably vary significantly. The generation system is likely to enter an era of tough price competition in which electricity will be bought and sold like other commodities, such as wheat, corn, and natural gas. The transmission system most likely will be a regulated common carrier providing open access under published tariffs or rates. Distributors of TVA power may find themselves in a market similar to the long distance telephone industry, with competition based both on price and value added services.

In an open access environment, TVA generating plants will compete primarily on a price basis. In any time period, plants with lower costs will operate, and those with higher costs will sit idle, earning no revenue. In the current regulated environment, prices are set by a fairly standard analysis of a utility's invested capital costs and operating expenses. In contrast, the price of electricity in an open market will be set by the balance between supply and demand,

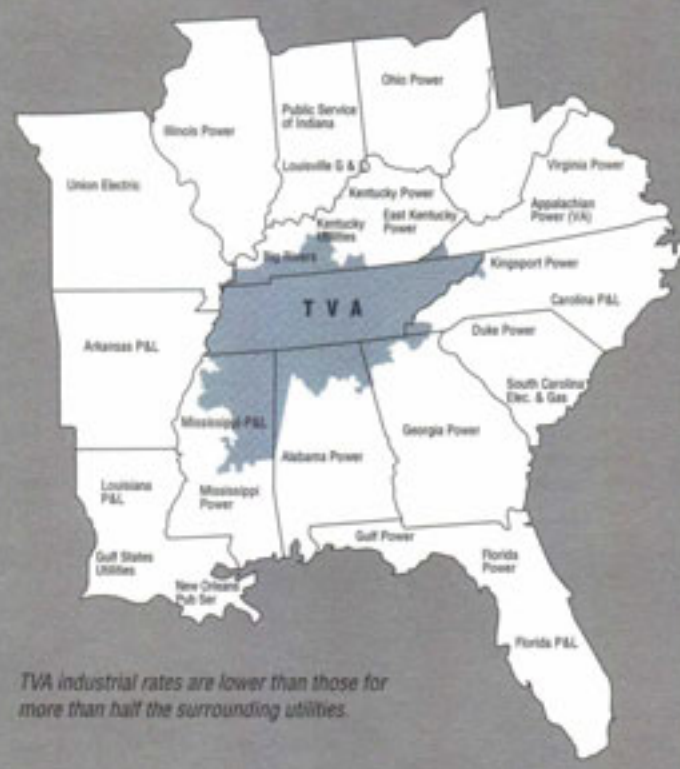
FIGURE 1-4. **1993 Industrial Rate Comparison**

Big Rivers	3.0 ¢/kWh [1]
Ohio Power	3.2
Kentucky Utilities	3.3
Kentucky Power	3.3
Public Service of Indiana	3.4
Kingsport Power	3.5
Mississippi Power	3.6
Louisville Gas & Electric	3.8
Appalachian Power (VA)	3.8
South Carolina Elec. & Gas	3.9
TVA	**3.9** [2]
Louisiana P&L	4.1
Duke Power	4.3
Gulf Power	4.3
Illinois Power	4.4
Virginia Power	4.4
Alabama Power	4.5
Gulf States Utilities	4.6
Georgia Power	4.7
Florida Power	4.8
Union Electric	5.2
New Orleans Pub Ser	5.3
Florida P&L	5.4
Carolina P&L	5.5
East Kentucky Power Coop	5.5 [3]
Arkansas P&L	6.0
Mississippi P&L	6.6

[1] Non-Aluminum Industrial is 3.9 cents/kWh

[2] TVA's directly served industrial cost is 3.0 cents/kWh and the distributor served industrial cost is 4.6 cents/kWh

[3] Using South Kentucky REC Corp. as representative of East Kentucky Power Coop



TVA industrial rates are lower than those for more than half the surrounding utilities.

Source: DOE 826, REA Forms 7 & 12, and TVA Electric Sales Statistics

given transmission constraints. Market prices will vary by hour, day, and season as electricity demand, plant availability, and costs vary across the nation.

In such an environment, a utility's decision to invest in generating facilities, or other services, will depend on whether the utility has the ability to bring the resource to market and make a profit. In an openly competitive environment, a utility's market for generation will no longer be within a well-defined service territory, but will be as large as the transmission cost of electricity will allow.

With retail open access, which is being evaluated as part of electric industry restructuring proposals by state regulatory commissions in some states, such as California, retail consumers will be allowed to choose from whom they will purchase electricity. This will create additional uncertainty in the power markets.

TVA has incorporated assumptions about competition into its electricity demand forecasts. In the range of load forecasts, TVA has identified the potential for the gain or loss of both wholesale and retail customers. These gains or losses are somewhat dependent on changes in future industry regulations such as open access, legislation on the TVA "fence," and potential competition among power suppliers. For more detailed information about TVA's load forecasts, see Chapter 6 and Volume 2, Technical Document 5, Load Forecast.

PLANNING ALTERNATIVE ENERGY RESOURCES FOR A COMPETITIVE MARKET

The increasingly competitive nature of the electric utility industry requires all utilities to consider more carefully the full range of resource alternatives. Sales projections may no longer be based on a load forecast for a protected territory or a given geographic area. Future resources no longer will be built and operated only by a designated utility. A quickly changing marketplace with non-traditional participants will offer a broader range of choices to utility customers.

In Energy Vision 2020, TVA has identified three different types of resource options well suited to address competition: (1) bulk power purchases and sales from other utilities, (2) purchases of power from cogenerators and independent power producers, and (3) market-based alternatives, such as call options on future capacity additions. These resource options are discussed in more detail in Chapter 7.

Public Participation in Energy Vision 2020

In addition to using state-of-the-art methods for analyzing energy resource options, Energy Vision 2020 provided significant opportunities for public participation. TVA purposefully sought to incorporate a broad base of public input into the scope of the planning process. Key analytical elements such as evaluation criteria, resource options, and uncertainties were drawn from public comments during the scoping period. This effort to obtain widespread public review and input was continued after release of the draft plan and environmental impact statement on July 26, 1995.

TECHNIQUES FOR COLLECTING PUBLIC INPUT DURING SCOPING PERIOD

TVA used four techniques to collect public input during the scoping period: (1) "opinion leader" interviews, (2) public meetings, (3) a stakeholders' review group, and (4) written comments.

Opinion Leader Interviews

During the summer of 1994, TVA conducted one-on-one interviews with 96 opinion leaders in the Tennessee Valley. These included elected officials, TVA customers, and other individuals who occupy leadership positions in Valley communities, industries, businesses, and organizations. They were asked to share their views on goals and issues they believe should be important to TVA as it plans to provide future energy services.

Public Meetings During Scoping

From July 28 through November 3, 1994, TVA held 12 public meetings throughout the Tennessee Valley. Notice of these meetings was announced

in local and regional newspapers and other media. The meetings were held in the following cities:

Knoxville, TN	Bristol, TN	Bowling Green, KY
Paducah, KY	Nashville, TN	Jackson, TN
Memphis, TN	Tupelo, MS	Columbus, MS
Muscle Shoals, AL	Huntsville, AL	Chattanooga, TN

At each of these meetings, interactive computer-video displays were available that addressed key issues related to the development of Energy Vision 2020. TVA technical experts also attended every meeting to discuss issues, respond to questions, and help record people's comments. While the meetings were primarily designed as an informal, open-house format, four meetings were supplemented to give participants an opportunity to make public statements about their concerns. Rigorous attendance counts were not kept at the meetings, but TVA estimates that approximately 300 people attended and, of these, approximately 115 individuals provided comments.

Stakeholders' Review Group

Although TVA sought input from the general public and key opinion leaders, it recognized that it would be difficult to get specific and continuous guidance from these audiences as the plan developed. To obtain more in-depth, ongoing discussion and input from different stakeholder viewpoints, TVA established a 17-member Energy Vision 2020 Review Group. The interests represented by the Review Group included business and industry, distributors of TVA power, minority businesses, environmental organizations, state agencies, academia, and civic organizations.

The members of the Energy Vision 2020 Review Group and their affiliations are as follows:

Mike Dalen	Alabama Sierra Club
Ron Fogel	Associated Valley Industries
Jim Navolio	Kentucky Economic Development Cabinet
Susan Gawarecki	League of Women Voters
Carol Crawley	Mid-South Minority Purchasing Council
Chester Smith	Mississippi Department of Economic and Community Development
Eric Hirst	Oak Ridge National Laboratory
Carter Witt	Tennessee Association of Business
Anne Murray	Tennessee Conservation League
Elizabeth Owen	Tennessee Consumer Affairs Division
Stephen Smith	Tennessee Valley Energy Reform Coalition
Allen Cunningham	Tennessee Valley Industrial Committee
Mike Browder	Tennessee Valley Public Power Association
Quentis Fuqua	Tennessee Valley Public Power Association
Bill Pippin	Tennessee Valley Public Power Association
Jim White	Tennessee Valley Public Power Association
Mary English	UT Center for Energy, Environment and Resources

Alternates

Sheila Holbrook-White	Alabama Sierra Club
Sharon Fidler	League of Women Voters
Josh Ellis	Tennessee Association of Business
Ed Passerini	Tennessee Valley Energy Reform Coalition
Darrell Anderson	Tennessee Valley Industrial Committee

The Review Group met monthly with TVA from June 1994 through March 1995 and in June 1995. These meetings were held at various locations throughout the Valley and were open to the public. Opportunities were provided for the public who attended to submit written comments on the topics of discussions or other associated concerns.

At each meeting, TVA facilitated discussions among Review Group members on the issues they believed were important to a successful integrated resource plan. Review Group members' views were collected on the entire range of assumptions, analytical techniques, and proposed energy resource options and strategies.

Given the diversity of the makeup of the Review Group, there were at times a wide range of views on specific issues, such as the value of energy conservation programs, environmental concerns, and the appropriateness of some new technologies. In some cases, open discussions among the members and TVA staff, supported by additional data, brought closer understanding and agreement on particular issues. On some issues, however, members of the Review Group and TVA staff agree that the objective was not consensus, and differing views were honored.

TVA retained several outside consultants to advise Review Group members on their primary issues of concern. These included the accuracy of TVA's load forecast, the cost and operating assumptions about its nuclear generating facilities, and the results obtained from the resource integration portion of TVA's planning process. Review Group members also met with TVA staff in small groups to discuss special areas of interest such as demand-side management and renewable energy options. This provided an opportunity to exchange more detailed information and develop a better understanding of concerns among Review Group members and with TVA staff. During the course of 12 months of meetings, many bridges of understanding and guidance were built that make this a better plan.

Written Comments During Scoping

TVA began the public comment period on the scope of Energy Vision 2020 on February 8, 1994. In addition to publishing an official notice in the Federal Register, TVA announced the start of the process in newspapers, television reports, and other communication media throughout the Tennessee Valley. TVA compiled written comments on concerns and recommendations from the public for approximately nine months (until December 5, 1994). These comments were used by TVA to better define the full scope of its integrated resource

planning analysis. During this period, TVA received approximately 600 written comments from more than 100 people and organizations.

TECHNIQUES FOR COLLECTING PUBLIC INPUT DURING DRAFT DOCUMENT STAGE

TVA primarily used two techniques to collect public input during the draft document stage: (1) public meetings, and (2) written comments.

Public Meetings

From August 28 through October 2, 1995, TVA held nine public meetings throughout the Tennessee Valley. Notice of these meetings was announced in local and regional newspapers and other media. The meetings were held in the following cities:

Muscle Shoals, AL	Huntsville, AL	Knoxville, TN
Bristol, TN	Paducah, KY	Nashville, TN
Starkville, MS	Memphis, TN	Chattanooga, TN

At each of these meetings, TVA technical experts were available to respond to questions, discuss issues, and help members of the public understand Energy Vision 2020. Two mechanisms were used to record public comments: (1) a "hearing" room in which those choosing to comment could address a TVA "hearing" officer and have his or her comments recorded by a court reporter; or (2) a "speed" room in which those choosing to make comments but not wanting to speak in front of others could have their comments recorded by a TVA employee.

At the request of a representative of the Tennessee Energy Valley Reform Coalition, TVA commenced these public meetings in late August (August 28) after the release of Energy Vision 2020 on July 26, 1995, in order to provide the public an ample opportunity to review the draft document before the public meeting process began. The last public meeting was held on October 2. The public comment period formally closed on October 15. Rigorous attendance counts were not kept at these public meetings, but TVA estimates that approximately 350 people attended. Approximately 160 people provided about 1,200 oral comments at these meetings.

Written Comments

TVA provided approximately 80 days for receipt of written comments. This is almost 80 percent longer than the minimum time period required by applicable procedures which implement the National Environmental Policy Act. TVA received approximately 800 written comments. These were either mailed or faxed to TVA, or were provided at one of the public meetings.

INTEGRATION OF PUBLIC SCOPING COMMENTS INTO ENERGY VISION 2020

Overall, TVA received more than 1,300 comments from approximately 375 individuals and organizations either in writing or verbally. All of these comments were collected, categorized, and consolidated into scoping comments for TVA's integrated resource plan and environmental impact statement—Energy Vision 2020.

The comments included a broad range of concerns and issues. Many recommended that TVA consider—or not consider—specific resource options such as renewable energy resources or nuclear plants. Others expressed views on the values that TVA should consider in weighing its options and strategies. People urged TVA to maintain competitive rates, to reduce its debt, and to protect the environment. Some respondents expressed concerns about future uncertainties that TVA should consider in developing strategies. These included loss of customers and electric load due to competition, more stringent environmental regulations, and future fuel prices. TVA also received a number of comments about its mission, organizational structure, workforce, and other activities. All of the comments TVA received were categorized into five broad areas as listed in *Figure 1-5.*

Through this process, TVA was able to incorporate most of the comments into its analysis. For example, the wide array of resource options evaluated during the integrated resource planning process includes either specific public recommendations for resource options or generic variations of resource options. Recommended values were incorporated into TVA's evaluation criteria to compare resource options and strategies. The uncertainties (or possible future events) used in the process capture concerns identified by the public

RESPONSES TO PUBLIC COMMENTS ON DRAFT DOCUMENT

The introduction to Volume 3 of Energy Vision 2020 explains how TVA responded to the comments that it received during the draft document stage. Volume 3 contains TVA's responses to the comments it received. When appropriate, Energy Vision 2020 was changed. Typically this was done to clarify discussions or to correct errors in the presentation of information. Some comments asked that TVA conduct additional analyses or to analyze issues differently. As appropriate, the results of such analyses were either included in the Energy Vision 2020 long- and short-term plans or in Volume 3, Responses to Public Comments.

FIGURE 1-5. **Scoping Categories**

Evaluation Criteria	Total Cost/Customer Value, Rates, Financial, Environment, Economic Development, Risk Mitigation, Reliability, Equity
Options	Supply: Nuclear Conversion to Alternative Fuels, Coal, Clean Coal, Natural Gas, Renewables, IPP/Cogeneration/Purchased Power, Peaking/Storage, Other Customer Service: Energy Efficiency, Load Management, Beneficial Electrification, Self-Generation, Rates, Other New Technology Environment Other
Uncertainties	Market/Load Forecast, Fuel Process Regulatory: Environment, Competition, Other Technology/Option-Related: Cost, Performance
Process	Format of Public Meetings, Input from National Organizations, Outside Review, etc.
Miscellaneous	TVA Administration, TVA Mission, Social Equity, etc.

All of the public comments received during scoping were categorized into five broad areas.

PUBLIC ISSUES NOT TREATED IN ENERGY VISION 2020

Below are a number of public recommendations made that TVA did not address specifically in Energy Vision 2020.

Site-Specific Impacts

TVA received a number of comments recommending that it address potential environmental impacts that may vary from one location to the next. These included the likely impact of energy resource development on endangered species or wetlands, the conversion of prime farmland, or aesthetic impacts. While these potential impacts are very important to consider in the actual siting or deployment of energy resource alternatives, it would be impossible, however, to analyze them at the programmatic or strategy level. Prior to deployment of any option, TVA will conduct an appropriate site-level environmental review.

Monetization of Environmental Externalities

An "externality" is a cost or benefit that results from the production or consumption of goods and services that is not reflected in the prices of those goods or services. For example, driving a car or generating electricity may produce various forms of pollution that can damage vegetation. If such pollution is not controlled at the source such that the cost of control is included in production costs, it is an environmental externality or a cost borne by society. TVA and other federal agencies have long assessed potential environmental externalities in the context of the National Environmental Policy Act reviews they perform.

Several commenters asked TVA to monetize the environmental externalities that may result from the strategies or options in Energy Vision 2020. Monetization involves directly adding the cost of externalities to other costs, such as construction and fuel costs. Given the many difficulties in monetizing externalities, and the lack of a consistent position in the utility industry on the values to be used, TVA has decided to address externalities by using a multi-attribute trade-off approach. More information about various treatments of externalities can be found in Volume 2, Technical Document 4, Evaluation Criteria. In addition, all appropriate environmental issues have been addressed qualitatively as a part of the environmental impact statement component of this plan. A more detailed discussion of these issues is located in Volume 2, Technical Document 1, Comprehensive Affected Environment, and in Volume 2, Technical Document 2, Environmental Consequences.

Unbundling of Services

Many of the functions necessary to ultimately deliver electricity to a home or place of business are generally provided by one company or utility. For some utilities, these functions include the process of generating, transmitting, and distributing electricity to the customer (end user). Utility service also may include specialized energy services that enhance the use of electricity. These may range from personalized energy management services to specialized metering and

billing. The costs for these services are most often consolidated into a standard rate for kilowatt-hours consumed that reflect generalized cost of service estimates among different classes of customers.

The experience with deregulation of electric utilities in other countries and of other industries in the United States, most notably the telecommunications industry, suggests that utilities may need to "unbundle" their operations to be more competitive in the future. Several commenters asked TVA to assess the ramifications of possibly unbundling its services. For TVA, this would largely amount to pricing and offering power generation and transmission as separate services. Since this is predominantly a rate-making issue, it is not addressed directly in Energy Vision 2020. The question of how unbundling services might affect TVA is being studied in a separate analysis that will use results from Energy Vision 2020.

Treatment of Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3

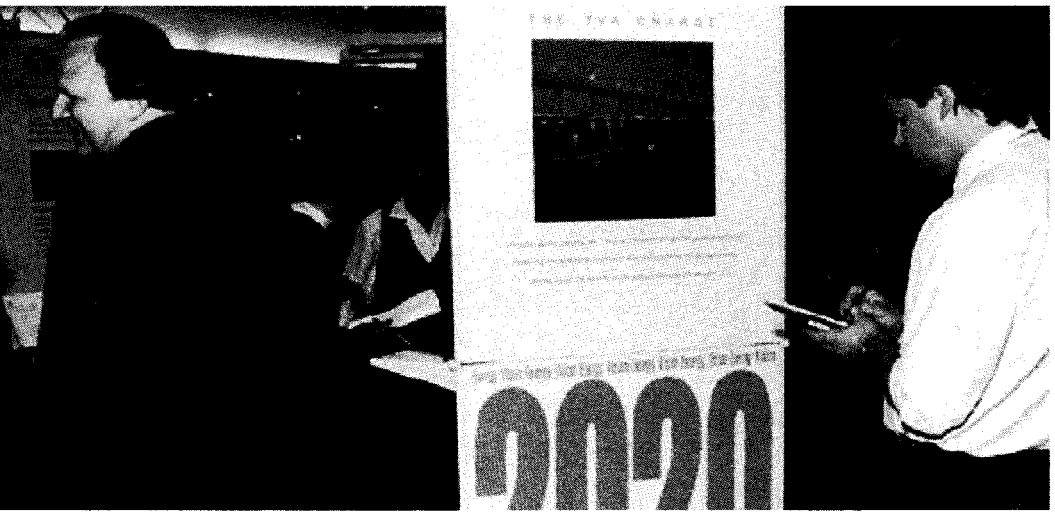
Several commenters asked TVA to include Watts Bar Nuclear Plant (WBN) Unit 1 and Browns Ferry Nuclear Plant (BFN) Unit 3 as resource options in Energy Vision 2020. However, TVA included these units as existing generating resources since these units were important for meeting TVA's near term load requirements and were essentially complete at the start of the Energy Vision 2020 process. Watts Bar Nuclear Plant Unit 1 was granted a license to load fuel and perform low power testing in November 1995. Fuel loading was completed in November, and Watts Bar Nuclear Plant Unit 1 is expected to begin commercial operation in spring 1996. Browns Ferry Nuclear Plant Unit 3 fuel load was completed in October and is scheduled to return to service in early 1996. As with other operating TVA resources, Energy Vision 2020 evaluated the impacts of these units on electric rates, debt, and the environment. For further explanation of the need and economics of Watts Bar Nuclear Plant Unit 1, see the comments and responses on this unit in Volume 3.

Privatization of TVA

Since the purpose of Energy Vision 2020 is to identify the long- and short-term actions TVA can take to meet its existing and future customer energy resource needs, the issue of privatization of TVA's utility operations is not addressed.

Chapter Two

Integrated Resource Planning



Chapter Two: Integrated Resource Planning

Dramatic changes in the electric utility industry since the early 1970s have created a need for more sophisticated planning tools to guide utility resource decisions. Today's integrated resource planning process has improved the concept of least-cost planning, which was introduced in the mid-1980s.

The best industry practices in integrated resource planning include looking at a broad range of supply-side and customer service options, using multiple evaluation criteria, involving the public, and considering uncertainty associated with future events.

TVA's approach to integrated resource planning has built on these best practices. It also includes more extensive planning interaction with stakeholders and with technical experts inside and outside TVA. Energy Vision 2020 also goes beyond the traditional regulatory focus on least-cost plans and demand-side management to consider the growing issue of competition and its potential effects on resource decisions.

This Chapter Includes:

- Integrated Resource Planning History
- Integrated Resource Planning Process Overview
- TVA's Approach to Integrated Resource Planning

Integrated Resource Planning

Integrated Resource Planning History

Through the 1960s, planning for the future in the electric utility industry was straightforward. Growth in the demand for electricity was consistently strong. This allowed for continuing economies of scale for power plant construction, which kept driving down the cost of incremental resource additions. Therefore, electricity rates stayed constant, and during some time periods, actually decreased. Planning consisted primarily of determining the schedule for adding large, bulk-power generators to the system to meet rapidly increasing loads. Simple trending techniques seemed to be sufficient guidance to questions about future resource requirements.

All of this changed dramatically in the 1970s as many factors produced significant volatility in the electric power industry's cost structure. These included the Arab oil embargo, rampant inflation, the regulatory consequences of the Three Mile Island incident, and air emission controls on power plants. As a result of these events, electric rates began to increase significantly, load growth slowed, and the future became far less predictable. In addition, competitive wholesale generation markets began to emerge as a result of the Public Utilities Regulatory Policy Act of 1978. By the 1980s, energy conservation evolved into the concept of demand-side management, focusing on the long-term efficient use of resources. All of these issues required new planning approaches and techniques to help utilities integrate these changes into their planning process.

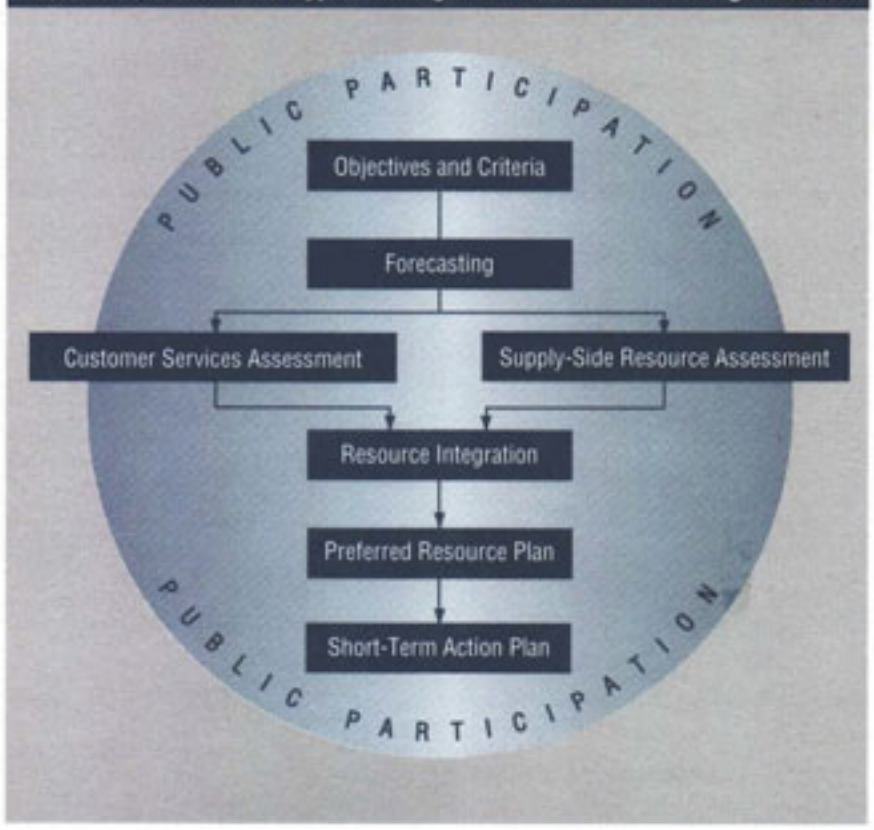
Least-cost planning, with its emphasis on end-use efficiency, was introduced in the mid-1980s to help address these issues. Least-cost planning has evolved into the concept of integrated resource planning defined in the National Energy Policy Act of 1992. Integrated resource planning is continuing to change to meet the increasingly competitive environment in the electric utility industry.

Integrated resource planning is continuing to change to meet the increasingly competitive environment in the electric utility industry.

Integrated Resource Planning Process Overview

An effective integrated resource planning process results in a plan that broadly identifies the long- and short-term actions a utility anticipates undertaking to meet future demands for energy services and to achieve its objectives. The integrated resource planning process evaluates both supply-side options

FIGURE 2-1. **A View of a Typical Integrated Resource Planning Process**



and customer service options. Supply-side options refer to various methods for generating or acquiring additional electrical energy. Customer service options encompass a wide range of technologies, programs, pricing strategies, and other activities that change the way consumers use electricity. Consumer actions improve the value of energy services. They can also provide resource benefits for the power system by avoiding the need to build or otherwise acquire supply-side resources.

A typical integrated resource planning process is illustrated in *Figure 2-1.* A utility must first look at its objectives and the issues affecting its operations, then develop evaluation criteria consistent with its objectives. These criteria are used as a guide in evaluating its energy resource options. The utility next looks at its projected need for power, which includes the utility's load forecasts and an assessment of its existing power system to meet the projected loads. If a need for new resources is identified, the utility evaluates potential supply-side and customer service resource options to meet these needs.

Integration is an interactive process that evaluates specific combinations of existing and new resource options called strategies. These strategies are evaluated based on the utility's evaluation criteria and future uncertainties that may affect resource choices. After the utility evaluates all its resource options and strategies against its criteria, it chooses a long-term resource strategy or plan that adequately and reliably meets its projected need for power and other customer services. A preferred plan is one that will score well on as many of the evaluation criteria as possible and will provide the utility with the necessary flexibility to deal with future uncertainties.

A good integrated resource planning process also yields the utility's short-term action plan. This plan lists the specific steps the utility will take in the next three to five years to support its long-term plan. For example, if the preferred long-term plan calls for an additional power plant in the future, the short-term action plan would include acquiring a site for the plant.

Some of the best practices used by leading electric utilities in preparing integrated resource plans include:

- Identifying a broad range of supply-side and customer service options and their unique operating characteristics.
- Using multiple evaluation criteria that include total cost and rate impacts, environmental impacts, and risk management to compare specific resource plans or strategies. To these standard evaluation criteria, TVA added a measure of economic value, which broadens the range of options considered in the planning process.
- Integrating multiple perspectives through a variety of public participation techniques designed to receive and consider the comments of the general public and "stakeholders."
- Incorporating uncertainties into the planning process, such as the uncertainty associated with the future demand for electricity, fuel prices, and the enactment of future environmental regulations. These uncertainties have the potential for dramatically changing a utility's future course of action. Several analytical techniques allow utilities to consider such uncertainties and build flexibility into their plans.

TVA's Approach to Integrated Resource Planning

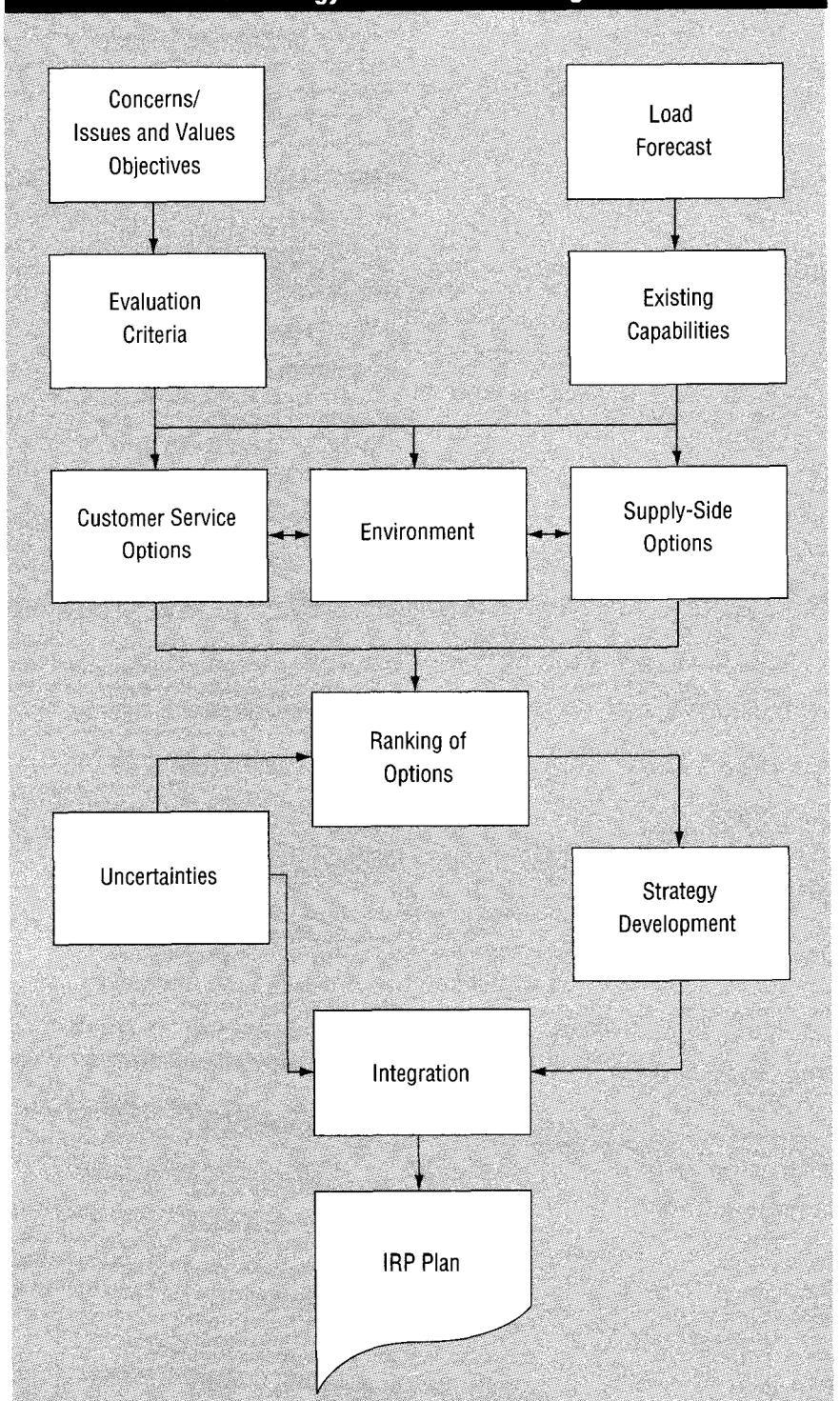
TVA's Energy Vision 2020 has incorporated the best industry practices and added several improvements to meet its unique situation and the changing utility environment.

First, TVA developed a highly interactive planning process to build Energy Vision 2020. This included a great deal of interaction between TVA and its stakeholders, and among stakeholders themselves. Also, there was extensive involvement from a broad cross-section of TVA staff, who have technical expertise and program responsibilities for the areas covered by integrated resource planning. They worked in different building block teams for each step of the process identified in *Figure 2-2*. Each team had members that not only represented the primary staff responsible for a technical area, but other members who could help the team understand issues or concerns from other perspectives (e.g., customers, environmental).

This process of increasing involvement by TVA stakeholders and employees has expanded the general awareness of the highly complex issues associated with utility decision-making. It will also help in building an understanding of the decisions the TVA Board of Directors will make concerning TVA's long- and short-term resource plans.

Second, most utility integrated resource plans to date have focused on meeting their business objectives in a regulated environment and on meeting regulatory commission standards and expectations. To go beyond best industry practices, Energy Vision 2020 focused on meeting customer expectations, while recognizing the potential challenges of a less regulated electric utility environment.

FIGURE 2-2. **Energy Vision 2020 Building Blocks**



This figure illustrates only the primary flow of information in developing Energy Vision 2020 and not the full process of building block interactions and feedbacks on common issues.

INTERACTIVE PLANNING

Interactive planning moves from the identification of issues and concerns to the development of preferred strategies. An interactive approach requires:

1. Identifying public issues and relevant concerns
2. Translating public issues and concerns into evaluation criteria, resource options, and uncertainties
3. Crafting resource options into strategies
4. Identifying possible future conditions (uncertainties)
5. Constructing scenarios
6. Using trade-off analysis to find the best strategies for the future

Value judgments about the importance of potential impacts from various resource options (e.g., on cost, rates, the environment, TVA's debt) are intentionally deferred until later in the process, when extensive discussions take place about making trade-offs among issues people value. Although TVA has had discussions with its stakeholders about the possible trade-offs among different values, the decision-making authority ultimately resides with TVA's Board of Directors. The Board is responsible for deciding which short-term and long-term energy strategy TVA will adopt to best serve its customers and meet the agency's other goals.

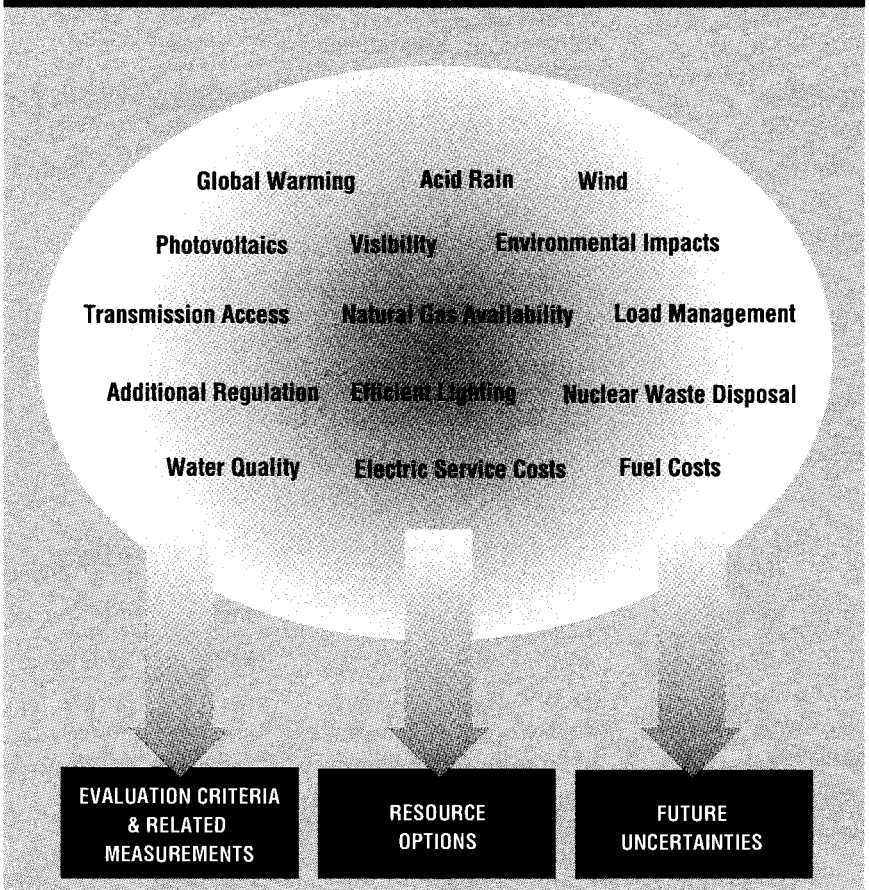
TVA'S IMPLEMENTATION OF THE INTERACTIVE PLANNING PROCESS

Below is an outline of TVA's movement through each step to the development of preferred strategies.

Step 1: Identifying Public Issues and Relevant Concerns

The objective in the early stages of the planning process was to accumulate as many relevant issues and concerns as possible from customers, TVA employees, environmental groups, and other key stakeholders. Some of these concerns are illustrated in *Figure 2-3*.

FIGURE 2-3. **Translating Public Concerns**



Issues and concerns from the public were translated into evaluation criteria, resource options, and future uncertainties used in Energy Vision 2020.

Step 2: Translating Public Issues and Concerns into Evaluation Criteria, Resource Options, and Uncertainties

TVA then categorized each issue or concern so that it could be systematically discussed and evaluated. This meant stating issues or concerns in a way that would allow as much quantitative evaluation as possible in the planning process. Quantitative evaluation provides a fact-based or numerical value system upon which to base decisions, and it reduces the subjective debate that can surround various issues or concerns.

TVA translated concerns about the Valley's energy future into the following categories:

Evaluation Criteria and Measurements

Statements that reflected TVA and stakeholder values were translated into evaluation criteria. For example, impacts on rates and the environment are important considerations that TVA needs to consider in evaluating various future resource strategies. TVA then identified attributes that could be used to measure various impacts. For example, if there is a concern that development of a resource will cause rates to increase too much, the attribute could be the projected level of TVA's rates by a certain year. If an environmental concern is greenhouse gases, the attribute could be the amount of carbon dioxide emitted by that resource option over the planning period.

For some of the criteria, TVA established constraints as minimum and/or maximum bounds of acceptable performance. For example, if the concern is

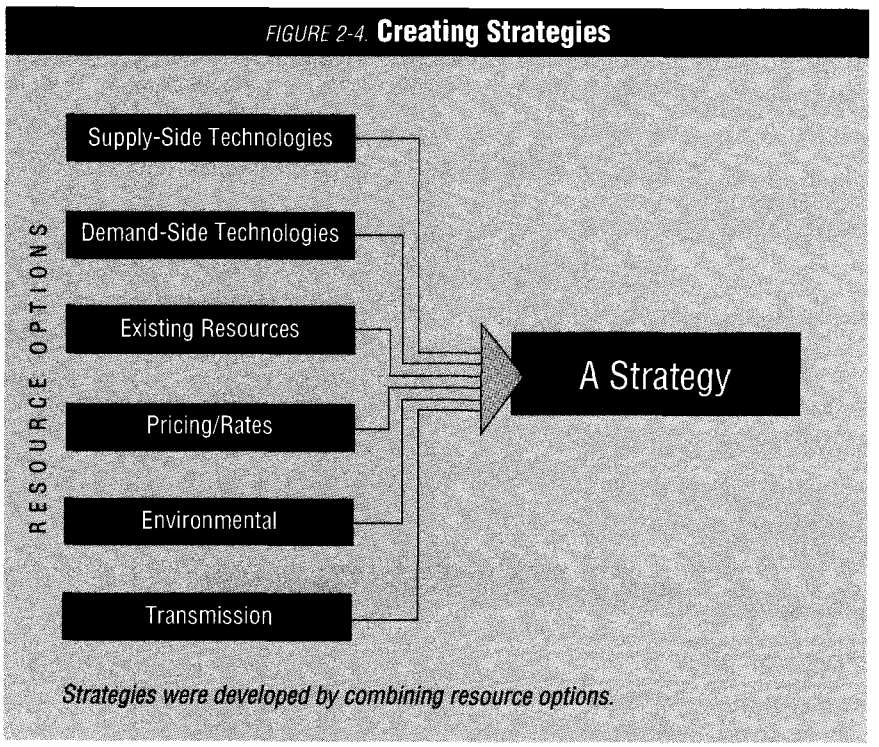


FIGURE 2-4. **Creating Strategies**

Strategies were developed by combining resource options.

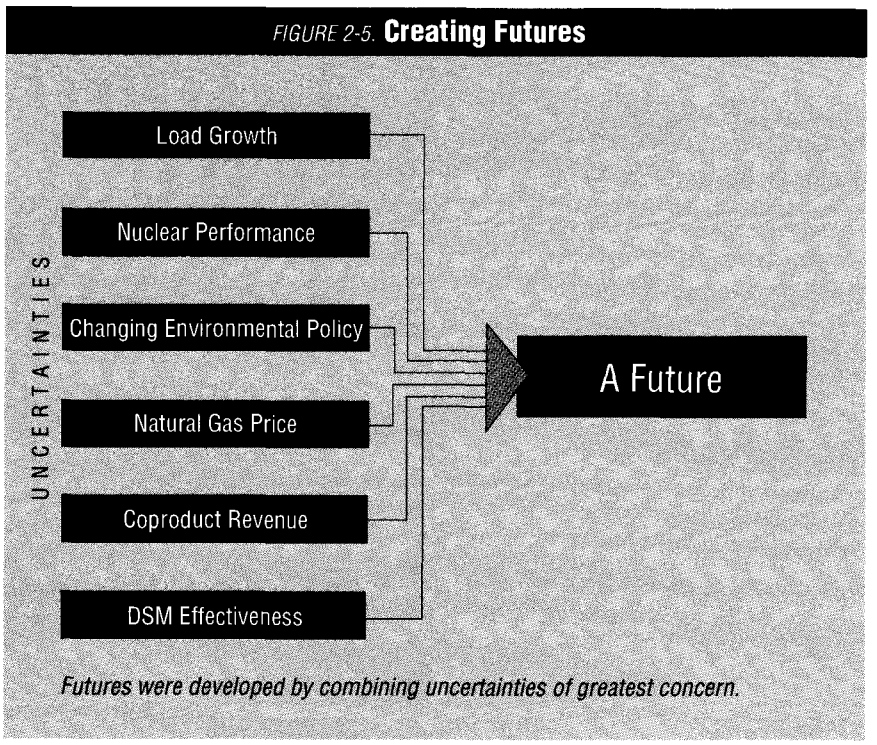


FIGURE 2-5. **Creating Futures**

Futures were developed by combining uncertainties of greatest concern.

the reliability of electricity, a constraint may be given in terms of minimum expectations for power quality or duration of power outages. For an environmental concern, such as greenhouse gases, a constraint may set a limit on the amount of carbon dioxide emissions a generating option may produce in a given time period.

See Chapter 5 for a detailed discussion of evaluation criteria, measurements, and constraints used in Energy Vision 2020.

Resource Options

Resource options grew out of suggested actions that stakeholders and others consider to be within TVA control and should be taken by TVA to meet its objectives, satisfy customer needs, and/or resolve issues. For example, if the issue is a shortfall in power supply in the year 2007, a suggested action or option for TVA could be to build a power plant to meet the demand. Another might suggest TVA pursue demand-side management programs to reduce consumer demand. More information about the supply-side and customer service options TVA considered in Energy Vision 2020 can be found in Chapters 7 and 8.

Uncertainties

Issues or concerns that may affect energy resources in the future but are beyond TVA's control are termed uncertainties. An example would be the future level of natural gas prices. This uncertainty is significant because natural gas is a source of fuel for power plants, as well as an alternative to electricity for some consumer needs. Critical uncertainties considered in TVA's integrated resource planning process can be found in Volume 2, Technical Document 8, Resource Integration.

Step 3: Crafting Resource Options into Strategies

After categorizing public concerns, TVA began identifying and characterizing resource options, ranking them based on costs, rates, debt, and environmental emissions, and screening out those that were clearly not feasible. *Figure 2-4* shows how the selected options were combined into a strategy to meet projected load and other criteria, as well as to address key uncertainties. More information on the development of specific strategies can be found in Chapter 9, Resource Integration/Alternative Strategy Comparisons.

Step 4: Identifying Possible Future Conditions (Uncertainties)

From the list of concerns that were translated into uncertainties, possible futures were defined. A future is a combination of one or more uncertain events. For example, a future could include high growth in electricity sales, high cost of natural gas, and increasing air emission controls in response to a global warming problem. Another future could be defined to include high electricity sales growth, low cost of natural gas, and no legislation requiring increased air emission controls. TVA created futures based on those uncertainties that could have the greatest impact on the resource strategies TVA might choose to implement. *Figure 2-5* illustrates how possible futures are created.

Step 5: Constructing Scenarios

A scenario is created by combining a single strategy for a single future. Each scenario can be discussed in terms of its relevant attributes and objectives. Scenarios are then evaluated using modeling and simulation techniques to measure their performance against the evaluation criteria.

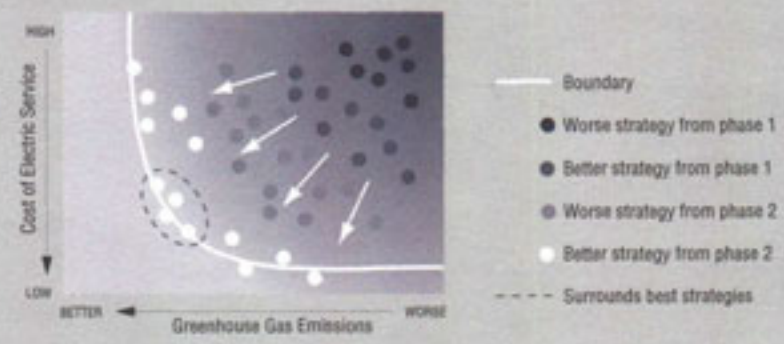
Step 6: Using Trade-Off Analysis to Find the Best Strategies for the Future

Once a set of feasible scenarios was developed, trade-offs among them were considered under the different futures. This trade-off analysis of scenarios was necessary because more than one evaluation criterion or measurement was relevant to evaluating the scenarios.

Discussions on trade-offs within TVA and with outside stakeholder representatives focused on how well various strategies might be able to meet selected evaluation criteria measurements. These discussions also considered what impacts the strategies might have on TVA's entire power system.

The purpose and nature of trade-off analysis are shown graphically in *Figure 2-6*. For illustration purposes, strategies were plotted in the trade-off graphs

FIGURE 2-6 **Using Trade-Off Analysis to Create Improved Strategies**



Better strategies were developed by analyzing trade-offs among various measures such as cost of electric service and greenhouse gas emissions. The strategies within the dotted line would be those with both the lowest electricity costs and the lowest greenhouse gas emissions.

for a given future. The axes of the graph identify two measures or attributes. In this example, the cost of electricity ($/kilowatt-hour) is on the vertical axis and greenhouse gas emissions (tons) are on the horizontal axis. The results for each strategy are plotted on the graph for given futures.

If there were only two evaluation criteria that TVA had to consider, the ideal strategy would be located closest to where the two axes meet (in the lower left hand corner). In this example, strategies within the dotted line would be those with the lowest electricity costs and the lowest greenhouse gas emissions.

Once trade-offs are initially analyzed (phase 1), strategies are modified and improved where possible (phase 2, etc.) to move them closer to the corner. In cases where an unavoidable trade-off exists, the decision-maker must choose between strategies. As an example, if there is no strategy with both the lowest costs and the lowest greenhouse gas emissions, the decision-maker may have to choose one over the other. After extensive reviews of different trade-offs among many pairs of evaluation criteria, those strategies that, in the opinion of the decision-maker, best meet the criteria and provide flexible choices are developed into the long-term resource plan. More information on the development of strategies and trade-offs can be found in Chapter 9.

Chapter Three

Affected Environment

Chapter Three: Affected Environment

This chapter contains an assessment of those natural and socioeconomic resources in the region that may be influenced by Energy Vision 2020 decisions about future energy resources. The assessment is made at a macro, or regional, scale rather than at a micro, site-specific scale.

The primary study area covers the TVA power service area and the Tennessee River watershed, comprising 201 counties within a 58-million acre area.

Appropriate elements of the Cumberland River in Tennessee, and the Mississippi River in Tennessee, both in the primary study area, and a portion of the Green and Ohio Rivers in Kentucky outside the study area, are included in this report, since TVA power plants are located in these river basins and, in the case of the Cumberland River, one hydroelectric plant. The assessment region for air quality is not limited to the TVA service area. There are pollutant emissions originating outside the region, pollutants leaving the area, and pollutant effects such as haze, ozone, and acidic precipitation that are recognized as regional issues.

Natural resources include regional air, water, and land resources. Overall, air and water quality are generally good and have been steadily improving. Land resources are adequate for siting energy supply facilities.

Understanding the conditions of these resources, trends in the region's environmental quality, and the relationship to TVA's activities is important. This provides the necessary reference or baseline for assessing the potential environmental consequences of implementing alternative energy strategies developed in Energy Vision 2020.

This Chapter Includes:

- Overview
- The Socioeconomic Environment
- Regional Air Resources
- Regional Water Resources
- Regional Land Resources

Affected Environment

Overview

Energy Vision 2020 evaluates the affected environment to help provide a baseline for assessing the environmental consequences of alternative energy strategies. Because Energy Vision 2020 includes an environmental impact statement, special emphasis is being given to the environment. A regional perspective takes in both natural conditions and those resulting from human development. It considers socioeconomic, air, water, and land resources. All topics in this chapter are considered in more detail in Volume 2, Technical Document 1, Comprehensive Affected Environment.

Because Energy Vision 2020 includes an environmental impact statement, special emphasis is being given to the environment in this report.

The primary study area for Energy Vision 2020, shown in *Figure 3-1*, includes the TVA power service area and the Tennessee River watershed, comprising 201 counties within a 58-million acre area. Within this study area, appropriate elements of the Cumberland River in Tennessee, and the Mississippi River in Tennessee are considered because TVA coal-fired plants are located on these rivers and, in the case of the Cumberland River, one hydroelectric plant. Outside the study area, a portion of the Green and Ohio Rivers in Kentucky are considered because TVA coal-fired plants are located on these rivers.

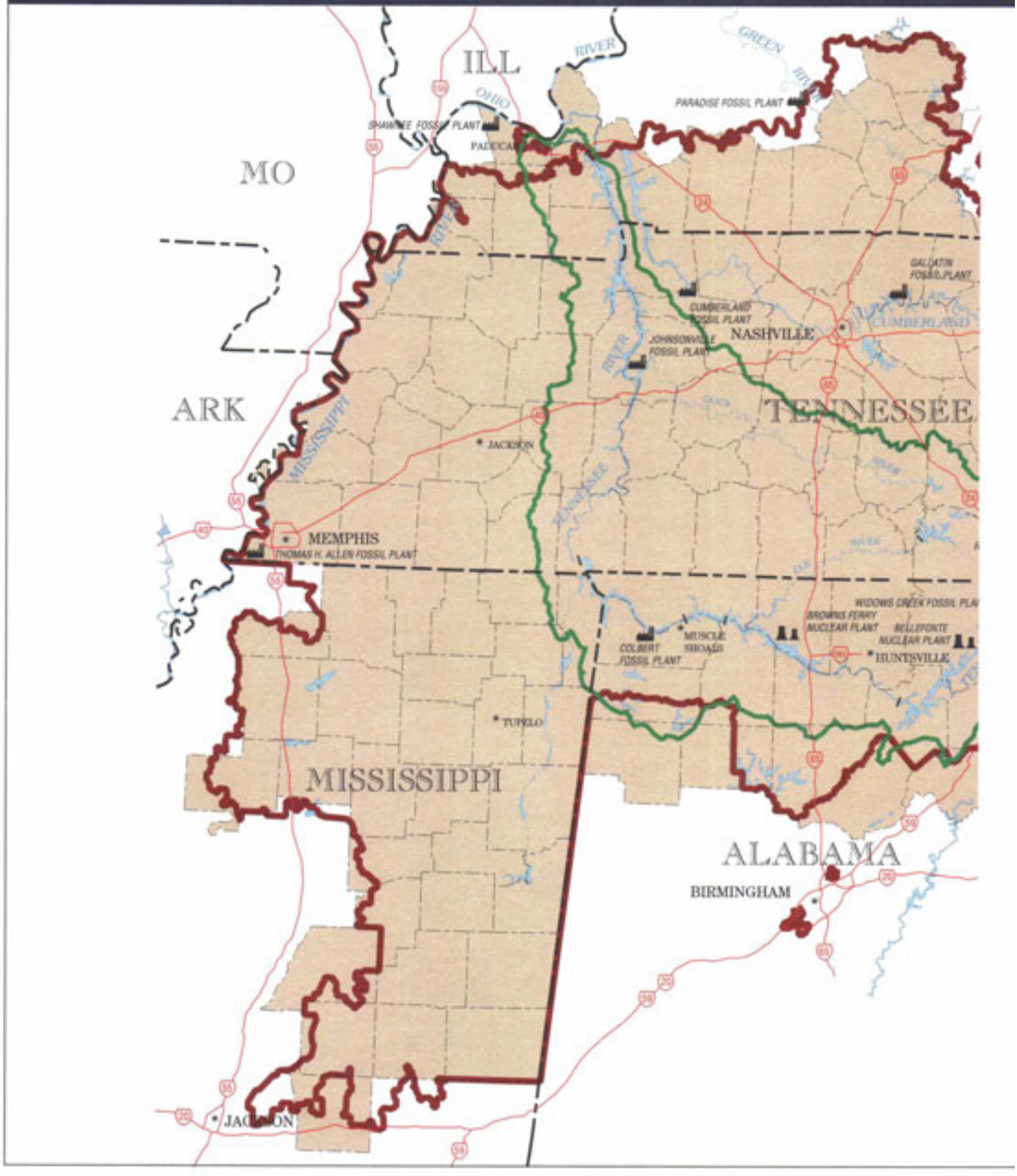
The Socioeconomic Environment

In 1994, the TVA power service region had an economy of $146 billion in total personal income, 3.6 million in total non-farm employment, and $175 billion in gross product. The population was 7.7 million in 1994. Per capita income in the region was about $19 thousand the same year, or about 86 percent of the national average.

Close to half of the region's population lives in non-metropolitan counties, compared to less than one-fourth in the nation. In 1994, about 26 percent of total non-farm employment in the region was in manufacturing, as compared to 16 percent for the United States. Manufacturing's predominance in the region is due to several advantages that have helped it in the past and should continue in the future. They include:

- A location in the South, with good access to the markets of the Northeast, the Midwest, the Southwest, and Florida
- Good transportation for shipping commodities to these markets
- A low wage (for the U.S.) workforce with good work habits
- Abundant, relatively low-cost resources including water, electricity, and land.

FIGURE 3-1. **The Energy Vision 2020 Study Area Includes the TVA Service Area and the Tennessee River Watershed**



LEGEND

Tennessee Watershed Boundary

Power Service Boundary

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

ECONOMY

A large manufacturing base has helped this area outperform the United States economy and is expected to continue to do so. Strong manufacturing gains since 1985 have stimulated the region's growth. Three critical factors hampered manufacturing in the early to mid-1980s: exceptionally high oil and energy prices, high interest rates, and high foreign exchange rates. These have returned to relatively lower levels and are expected to remain there, creating favorable conditions for growth in the region's manufacturing capabilities.

A strong manufacturing base has helped this area outperform the United States economy and is expected to continue to do so.

Although manufacturing is the core of the region's economic base, non-manufacturing industries accounted for two-thirds of total gross regional product in 1994. The service sector, which makes up the bulk of the non-manufacturing side of the economy, has provided, and is expected to continue to provide, the great majority of all new jobs created in the region.

For the balance of the decade, the region's performance is expected to continue the trend of the 1985-1994 period. Relatively favorable national conditions and TVA's electric rates for regional manufacturing are both expected to continue. TVA expects the region's newer manufacturing industries to continue further expansion. After the year 2000, TVA expects the region's growth will slow considerably as the area's newer manufacturing industries reach maturity. Nevertheless, manufacturing's intensity is expected to continue to provide enough impetus for the region to expand somewhat faster than the national rate.

POPULATION

In 1994, about 7.7 million people lived in the TVA power service area, with almost half residing in the major metropolitan areas of Nashville, Memphis, Knoxville, Chattanooga, and Tri-Cities, Tennessee, and Huntsville, Alabama. These metropolitan areas are all mid-sized, without any one large dominating area in the region and are distributed fairly evenly throughout the region. Surrounding these metropolitan areas are a few smaller metropolitan areas and numerous satellite cities, along with the surrounding rural communities connected by both economic and transportation links. Thus, the region, while largely rural, is generally well served by centers of commerce and government, and the workforce is evenly distributed across the region rather than focused in any particular central area.

Regional Air Resources

Natural resources such as soils, forests, crops and other vegetation, surface waters, aquatic ecosystems and aquatic life are sensitive to air quality impacts of acidic deposition (including acid rain), ozone exposure, and deposits of heavy metals. TVA affects air quality through emissions from power plants. Air quality in the TVA region is generally good.

CRITERIA AIR POLLUTANTS

Air quality is important to protect human health and natural resources. Regional compliance with the Federal National Ambient Air Quality Standards serves as a key indicator of how well human health and the environment are protected.

The Environmental Protection Agency has established standards for six "criteria" pollutants. Pollutant concentration levels were established for two classes of effects: primary and secondary. Primary standards protect public health, and secondary standards protect public welfare (e.g., visibility, aquatic ecosystems, crops and forests, soils, materials). Current national ambient air quality standards are shown in *Figure 3-2*.

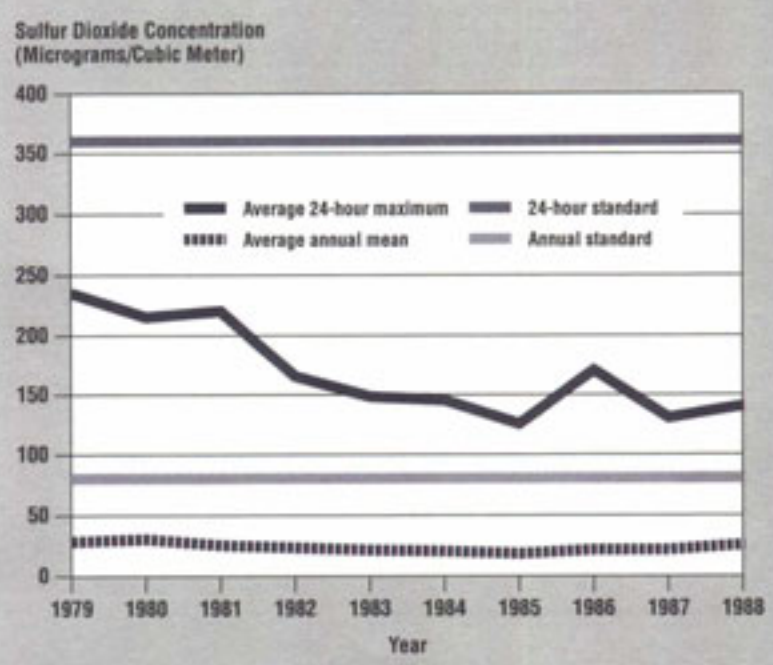
Locales where concentrations do not exceed the level of the standards are considered to be in compliance with the National Ambient Air Quality Standards and are thus designated as attainment areas. Areas where standards are not achieved are designated as non-attainment. (See *Figure 3-3 through 3-5.*)

FIGURE 3-2 **The National Ambient Air Quality Standards Set Limits for Six Pollutants to Protect Human Health and the Environment**

Pollutant	Averaging Time	STANDARD Primary	STANDARD Secondary
Carbon Monoxide	8-hour	9.0	none
	1-hour	35.0	none
Lead	Quarter Year	1.5	1.5
Nitrogen Dioxide	Annual	0.053	0.053
Ozone	1-hour	0.12	0.12
Particulate matter less than 10 microns in size (PM10)	24-hour	150 $\mu g/m^3$	150 $\mu g/m^3$
	Annual	50 $\mu g/m^3$	50 $\mu g/m^3$
Sulfur Dioxide	3-hour	none	0.50
	24-hour	0.14	none
	Annual	0.03	none

National standards, other than annual standards, are not to be exceeded more than once per year (except where noted in the figure). Units are parts per million by volume of air except for particulate matter with diameters less than or equal to 10 microns which is expressed in micrograms per cubic meter. The ozone standard is attained when the expected number of days per calendar year in which the maximum hourly average concentration is above the standard is equal to or less than one day.

FIGURE 3-6 **Concentrations of Sulfur Dioxide in the Energy Vision 2020 Study Area Are 40 Percent Below 1979 Levels**

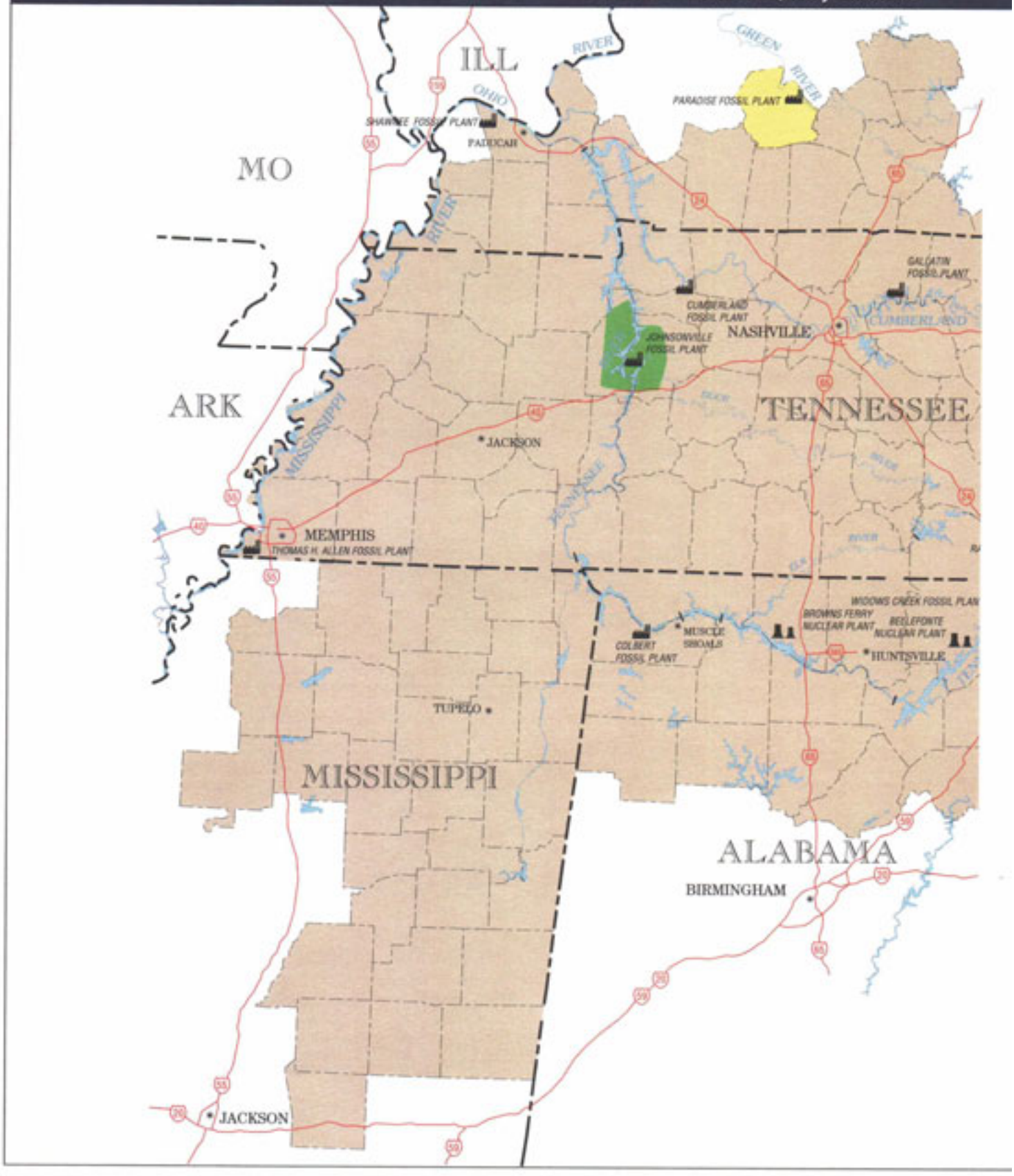


SULFUR DIOXIDE (SO_2)

Health and Welfare Concerns

Sulfur dioxide can impact human health at sufficient concentrations. Concentrations of sulfur dioxide in the Tennessee Valley have been reduced by more than 40 percent since 1979 *(Figure 3-6)*. Current ambient levels of sulfur dioxide are generally below thresholds that pose risk of damage to vegetation and materials. Sulfur dioxide also combines with other elements to form sulfate, a secondary pollutant that contributes to acidic deposits and fine particles that can have an impact on human health and impair visibility.

FIGURE 3-3. **Areas in Nonattainment for Sulfur Dioxide Under the National Ambient Air Quality Standards**



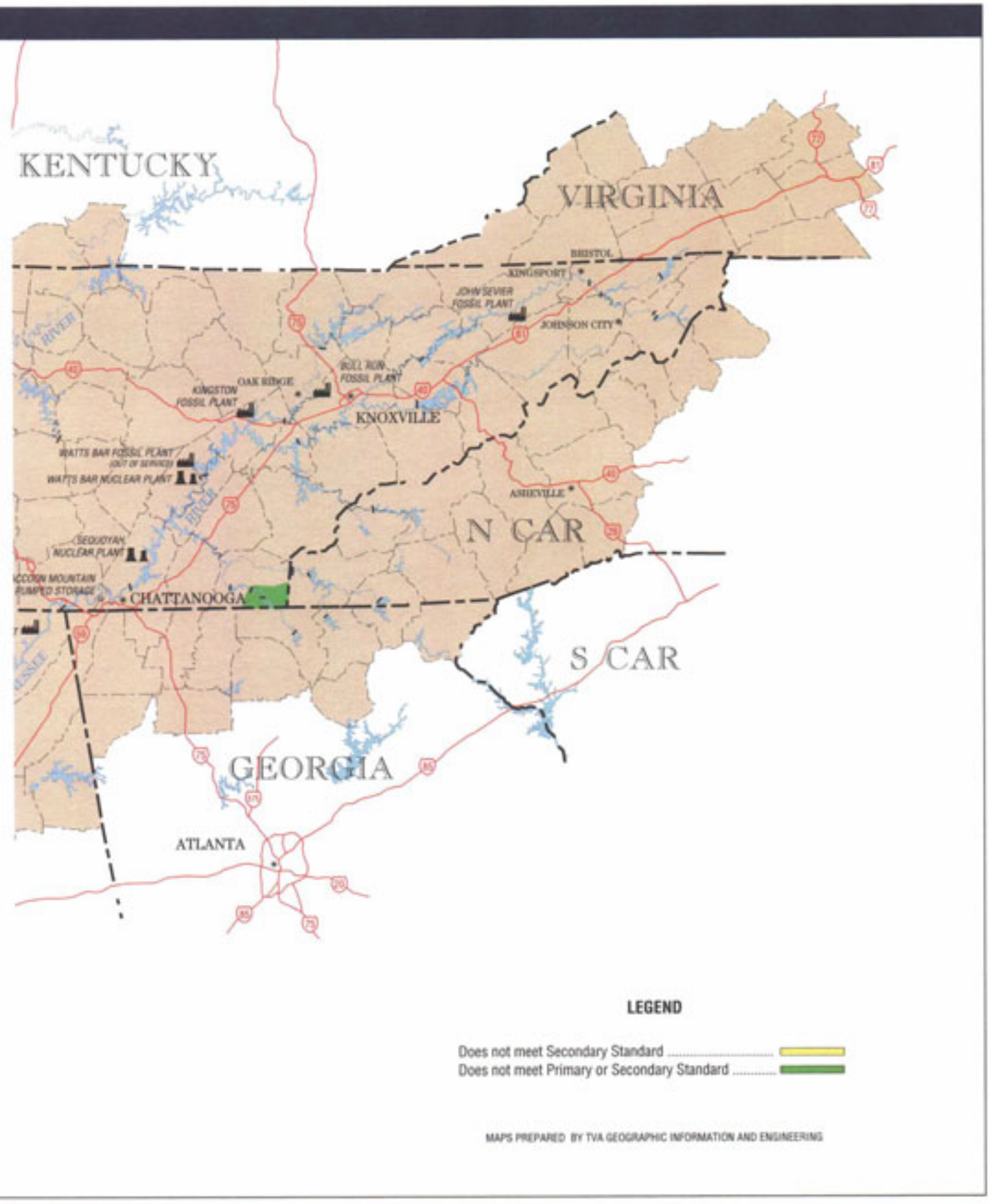
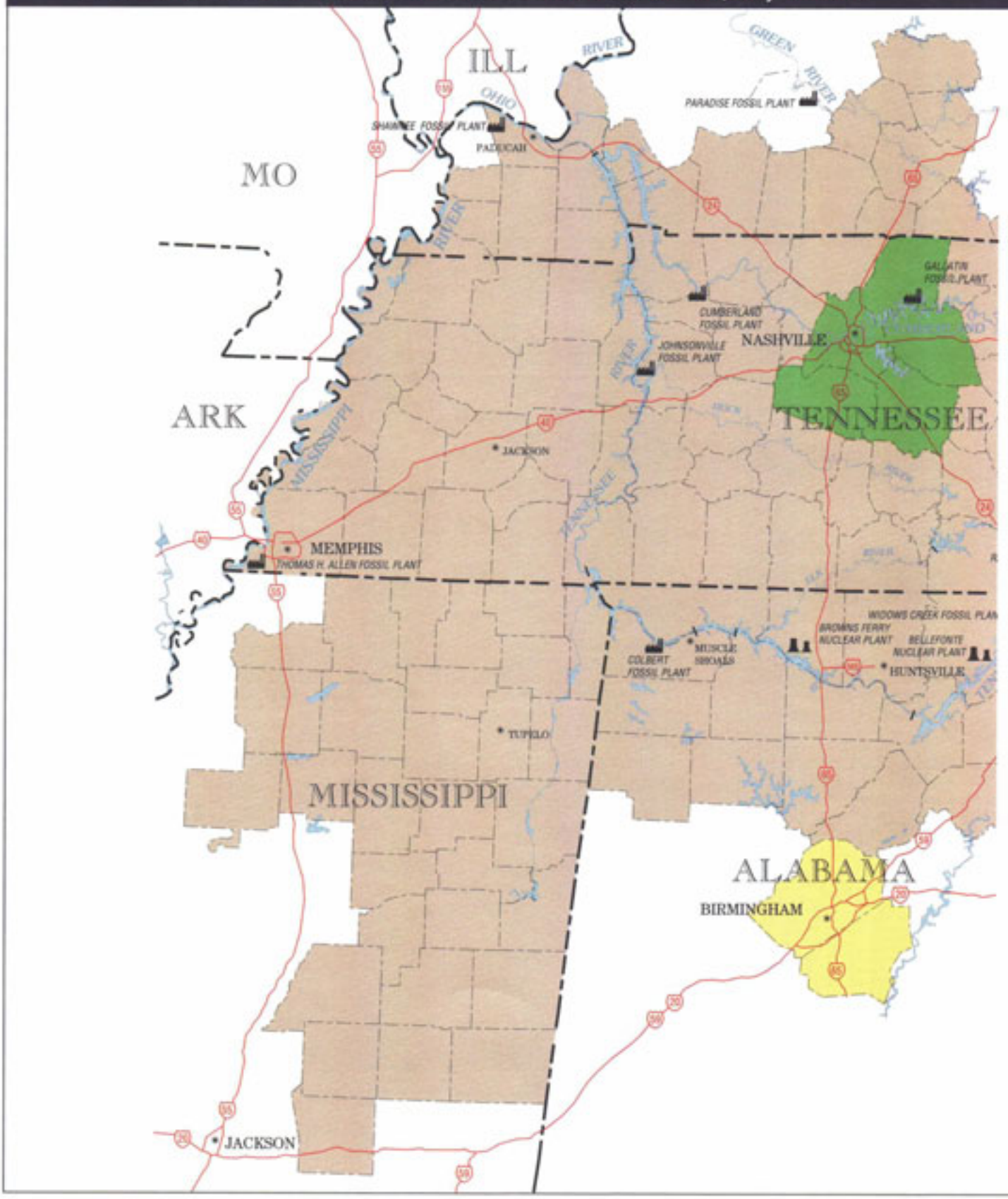

KENTUCKY
VIRGINIA
BRISTOL
KINGSPORT
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
BULL RUN FOSSIL PLANT
OAK RIDGE
KINGSTON FOSSIL PLANT
KNOXVILLE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
ASHEVILLE
N CAR
SEQUOYAH NUCLEAR PLANT
CHATTANOOGA
S CAR
GEORGIA
ATLANTA
LEGEND
Does not meet Secondary Standard
Does not meet Primary or Secondary Standard
MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE 3-4 **Areas in Nonattainment for Ozone Under the National Ambient Air Quality Standards**



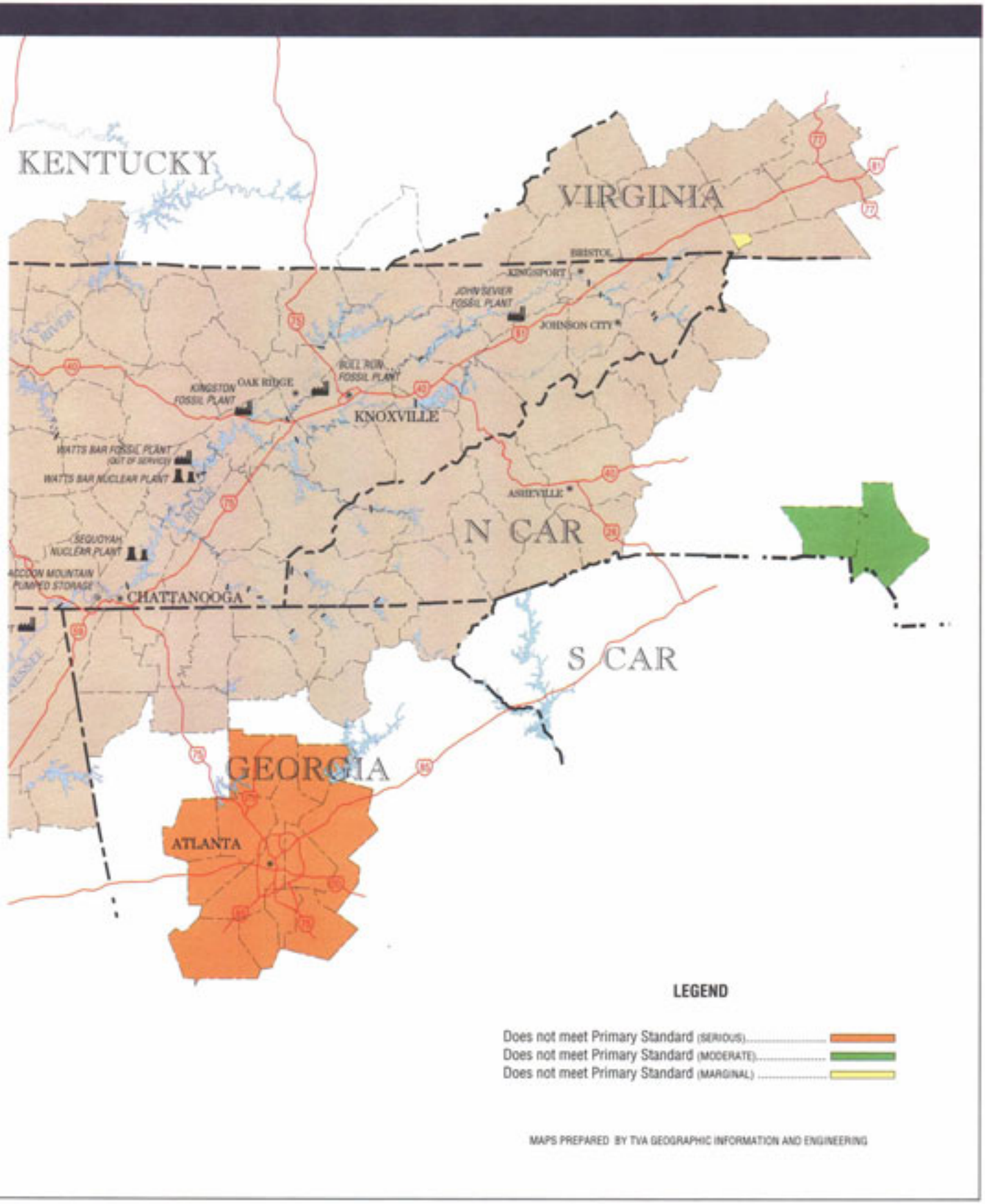
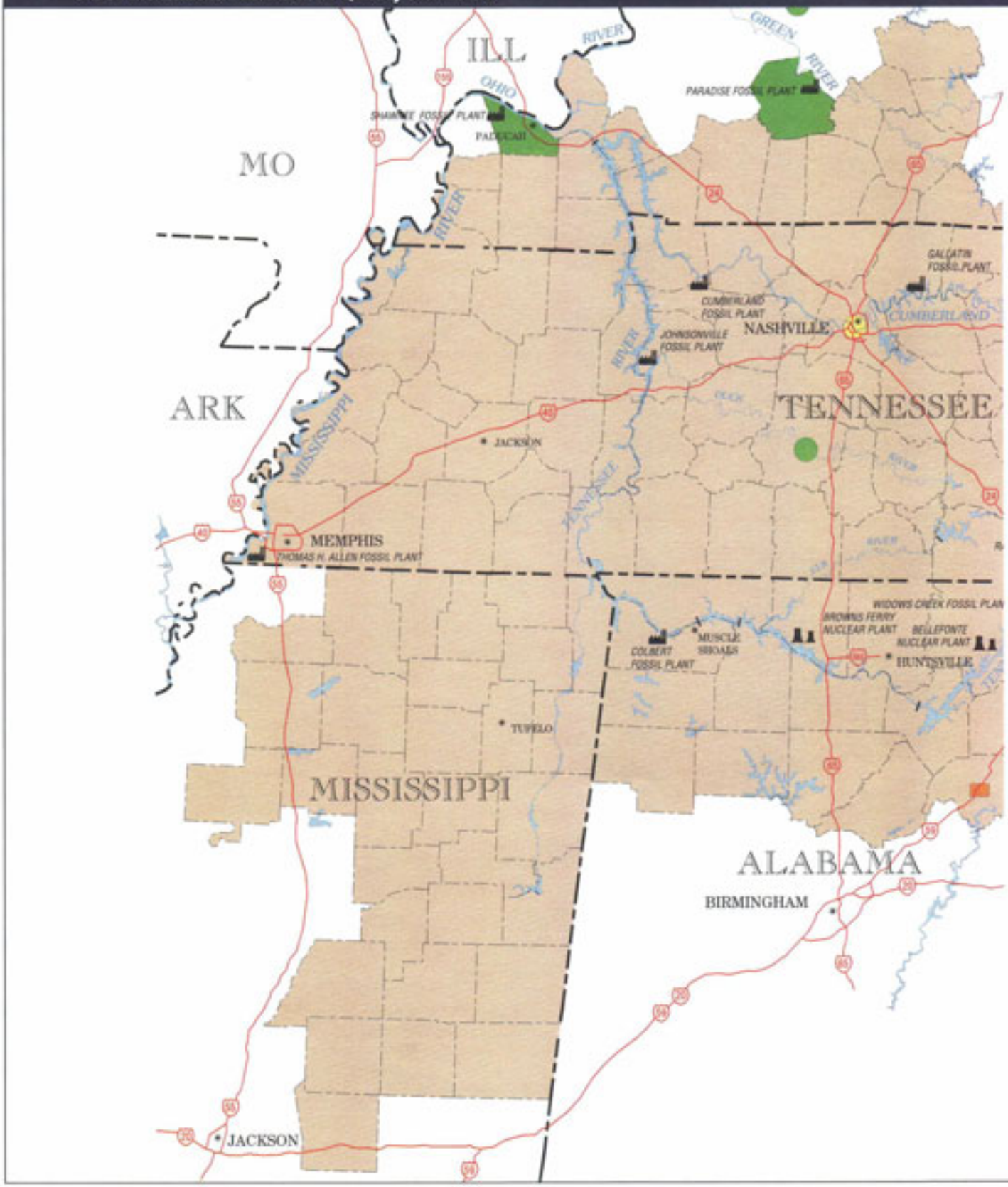
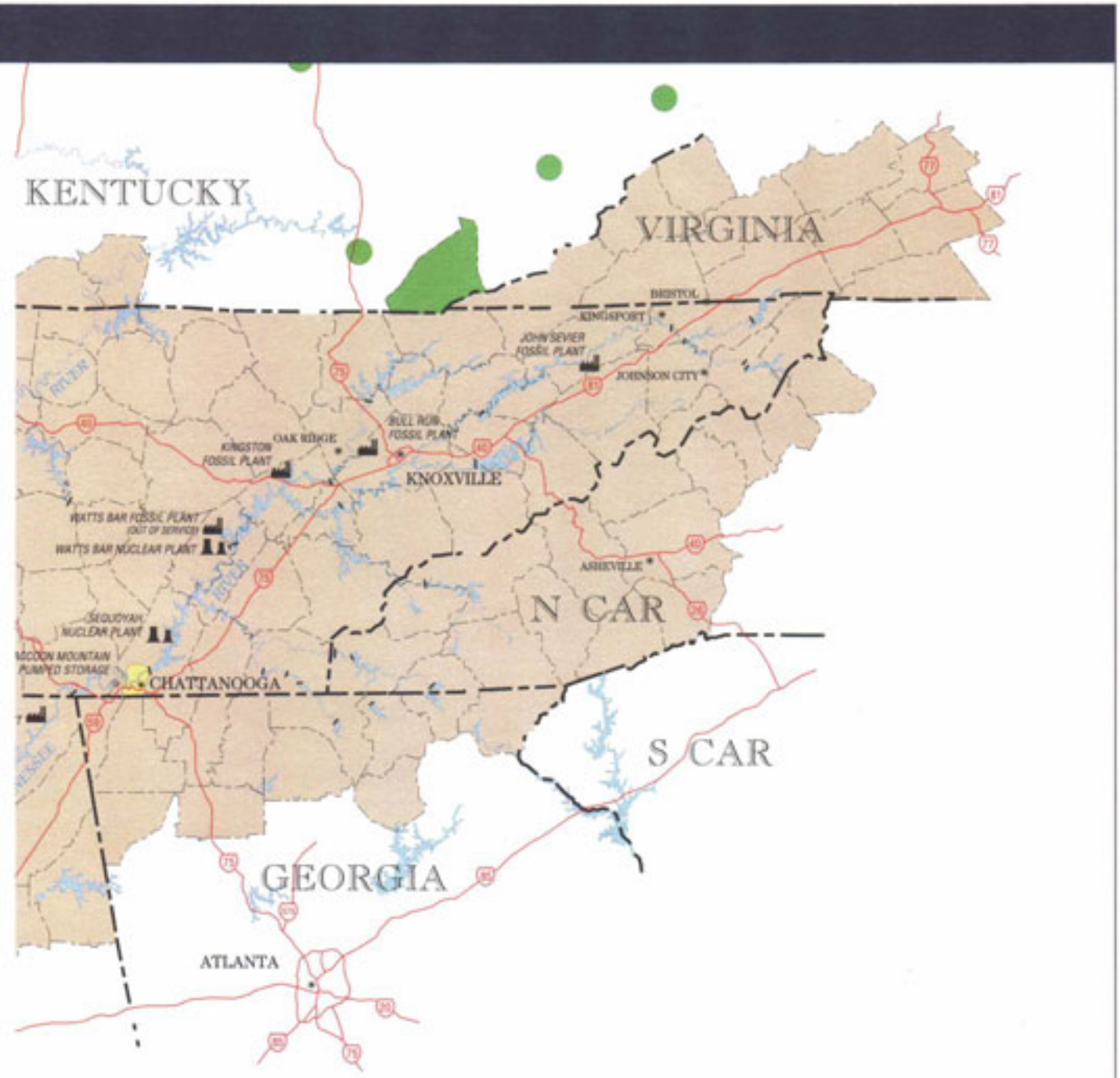

KENTUCKY
VIRGINIA
BRISTOL
KINGSPORT
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
BULL RUN FOSSIL PLANT
KINGSTON FOSSIL PLANT
OAK RIDGE
KNOXVILLE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
ASHEVILLE
N CAR
SEQUOYAH NUCLEAR PLANT
ACCOON MOUNTAIN PUMPED STORAGE
CHATTANOOGA
S CAR
GEORGIA
ATLANTA
LEGEND
Does not meet Primary Standard (SERIOUS)
Does not meet Primary Standard (MODERATE)
Does not meet Primary Standard (MARGINAL)
MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE 3-5. **Areas in Nonattainment for Total Suspended Particulate Matter Under the National Ambient Air Quality Standards**



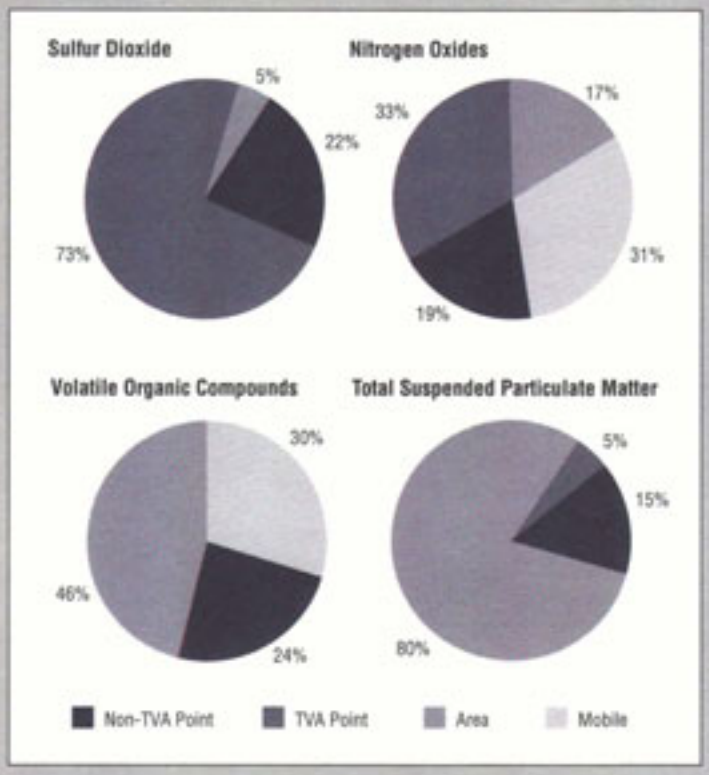


LEGEND

Does not meet Primary Standard
Does not meet Secondary Standard
Cannot be Classified

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE 3-7. **Total Emissions of Human-Produced Sulfur Dioxide, Nitrogen Oxides, Volatile Organic Compounds, and Total Suspended Particulate Matter from the 201-County TVA Service Area**



Total emissions of sulfur dioxide, nitrogen oxides, volatile organic compounds, and total suspended particulate matter. Emissions from point, area, and mobile sources from the 201-county TVA service area are derived from Environmental Protection Agency 1990 Interim Inventory. Total suspended particulate matter emissions are derived from the 1985 Interim Inventory.

Sources of Contributions

Coal-fired power plants, industrial boilers, ore smelters, and petroleum refineries are major human-produced sources (point or stationary sources). In the TVA region, TVA accounts for three-fourths of the total sulfur dioxide emissions produced by human activity *(Figure 3-7)*. In the greater source area that contributes to sulfur dioxide loadings in the Tennessee Valley, TVA's emissions are roughly one-fourth of total emissions. Installation of emission controls, coal washing, and switching to coals with lower sulfur content have reduced TVA's sulfur dioxide emissions by 60 percent over the past two decades *(Figure 3-8)*. Following full implementation of the 1990 Clean Air Act Amendments (i.e., following Phase II), TVA sulfur dioxide emissions are expected to remain below 500 thousand tons per year.

NITROGEN OXIDES (NO_X)

Health and Welfare Concerns

Nitrogen oxides can be a respiratory irritant but at typical outdoor concentrations, health impacts are negligible. Nitrogen oxides emissions, however, contribute to acid rain, ozone, and visibility impairment.

Sources of Contributions

Natural sources of nitrogen oxides include microbial activity, lightning, and forest fires. Major sources produced by humans include motor vehicles, fossil-fuel power plants, industrial boilers, nitrogen fertilizers, and agricultural burning. Within the TVA region, nitrogen oxides emissions from TVA power plants accounted for 33 percent of total human-produced nitrogen oxides emissions, with mobile sources a close second at 31 percent. *(See Figure 3-7.)* TVA emissions of nitrogen oxides annually have been 500,000 tons. These emissions will be reduced to roughly 300,000 tons annually as TVA installs control equipment in response to the 1990 Clean Air Act Amendments. (See *Figure 3-9.)*

The variations in nitrogen oxides emissions from 1984 to 1993 are a result of changes in coal-fired plant generation to meet varying load requirements

and also reflect the availability of both coal-fired and nuclear plants during this period. Reductions during 1993 to 1995 are partially a result of environmental control measures. The large reductions in 2000 are the results of the implementation of more significant environmental control measures in response to the Clean Air Act Amendments.

TOTAL SUSPENDED PARTICULATE MATTER (TSP)

Health and Welfare Concerns

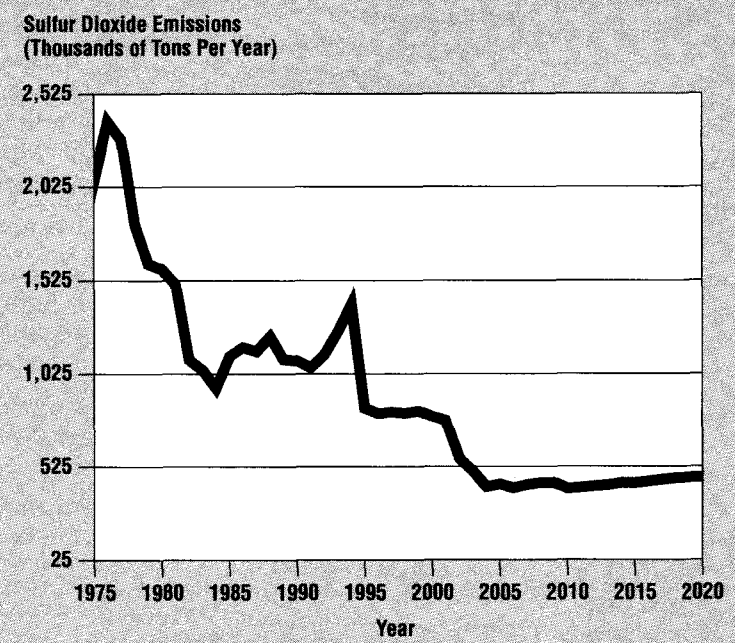
Particulate matter consists of small aerosol particles in the atmosphere that can impact the health of sensitive individuals and impair regional visibility. The particles of major concern for human health are less than 10 microns in size.

Particles emitted directly from a source are called primary particulate matter, whereas those formed in the atmosphere from emitted gases are called secondary particulate matter. Formation of secondary particulate matter of sulfates and nitrates from sulfur dioxide and nitrogen oxides and other elements occurs in the atmosphere as the pollutants are transported several hundred kilometers downwind from the points of origin. As with ozone, summertime conditions favor sulfate and nitrate particle formation. Because sulfate particles are the major contributor to regional haze in the eastern United States, visibility is usually poorest in the summer months.

Sources of Contributions

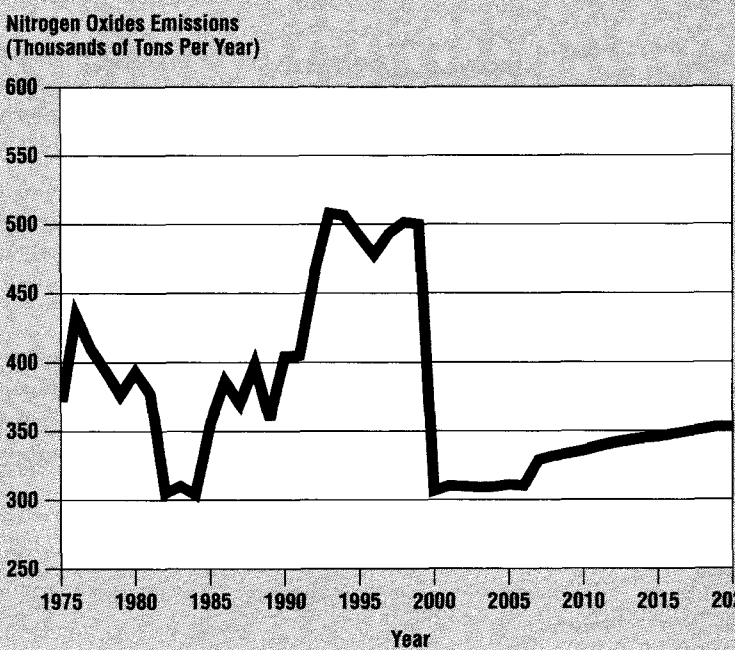
Particles in the air have many natural and human-produced sources. Human-produced sources include agriculture, waste incineration, industrial processing, fossil-fuel combustion,

FIGURE 3-8. **Historic and Projected TVA Emissions of Sulfur Dioxide**



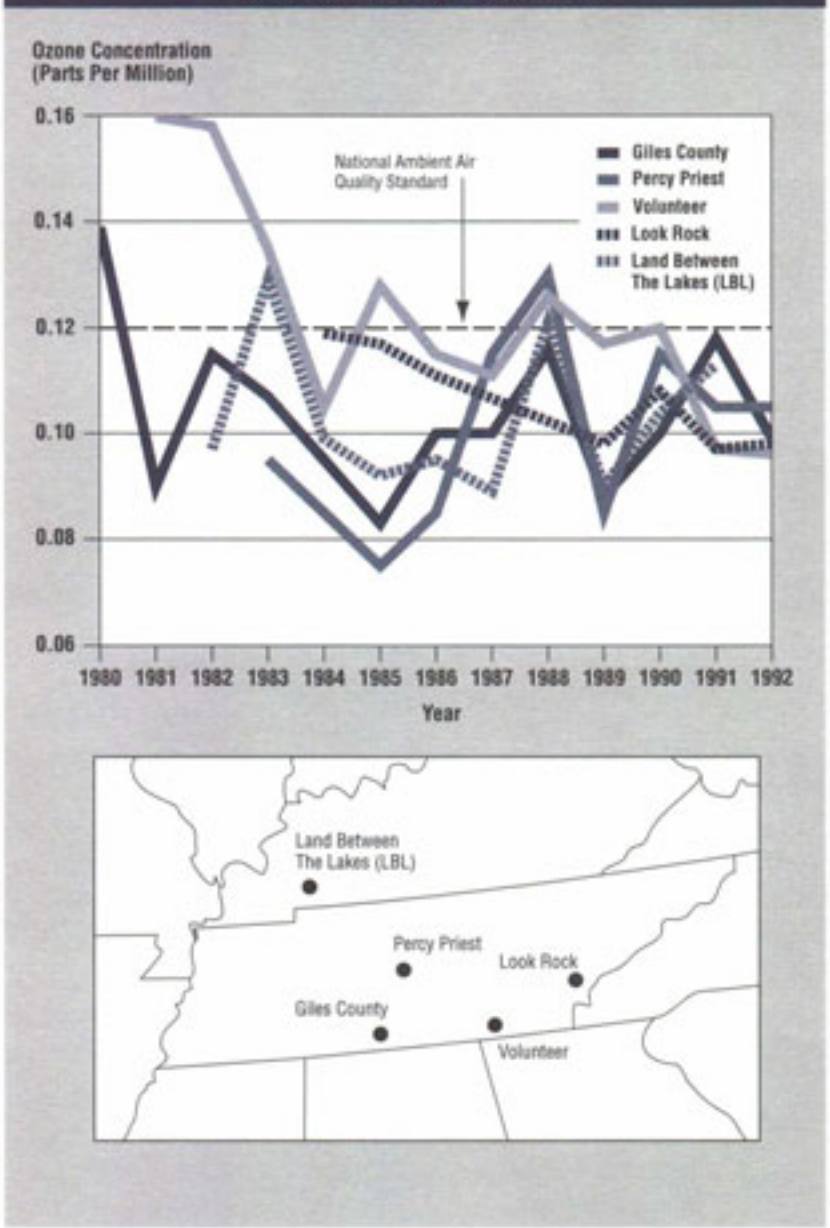
TVA emissions of sulfur dioxide have been reduced 60% since the 1970s and will be further reduced in compliance with the 1990 Clean Air Act Amendments.

FIGURE 3-9. **Historic and Projected TVA Emissions of Nitrogen Oxides**



TVA nitrogen oxides emissions increased during the 1990s as coal-fired generation increased. Emissions will decrease as TVA complies with the 1990 Clean Air Act Amendments.

FIGURE 3-10. **Maximum Hourly Ozone Concentrations at Five Monitoring Sites in the Energy Vision 2020 Study Area Have Shown Little Improvement**



construction, and mining. Human-produced emissions predominate in urban and industrial areas. Based on the 1985 emissions inventory by the National Acid Precipitation Assessment Program, TVA was found to contribute 5 percent of the human-produced total suspended particulate matter emitted in the 201 counties of the Tennessee Valley *(Figure 3-7)*. TVA emissions are primarily from coal-fired plants.

OZONE (INCLUDING NITROGEN OXIDES AND VOLATILE ORGANIC COMPOUNDS)

Health and Welfare Concerns

Ozone is a secondary air pollutant produced in the presence of sunlight from nitrogen oxides and volatile organic compounds in the lower atmosphere (troposphere). Ozone can irritate the eyes, nose, and throat, but typically the effects are temporary and pose no long-term health risks. Ozone at sufficient concentrations can harm vegetation and some materials.

In the Tennessee Valley, the cities of Chattanooga, Knoxville, Memphis, and Huntsville have recently attained the ozone standard. However, Nashville remains in non-attainment status. Other measures of ozone exposure across the Tennessee Valley have not shown any improvement that is discernable above the annual variability in trends due to meteorology *(Figure 3-10)*.

Sources of Contributions

Human-produced sources of nitrogen oxides, one of the contributors to ozone formation, were discussed earlier in this section. Human-produced sources of volatile organic compounds include motor vehicles, petrochemical storage and transport, chemical and industrial processing, and smaller sources. Vegetation, biological decay, and forest fires are natural sources of volatile organic compounds. In many areas of the southeastern United States, natural sources can contribute up to 90 percent of total volatile organic compounds. As shown in *Figure 3-7*, TVA emissions of volatile organic compounds are insignificant compared to the total amount emitted.

PREVENTION OF SIGNIFICANT DETERIORATION

The section of the 1977 Clean Air Act Amendments entitled "Prevention of Significant Deterioration" provides special protection for air quality and air quality-related values in national parks and wilderness areas, designated in the legislation as Class I areas. The Class I areas in the TVA region are designated on the map in *Figure 3-11.*

OTHER AIR QUALITY CONCERNS

Several air quality concerns have emerged in the past two decades. Acid deposition, regional visibility impairment, hazardous air pollutants, and greenhouse gases are now either regulated or being considered for regulation.

ACID DEPOSITION (INCLUDING SULFUR DIOXIDE AND NITROGEN OXIDES)

Health and Welfare Concerns

Acid deposition, or acid rain, is the acidification of rainfall below "natural" pH levels. Acid deposition can affect sensitive forests where ability to buffer incoming acids is depleted. High elevation spruce-fir forests, where loadings from wet, dry, and cloud deposition are greatest, are the most sensitive to acidification.

Data for the region around Tennessee indicate the most acidic (lowest pH) precipitation region to be Kentucky and portions of east Tennessee, with slightly lower acidity to the west and south. The lowest annual pH values for six sites across the TVA region are near 4.2 versus 5.2 to 5.6 for natural rainfall.

Sources of Contributions

TVA sulfur dioxide and nitrogen oxides emissions contribute to acid deposition. *(Figures 3-8 and 3-9)* The potential source area contributing to acid deposition in the Tennessee Valley is greater than that for ozone because the production rate of sulfate is slower than that for ozone. The rate of nitric acid formation is comparable to that of ozone. Conversion of sulfur dioxide to sulfate occurs within roughly 48 hours or an 800 to 1,000 kilometer distance from emissions sources. Thus, distant sources could be impacting sensitive areas such as the southern Appalachians, and TVA emissions could contribute to deposition outside the Tennessee Valley. However, the rate of sulfate formation can be very rapid in clouds, so depending on meteorological conditions, nearby sources may have greater contribution to deposition. TVA's contribution to acid deposition or acid rain is expected to decrease as its emissions of sulfur dioxide and nitrogen oxides are reduced in response to the 1990 Amendments to the Clean Air Act.

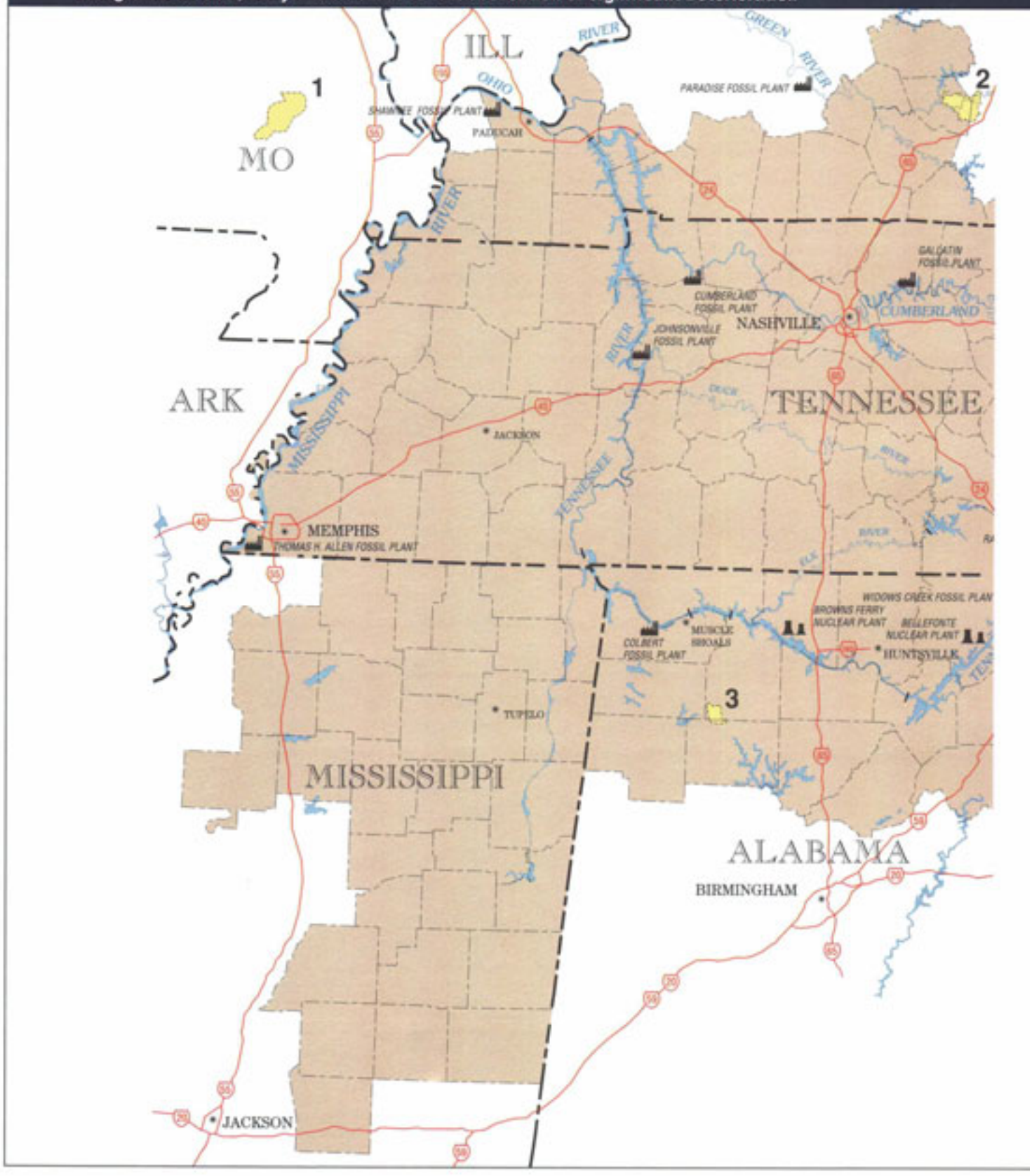
VISIBILITY IMPAIRMENT

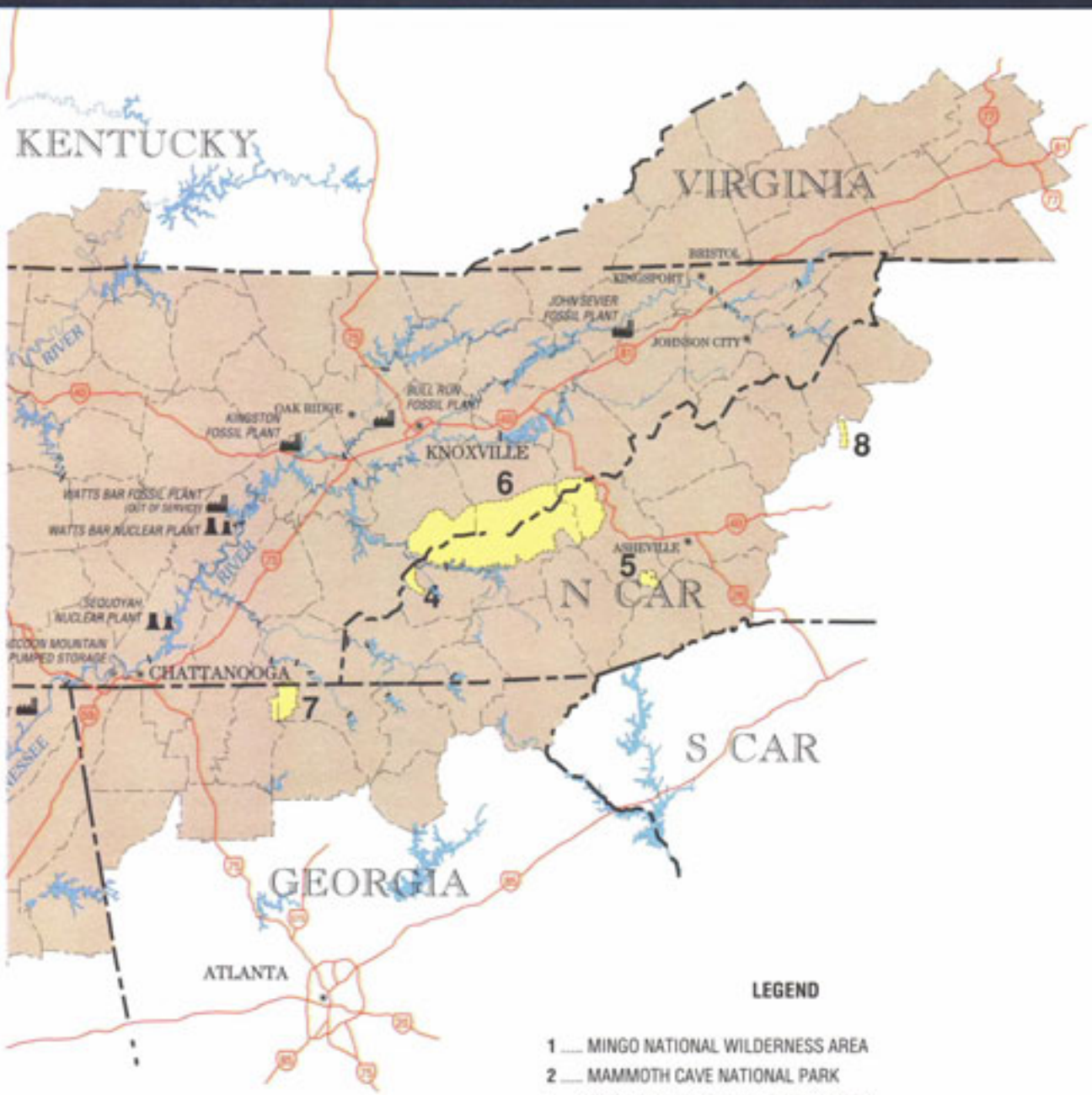
Health and Welfare Concerns

Visibility impairment refers to atmospheric conditions where the ability of an observer to discern form, color, or texture of a vista is reduced and therefore the scenic value of that vista is diminished.

Despite improvement in levels of sulfur dioxide *(Figure 3-6)* and particulate matter of less than 10 microns over the past decades, visibility has not

FIGURE 3-11. **National Park and National Wilderness Areas in the Energy Vision 2020 Study Area Designated as Air Quality Class I Areas for the Prevention of Significant Deterioration**





LEGEND

1 ..... MINGO NATIONAL WILDERNESS AREA
2 ..... MAMMOTH CAVE NATIONAL PARK
3 ..... SIPSEY NATIONAL WILDERNESS AREA
4 ..... JOYCE KILMER/SLICKROCK NATIONAL WILDERNESS AREA
5 ..... SHINING ROCK NATIONAL WILDERNESS AREA
6 ..... GREAT SMOKY MOUNTAINS NATIONAL PARK
7 ..... COHUTTA NATIONAL WILDERNESS AREA
8 ..... LINVILLE GORGE NATIONAL WILDERNESS AREA

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

improved in the TVA region. According to the U.S. Environmental Protection Agency's visibility studies, sulfates dominate visibility impairment in the eastern United States.

Sources of Contributions

The size of particles emitted directly from TVA facilities is generally larger than the size that impairs visibility. However, TVA sulfur dioxide and nitrogen oxides emissions contribute to levels of secondary sulfate and nitrate particles. The potential source area contributing to visibility impairment at areas of concern such as Class I areas in the southern Appalachians is roughly the same as that for acid deposition.

HAZARDOUS AIR POLLUTANTS

Health and Welfare Concerns

In the 1990 Clean Air Act Amendments, Congress identified 189 chemicals as air toxics. Depending on concentration, hazardous air pollutants can cause adverse health effects. From this list, the air toxics of greatest concern emitted by coal-fired power plants are arsenic, beryllium, cadmium, chromium, copper, and mercury. However, these pollutants are emitted in relatively small amounts.

Mercury is of special concern because levels observed in some sensitive watersheds in the upper midwestern United States, Canada, and Florida are sufficient to cause toxic effects to aquatic wildlife and to humans that consume contaminated fish. However, mercury levels in the Tennessee River and its tributaries are generally below thresholds set by the United States Environmental Protection Agency to protect human health. Atmospheric deposition in the Tennessee Valley is considered a minor contributor.

Radionuclides are one of the hazardous air pollutants being evaluated by the Environmental Protection Agency in its study of utility industry hazardous air pollutant emissions. Coal-fired boilers emit trace amounts of radioactive elements (uranium, radium, thorium, and their decay products) found in the fuel. These radionuclides become incorporated into fly ash and are released to the air in the particulate matter emitted from the boilers. Particulate air pollution control equipment, such as electrostatic precipitators, limit radionuclide emissions.

Sources of Contributions

The Electric Power Research Institute, the Environmental Protection Agency, and the Department of Energy have characterized toxic emissions for nearly 100 United States utility boilers representing a range of fuels, boiler configurations, and control technologies. On the basis of this data, the Electric Power Research Institute has estimated emissions and risk to human health from emissions at more than 600 utility plants. The Electric Power Research Institute's assessment indicated that none of the TVA plants and only 3 of the 600 plants in the study posed cancer risks greater than the 1-in-1-million criteria used by the Environmental Protection Agency as a level of possible health concerns.

GLOBAL CLIMATE CHANGE

The balance of solar energy received and heat radiated from the earth to space controls the earth's climate. Greenhouse gases absorb infrared (long wave) or thermal radiation emitted by the earth. This helps seal in some of the heat the earth would otherwise have lost from solar energy it received. The greenhouse effect is a natural phenomenon that makes the earth habitable. Greenhouse gases produced by human activities include water vapor, carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons.

Globally, atmospheric concentrations of greenhouse gases are believed to have increased from pre-industrial levels. The current rate of increase of carbon dioxide is 1.8 parts per million per year or 0.5 percent per year. Fossil fuel combustion and global deforestation are the primary contributors to carbon dioxide buildup. There is little doubt that carbon dioxide concentrations are increasing, but scientific debate continues about its consequences. Should changes in temperature and rainfall occur within a region such as the Tennessee Valley, there could be far-reaching impacts in areas such as energy, transportation, agriculture, forestry, and socioeconomic factors.

Despite the scientific uncertainties, TVA has agreed, along with some 75 other utilities, to participate in the United States Department of Energy's Climate Challenge initiative and to voluntarily limit equivalent TVA carbon dioxide emissions by the year 2000.

AIR QUALITY INDICES

TVA's existing energy resources and many of the resource options considered for Energy Vision 2020 can affect air quality in different ways. Air indices were developed to help characterize how TVA power system operations and alternative energy strategies might affect air quality impact areas.

A separate measure was also developed to sum the net greenhouse gas emissions for alternative future energy supply strategies. The measure is expressed in equivalent tons of carbon dioxide, the most common greenhouse gas.

A full explanation of the process used to develop measures for environmental evaluation criteria can be found in Volume 2, Technical Document 4, Evaluation Criteria.

Regional Water Resources

INTRODUCTION TO WATER RESOURCES AND POLLUTANTS

The quality of the region's water (surface water and groundwater) is critical to protection of human health and aquatic life. These water resources provide habitat for aquatic life, recreation opportunities, domestic and industrial water supplies, and other benefits.

Water quality can be affected through air emissions and deposition and wastewater from power plants, construction of facilities, and extraction of fuels to be used in power plants.

The scope of Energy Vision 2020 covers the TVA operating area, which includes the entire Tennessee and Cumberland River basins and portions of the lower Ohio, lower Mississippi, and Green and Ohio River basins *(Figure 3-12)*. Fresh water abounds in this area and generally supports most beneficial uses, including fish and aquatic life, public and industrial water supply, waste assimilation, agriculture, and water-contact recreation such as swimming. Water quality in the TVA region is generally good.

THE TENNESSEE RIVER

The Tennessee River basin contains all except one of TVA's dams and covers most of the TVA region. A series of nine locks and dams built mostly in the 1930s and 1940s regulates the entire length of the Tennessee River and allows nav-

FIGURE 3-13. **Principal Water Quality Concerns in TVA Reservoirs**

Navigation & West Tributary Reservoirs	USES AFFECTED				SOURCE	
	Aquatic Life	Fish Consumption	Recreation	Water Supply	Point	Non-Point
Kentucky			Aquatic Plants			
Normandy	Low Dissolved Oxygen			Taste, Odor, Iron, Manganese	X	
Pickwick				Algae		X
Wilson	Low Dissolved Oxygen			Taste, Odor		X
Wheeler	Low Dissolved Oxygen	DDT			X	X
Tims Ford	Low Dissolved Oxygen					X
Guntersville			Aquatic Plants			X
Nickajack		PCBs, Chlordane			X	X
Chickamauga	Low Dissolved Oxygen				X	X
Watts Bar	Low Dissolved Oxygen	PCBs			X	X
Melton Hill		PCBs				X
Ft. Loudoun		PCBs	Bacteria		X	X
Tellico	Low Dissolved Oxygen	PCBs				X
East Tributary Reservoirs						
Norris	Low Dissolved Oxygen					X
Cherokee	Low Dissolved Oxygen				X	X
Ft. Patrick Henry						
Boone	Low Dissolved Oxygen	Metals, Toxics			X	X
South Holston	Low Dissolved Oxygen					X
Wilbur						
Watauga						
Douglas	Low Dissolved Oxygen			Color	X	X
Nolichucky	Siltation		Siltation	Siltation		X
Fontana	Low Dissolved Oxygen					X
Ocoee 1-3	Metals, Siltation	PCBs	Siltation		X	X
Blue Ridge						
Appalachia						
Hiwassee	Low Dissolved Oxygen					X
Nottely	Low Dissolved Oxygen				X	X
Chatuge	Low Dissolved Oxygen					X

igation to Knoxville. Virtually all the major tributaries have at least one dam, creating 14 multi-purpose storage reservoirs and seven single-purpose power reservoirs. *Figure 3-12* is a map of the basin, showing dams and reservoirs. This system of dams and their operation is the most significant factor affecting water quality and aquatic habitats in the Tennessee River and its major tributaries.

Surface Water

Major water quality concerns within the Tennessee River drainage basin include point and non-point sources of pollution that degrade water quality at several locations on mainstream reservoirs and tributary rivers and reservoirs. The principal water quality concerns in TVA reservoirs are summarized in *Figures 3-13* and *3-14*. This informataion was derived primarily using data and analysis generated through TVA's comprehensive ecological health and use suitability monitoring program as well as other TVA aquatic monitoring and assessment activities. The criteria used in making the determinations were state water quality standards and fish consumption advisories.

Point and Non-Point Sources of Pollution

Point and non-point sources of pollution include:

- **Heat-release**—Utility plants and industry may release into streams or lakes water that has been heated above the temperature of the body of water.
- **Wastewater**—Sewage treatment systems, industry, and others dispose of waste into streams and lakes.
- **Runoff**—from agriculture, urban uses, and mined land are non-point sources that result in stream or lake pollution.
- **Air pollution**—Pollutant concentrations in the air can affect surface waters through rainout and deposition.

TVA Heat Releases

TVA conducts extensive aquatic monitoring programs to ensure that thermal and other discharges do not cause adverse impacts even at permitted levels. Recent programs have focused primarily on potential effects on spawning and development of cool-water fish species such as sauger, but have also included attraction of fish to thermal plumes from power plants and possible increases in undesirable aquatic micro-organisms, such as blue-green algae. In general, these monitoring programs have detected no significant negative effects resulting from release of heated water from TVA facilities. That is, there

FIGURE 3-14 **Principal Water Quality Concerns in Tennessee Valley Watersheds [1]**

	USES AFFECTED [2]			SOURCE	
Watershed	Aquatic Life	Fish Consumption	Recreation	Point	Non-Point
Chickamauga-Nickajack		PCBs	Bacteria		X
Pickwick-Wilson	Toxics				X
Watts Bar-Melton Hill	Siltation	PCBs	Bacteria		X
Duck River	Siltation		Bacteria		X
Guntersville-Sequatchie	Siltation		Bacteria		X
Clinch-Powell	Siltation				X
Wheeler-Elk		DDT, PCBs	Bacteria		X
Holston	Toxics	Mercury	Bacteria	X	X
French Broad	Siltation	Dioxin	Bacteria	X	X
Little Tennessee	Siltation	PCBs		X	X
Hiwassee	Metals, Siltation			X	X

[1] As designated by TVA's Clean Water Initiative

[2] Uses are affected by the problem noted on at least one stream in the watershed.

Figure 3-12. **Water Resources Considered in Energy Vision 2020 Include the Entire Tennessee River Basin and Portions of the Cumberland, Ohio, Mississippi, and Green River Basins**

LEGEND

State Boundary
County Boundary
Stream, Tributary, Lake
TVA Power Facilities; Fossil, Hydro
Nuclear, Pumped Storage
Major Cities

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

has been no demonstrable damage to established water uses or aquatic ecological integrity.

TVA Wastewater

Nuclear Plant Wastewater. Nuclear power plants have noncomplex wastewaters that are subjected to various levels of treatment and usually discharged to surface waters. These releases are controlled through state-issued National Pollutant Discharge Elimination System permits, which are part of Federal Clean Water Act statutes. Periodic toxicity testing is performed on this discharge as part of the National Pollutant Discharge Elimination System permit to ensure that plant wastes do not contain chemicals at deleterious levels that could affect aquatic life.

Coal-Fired Plant Wastewater. Coal-fired plants have several liquid waste streams that are treated and released to surface waters. These releases are permitted by each state under the National Pollutant Discharge Elimination System. Periodic toxicity testing of coal-fired wastewater ensures that there are no acute or chronic toxic effects to aquatic life.

Runoff and Air Pollution. Many non-point sources of pollution have not been subjected to government regulations or control and can contribute as much as five times more dissolved oxygen-consuming wastes than point sources. Principal causes of non-point source pollution are agriculture, including runoff from fertilizer, and pesticide and herbicide applications, erosion, and animal wastes; mining, including erosion and acid drainage; and urban runoff. Atmospheric deposition is another potential source of water pollution, particularly in relation to acid rain and fallout of toxic metals.

Low Dissolved Oxygen Levels

Another major water quality concern in the Tennessee River is low dissolved oxygen levels in stream reaches downstream of TVA dams. Long stretches of river can be affected, especially in areas where non-point source pollution uses up the dissolved oxygen restored through natural reaeration. TVA addressed this issue in its 1990 environmental impact statement, "Tennessee River and Reservoir System Operation and Planning Review." TVA has initiated a program to improve dissolved oxygen levels in water discharged from its dams based on this study.

Groundwater

Groundwater refers to water located beneath the surface in rock formations known as aquifers. Approximately half of the region has limited groundwater availability because of natural geohydrological conditions.

More than 64 percent of the region's residents rely totally, or in part, on groundwater for drinking water. More than 1.7 million residents (22 percent) in the region maintain individual household groundwater systems, usually a well. All areas in the Tennessee Valley region can generally supply enough

water at least for domestic needs. For the most part, the groundwater quality is adequate to support existing water supply uses even though some minimal treatment, such as filtration and chlorination, might be required.

Aquatic Life

The construction of the TVA dam and reservoir system fundamentally changed the character of the Tennessee River and its tributaries. While dams promote navigation, flood control, power benefits, and river-based recreation by moderating the flow effects of floods and droughts throughout the year, they also disrupt the daily, seasonal, and annual flow patterns that are characteristic of a river.

Tributary Reservoirs and Tailwaters

Reservoirs on the tributaries to the Tennessee River are typically of the deep storage type that retain water for long periods of time. Little flow and regular periods of thermal stratification result in oxygen depletion in the deeper water. These aquatic habitats are simplified relative to undammed streams, and fewer species are found. Lack of minimum flows and low dissolved oxygen in the first few miles below tributary dams may severely limit the habitat needed by native fish. This may restrict their movement, migration, reproduction, and available food supply.

Dams on tributary rivers affected the habitat of benthic invertebrates (benthos), which are a vital part of the food chain of aquatic ecosystems. Benthic life includes worms, snails and crayfish, which spend all of their lives in or on the stream beds, and aquatic insects, mussels and clams, which live there during all or part of their life cycle. Many benthic organisms have narrow habitat requirements that are not always met in reservoirs or tailwaters below dams. Further downstream from dams, the number of benthic species increases as natural reaeration occurs and dissolved oxygen and temperatures rise.

Mainstream Reservoirs

The nine mainstream reservoirs on the Tennessee River differ from tributary reservoirs primarily in that they are shallower, have greater flows, and thus retain the water in the reservoir for a shorter period of time. They generally do not become as strongly stratified as tributary reservoirs. Although dissolved oxygen in the lower lake levels is often reduced, it is seldom depleted. Winter drawdowns on mainstream reservoirs are much less severe than tributaries, so bottom habitats generally remain wetted all year. This benefits benthic organisms, but promotes the growth of aquatic plants in the extensive shallow overbank areas of some reservoirs.

Tennessee River mainstream reservoirs generally support healthy fish communities, ranging from about 50 to 90 species per reservoir. Good to excellent sport fisheries exist, primarily for black bass, crappie, sauger, white and striped bass, sunfish, and catfish. The primary commercial species are channel and blue catfish and buffalo.

OTHER RIVERS IN THE STUDY

The Tennessee River basin contains most of TVA's dams and power plants. In addition to these facilities, the Ohio, Green, and Mississippi Rivers each host a TVA coal-fired plant; and the Cumberland River basin, two coal-fired plants and a hydroelectric plant.

Any surface water, groundwater, and aquatic life characteristics in these rivers that differ from those described under the Tennessee River can be found in Volume 2, Technical Document 1, Comprehensive Affected Environment, as can a more detailed discussion of the affected environment of the Tennessee River.

WATER QUALITY INDICES

Water indices were developed to help characterize how TVA power system operations might contribute to each of the environmental impact areas selected. The indices provide measures to evaluate environmental impacts of alternative future energy supply strategies. Measures in the indices are weighted by the relative contribution of TVA power system operations to water quality impacts and issues. A full explanation of the process used to develop measures for environmental evaluation criteria can be found in Volume 2, Technical Document 4, Evaluation Criteria.

Regional Land Resources

INTRODUCTION TO LAND RESOURCES

The TVA region encompasses some 58 million acres. Of this area, non-federal rural land occupies about 50 million acres. As in all areas inhabited by humans, resource problems do exist. Humans have influenced the entire Tennessee Valley and its adjacent region through agriculture, timber harvesting, and other land uses.

A broad range of land uses takes in management of the natural ecosystem, agriculture, forestry, urban and industrial use, and recreational use. Factors such as soils, groundwater, wildlife, sensitive or threatened ecosystems, threatened and endangered species, cultural resources, and terrestrial environments, such as wetlands and forests, are critically important in supporting and preserving these uses.

TVA affects land resources through site selection for power plants, reservoirs, and transmission lines; fuel procurement; air emissions; radioactive waste management; and solid waste management.

AGRICULTURAL LANDS AND CROP PRODUCTION

The TVA region is a predominantly rural area with 40 percent of the land area in crop production or pasture and 55 percent in forest. Small farms that grow and market a wide diversity of agricultural products characterize agriculture in the Tennessee Valley. Corn, cotton, soybeans, tobacco, wheat, and vegetables account for the major crops produced in the region. Livestock production is

another major agricultural activity and land use. About 14 million acres of prime farmland occupy the Tennessee Valley region, distributed as 55 percent cropland, 23 percent pasture, 20 percent forest, and 2 percent nonagricultural.

FOREST RESOURCES

Fifty-five percent of the TVA region is forested. Reserved forest land, consisting of parks, wilderness areas, and other forested lands specifically withdrawn from commercial timber cutting by legislation or administrative designation, totals 944,976 acres. The remainder of the forested area, 31 million acres, or 97 percent of the forest, is classified as timberland.

Forest stressors include past land use practices that resulted in erosion and site degradation, extreme climactic conditions (freezing injury, ice damage, drought, flooding), air pollutants, and exotic, as well as native, forest insects and diseases.

CULTURAL RESOURCES

The Tennessee Valley region features many archaeological sites. The National Historic Preservation Act requires federal agencies to appropriately identify, protect, and manage significant cultural resources on their land or those affected by their undertakings whether on federal or nonfederal property.

OTHER LAND USE CONDITIONS

Electric and Magnetic Fields

Electric and magnetic fields (EMF) are both natural and man-made. For example, every device that generates, transmits, or uses electricity produces these two types of energy fields. These include electric power lines, electric appliances, motor vehicles, and electric wiring.

A 1979 epidemiological study suggested that there might be a potential link between magnetic fields associated with electric distribution lines and childhood leukemia. After 15 years of further research, results have been mixed. If EMF does indeed pose a risk, most researchers believe that it is low.

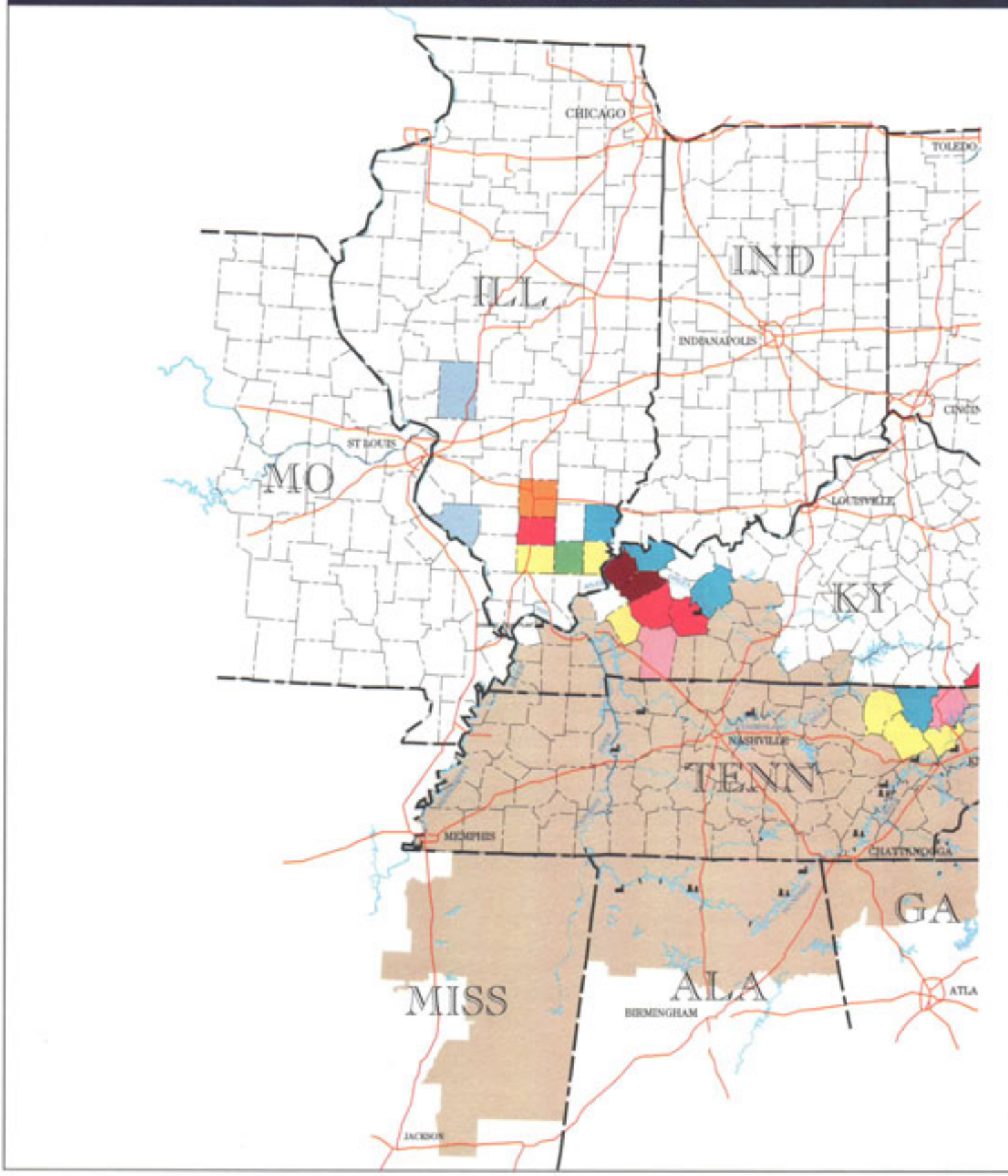
No federal regulations govern EMF exposure levels. TVA adopted interim guidelines in 1993 that address EMF exposures. Under these guidelines, TVA will take into account EMF exposure when planning new transmission lines. In addition, TVA will design upgrades of existing lines to reduce EMF levels when practicable.

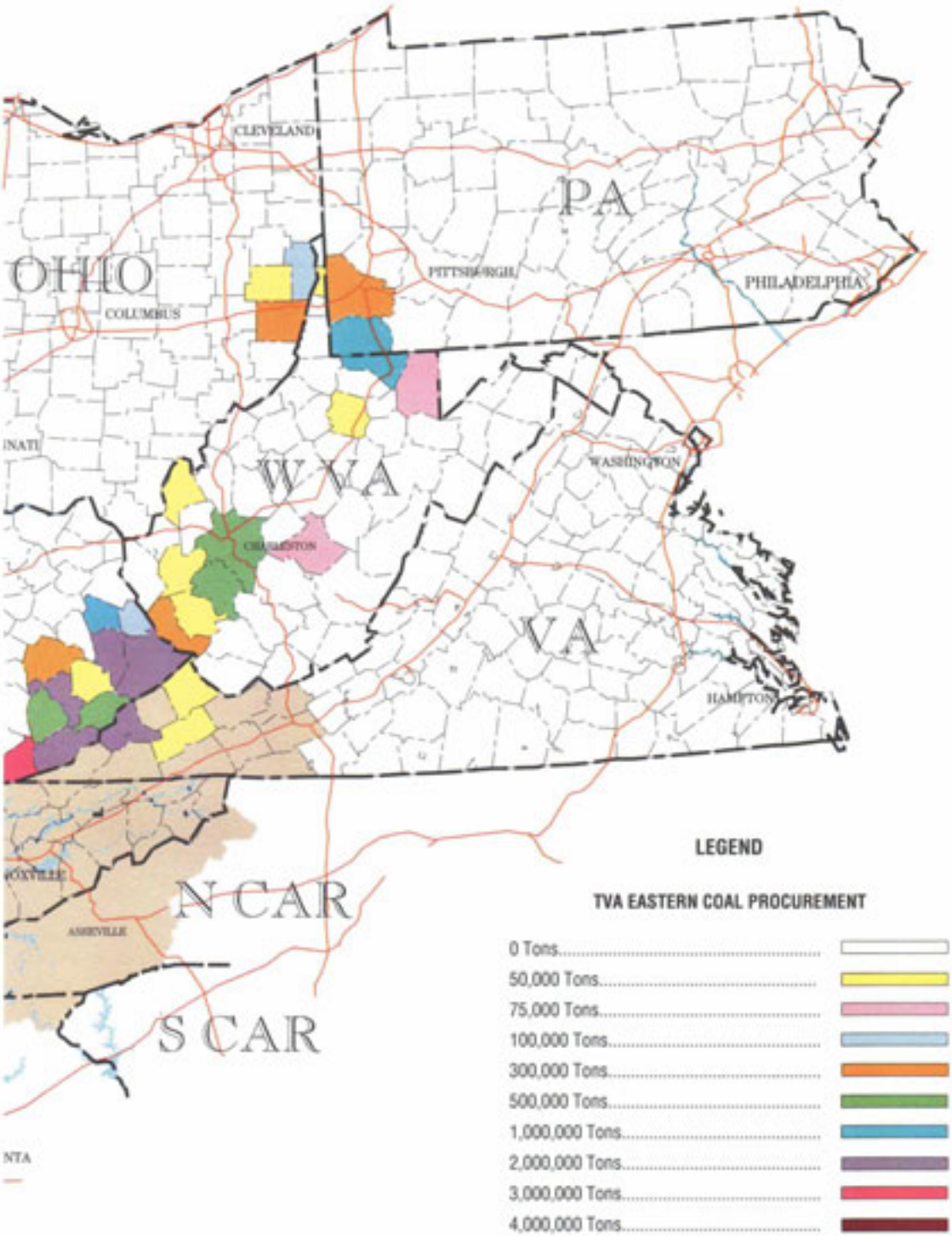
Fuel Procurement

TVA's eastern coal procurements are about 7.1 percent of the eastern United States production (east of the Mississippi River) and about 0.36 percent of the western United States production. The map in *Figure 3-15* shows the location and intensity of TVA coal procurement in the eastern United States by county for fiscal year 1994.

Land-related environmental impacts of mining are primarily the direct and indirect effects of changes in land use. These impacts may include acid drainage from exposed sulfur-bearing rock, erosion from disturbed mining areas

FIGURE 3-15. **TVA Procured Coal From Seven Eastern States in Fiscal Year 1994**





MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

and coal transport roads, loss of wildlife habitat, stream siltation, unstable land situations, and fugitive dust. Various regulations, including those implementing the Surface Mining Control and Reclamation Act of 1977, have reduced the potential risk of significant impacts.

The natural uranium for TVA's nuclear plants comes from uranium producing areas all over the world. TVA's five nuclear units use a total of about 2.5 million pounds of U308 per year. TVA currently has sufficient inventory to last until 1999. TVA and a number of other United States utilities are expected to soon be using commercial grade slightly enriched uranium derived from nuclear warheads. The highly enriched uranium obtained from both United States and Russian nuclear warheads will be diluted to low levels, which allows its use in commercial nuclear plants.

Coal Combustion Solid Wastes

The combustion of pulverized coal in power plant boilers produces solid wastes such as fly ash and bottom ash (or boiler slag in some boiler designs). Any of these wastes may be marketed as byproducts, depending on their quality and on market conditions.

TVA production of these byproducts during fiscal year 1994 was nearly 6 million tons, with almost half being fly ash. Of the 6 million tons, 1.177 million tons, or 20 percent, were utilized or marketed. The remainder of the byproducts is either disposed of or stored on the plant site in ash ponds or in dry-stacked landfills.

Nuclear Waste

The nuclear fuel used for power plants produces radioactive solid wastes requiring storage and disposal. These wastes are placed in two categories: high-level radioactive waste and low-level radioactive waste. These indicate the type of radioactive material, the intensity of its radiation, and the time required for decay of the radiation intensity to natural levels.

High-Level Nuclear Waste

Background. Operation of TVA's 5 nuclear units will produce about 115 metric tons of used fuel each year. After it is removed from the reactor, used or spent fuel is stored at nuclear plant sites either in pools or in dry casks. The Nuclear Waste Policy Act of 1982 established a program to build the nation's first underground high-level waste repository early in the next century. In 1987, amendments to the Nuclear Waste Policy Act designated the remote area of Yucca Mountain, Nevada, northwest of Las Vegas, for study as a permanent repository site. The Department of Energy has begun site characterization and the comprehensive scientific investigation of Yucca Mountain's suitability.

TVA Spent Fuel Storage. TVA plans to continue to store spent nuclear fuel on-site at plant locations until the Department of Energy accepts physical custody by shipment off-site to a monitored retrievable storage facility or to an underground repository for ultimate disposal by burial. Current spent fuel storage capacity is sufficient at Sequoyah Nuclear Plant until 2004, and Browns

Ferry Nuclear Plant until 2007. Based on a one-unit operation of Watts Bar Nuclear Plant, spent fuel storage capacity will be sufficient until 2018.

TVA has sufficient outside site area at each of its nuclear facilities to store any high-level waste associated with decommissioning activities and life-of-plant quantities of used fuel. As the pools approach the current storage limits, TVA will initiate studies to increase on-site storage capacity.

Low-Level Nuclear Waste

In a nuclear energy plant, the low-level radioactive waste comes from items such as filters, cloth and paper wipes, plastic shoe covers, tools and materials, water purification media (resins), and other residues.

Until July 1995, the low-level waste generators located in the eight Southeastern states were required to dispose of their waste at the Barnwell, South Carolina disposal facility. In July, South Carolina withdrew from the Southeast Compact Commission in order to open the Barnwell facility to all states except North Carolina. The states participating in the Southeast Compact Commission have selected North Carolina as the host state to select, license, and construct a new disposal site. TVA plans to continue to use the Barnwell facility for low-level radioactive waste disposal until the North Carolina facility is opened. Should either or both of the disposal facilities close unexpectedly, low-level radioactive waste will be stored in on-site facilities at the TVA nuclear plants. These facilities are sized to handle any anticipated storage needs for the foreseeable life of the plants.

BIOLOGICAL RESOURCES

The biological resources of the Valley are summarized in this section.

Terrestrial Ecology

Wetlands

Wetlands are typically lands that are covered by shallow water or have a water table near the surface, or support plants typically found in wet habitats. Although wetlands occur throughout the TVA region, they are most extensive in the south and west.

Wildlife

The TVA region contains portions of seven physiographic regions and a great variety of plant and animal communities. About 70 species of mammals, 300 species of birds (including 175 which nest within the region), 65 species of reptiles, and 77 species of amphibians can be found regularly in the region. Several salamander species are only found in the TVA region (endemic). Few other terrestial vertebrate species are restricted to the TVA region

Vegetation

TVA's 201-county region contains approximately 4,300 species of herbs, shrubs, and trees in numerous habitats and plant communities. Much of the region is heavily forested. Based on an analysis of mature forests, Braun recognized

five major forest regions in the TVA area. Local vegetation types vary greatly within Braun's regions because of variation in elevation, relief, soil fertility, moisture, and the degree of human disturbance. These forest regions are described in more detail in Volume 2, Technical Document 1, Comprehensive Affected Environment.

Sensitive or Threatened Ecosystems

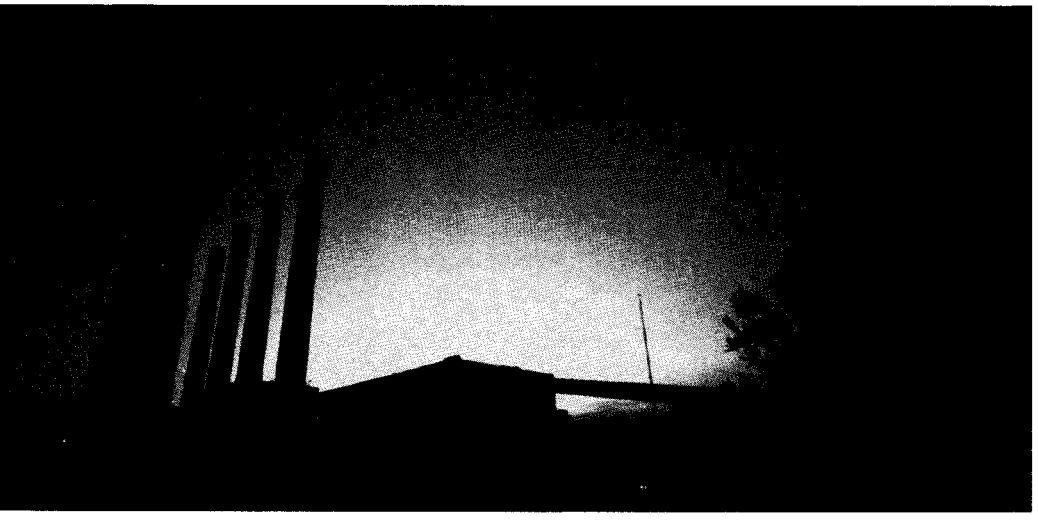
The TVA region includes several terrestrial communities that are either restricted to the TVA region, are best represented there, or include a large proportion of their total area in the region. These include the Southern Appalachian spruce-fir, cedar glade, and limestone cave systems. Several endangered plant and/or animal species, as well as species not found outside the TVA region, occur in each of these communities.

Threatened and Endangered Species

Thirty-eight species of plants and 100 species of animals in the TVA region are either listed as endangered or threatened species or formally proposed for such listing by the United States Fish and Wildlife Service. These species, their distribution by river basin, and their habitats are listed in Volume 2, Technical Document 1, Comprehensive Affected Environment. An additional 380 species in the TVA region have been identified by the United States Fish and Wildlife Service as candidates for listing.

Chapter Four

Existing Power System



Chapter Four: Existing Power System

TVA's existing power system provides 25,600 megawatts of dependable generating capacity in the summer—57 percent from coal-fired plants, 16 percent from hydro facilities, 13 percent from nuclear, 8 percent from combustion turbines, and 6 percent from pumped-storage hydro.

TVA will add two nuclear units in 1996 (Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3), which will bring the total capacity to 28,000 megawatts.

TVA's existing coal-fired plants will continue to provide the largest part of TVA's generating supply during the Energy Vision 2020 planning period. Although the 1990 Clean Air Act Amendments imposed significant requirements on utilities to reduce sulfur dioxide emissions, as well as other air pollutants, TVA is taking actions that will meet or exceed these requirements.

TVA operates approximately 16,000 miles of transmission lines to carry power from 42 generating sites to 750 wholesale delivery points. TVA also connects with 13 neighboring utilities at 57 different locations.

In 1994, TVA generated 134 billion kilowatt-hours of electricity—84 percent was wholesaled to distributors, with the balance to directly served industrial and federal customers. The total revenue from these sales was $5.4 billion.

In 1988, TVA changed its wholesale rate design to meet several objectives, including equity, efficient operations, and competitiveness. Looking to the future, TVA recognizes that rates for electric services will have to be more flexible to meet customer and consumer needs and expectations.

This Chapter Includes:

- TVA Customers and Sales
- Generating Resources
- How Power Supply Decisions Are Made
- 1990 Clean Air Act Amendments' Impact on Generating Facilities
- Customer Service Programs/Demand-Side Management
- TVA's Transmission System
- TVA's Financial Condition and Results of Operation
- TVA's Electric Rate Structure

Existing Power System

TVA Customers and Sales

TVA is the nation's largest public power utility, generating more than 134 billion kilowatt-hours of electricity annually, enough power to supply three cities the size of New York City. Through 160 municipal and cooperative power distributors, TVA serves 7.7 million people in parts of 7 states.

Revenues from power sales totaled $5.4 billion for fiscal year 1994. In addition, Congress provides appropriated funds (tax money) to TVA for regional resource and economic development and stewardship of the federal investment. Appropriations for fiscal year 1994 were $140 million, or 2.6 percent of TVA's total budget. TVA's power program is self-financing, and Congress provides no funds for it.

TVA is the nation's largest public power utility, generating more than 134 billion kilowatt-hours of electricity annually, enough power to supply three cities the size of New York City.

TVA IS A POWER WHOLESALER

TVA is primarily a wholesaler of power. Wholesale power is delivered to 160 power distributors that, in turn, distribute electricity to homes and businesses within their service areas. These distributors are a diverse group. The largest distributor of TVA power, Memphis Light, Gas & Water Division, serves 360,000 customers with annual electric sales of almost 12 billion kilowatt-hours. Some of the smaller municipal systems serve 1,500 customers or fewer. Electric cooperatives range in size from 3,500 customers to 95,000 customers.

TVA also sells power directly to 54 industries that have large or unusual loads and to 10 federal installations. Together, these directly served customers account for about 16 percent of TVA's energy sales. The directly served industries include chemical, metal, paper, textile, and automotive manufacturers.

TVA also has arrangements for exchanging power with 13 neighboring electric systems with which it buys and sells power on an almost daily basis.

Figure 4-1 provides a breakdown of TVA customers and sales for fiscal year 1994.

TVA POWER EXCHANGES

TVA exchanges, or buys and sells power, with neighboring electric systems through 57 interconnections. The sale of power by TVA provides a way to earn revenue. The purchase of power is sometimes necessary to meet heavy demand; at other times, it may be more economical for TVA to purchase excess power from a neighboring utility than to generate it. TVA also "wheels" power

FIGURE 4-1. **TVA Customers and Sales for Fiscal Year 1994**

	Customers	Annual Energy (Millions of kWh)	Estimated Impact on Annual Peak (MW)
DISTRIBUTOR SERVED SALES			
Residential	3,068,076	46,330	11,900
Commercial	501,198	33,408	5,400
Manufacturing	3,036	23,101	2,900
Outdoor Lighting	14,216	1,235	0
Direct-Served Industrial Sales	54	16,706	1,700
Direct-Served Federal Sales	10	2,309	700
Other Sales and Losses		11,077	1,800
Total Requirements		134,166	24,400

TVA wholesales electricity to power distributors and sells electricity directly to some large industrial customers and federal agencies. In addition, TVA at times sells power to neighboring utilities who are connected to the TVA power transmission system. Figure 4-1 shows the number of customers served by distributors and TVA and the electricity sales to each group.

at a fee for other utilities. Wheeling is transporting power from one utility to another through TVA's transmission system.

For fiscal year 1994, power exchanges with other utilities were as follows:

- **Sales to other utilities** – 8.6 billion kilowatt-hours (6 percent of TVA's total sales)
- **Purchases from other utilities** – 8.2 billion kilowatt-hours
- **Wheeling transactions** – 0.9 billion kilowatt-hours

It is interesting to note that in 1988, TVA was a net purchaser of power at a cost of $330 million. In 1992, TVA became a net seller, producing off-system sales revenue of almost $95 million. By 1994, revenue from net sales climbed to $193 million. This increase in sales can be attributed to improvements in TVA's generating system, increasing both efficiency and production capacity.

Generating Resources

TVA currently has 25,600 megawatts of generating capacity. Electricity is produced through a combination of coal-fired, hydroelectric, nuclear, combustion turbine, and pumped-storage hydro plants. *Figure 4-2* shows the capacity mix and the percentage of capacity supplied by each type of generation.

TVA plans to begin operating Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3 in 1996, which will add 2,235 megawatts of generating capacity to the power system. Other adjustments to generating capacity will include improvements to the hydro and coal-fired plants and the sale of steam, bringing total capacity to 28,000 megawatts in 1996.

FIGURE 4-2. **TVA's 1994 Capacity Mix**

Type of Capacity	Megawatts	Percent
Conventional Hydro	4,044	16
Pumped-Storage Hydro	1,532	6
Coal	14,743	57
Combustion Turbines	1,952	8
Nuclear	3,282	13
TOTAL	25,553	100

TVA produces power from a number of different types of generating sources. This chart shows the generating capacity for various types of resources and the percentage of TVA's overall generating capacity provided by each.

In addition to conventional power generation, TVA has more than 2,500 megawatts of interruptible power contracts that allow TVA to interrupt power to industrial customers during peak load periods. This interruptible power is used as part of TVA's available capacity; however, due to variations in industrial plant operations, not all of the contracted power is available for interruption at the same time. Typically, about 1,700 megawatts of industrial load reduction are available at peak times.

TVA's generating sources are a diverse mix that offers TVA a distinct advantage over many other utilities. The varied mix provides a buffering effect that helps TVA absorb the impacts of changes that affect only one particular

type of generation, such as more stringent nuclear regulations or coal-fired air emission reduction requirements. By "averaging" the impacts across the system, the effects are greatly reduced compared to a utility that is chiefly dependent on a single type of generating source.

A description of TVA's various generating resources—hydro (conventional and pumped-storage), coal-fired, combustion turbine, and nuclear plants—follows. Generating capacity for fiscal year 1994 is included for each source of production.

TVA'S HYDRO SYSTEM

The TVA hydro system includes 109 conventional hydroelectric generating units and four pumped-storage units at Raccoon Mountain Pumped-Storage Facility. These conventional hydro units are located at 29 sites along the Tennessee River and its tributaries.

Hydro capacity is 4,044 megawatts, which includes 405 megawatts available from the U.S. Corps of Engineers' hydro generating plants along the Cumberland River and 321 megawatts from Aluminum Company of America plants. Aluminum Company of America owns hydro plants located on tributaries of the Tennessee River, and TVA operates these plants as part of its power supply system.

Hydro generating capacity will be increased as the result of ongoing modernization projects. Upgrades and improvements at TVA's plants will add approximately 360 megawatts of capacity by 2005, while improving the efficiency of these plants by 3 percent.

COAL-BURNING POWER PLANTS

TVA has 59 active coal-fired units located at 11 plant sites throughout the Valley. The coal-fired units range in size from 107 megawatts for each of the Johnsonville units 1-4 to 1,224 megawatts for each of the two units at Cumberland. The oldest active coal unit was placed in service in 1951, and the newest unit is Cumberland 2, which began operation in 1973. A recent review identified no technical problems that would prevent the continued operation of these generating units through the study period covered by Energy Vision 2020.

TVA's coal-fired units have a combined capacity of 14,743 megawatts. TVA anticipates some minor reductions in coal system capacity as the result of the installation of pollution control equipment and the sale of steam, rather than electricity, to a DuPont facility adjacent to TVA's Johnsonville Fossil Plant.

COMBUSTION TURBINES

TVA has 48 combustion turbine units that are located at four coal-fired plant sites. Of this total, 28 are capable of burning natural gas or oil. The other 20 units have the capability to burn oil only. The combined capacity of these combustion turbines is 1,952 megawatts. The average age of TVA's combustion turbine units is approximately 23 years, and all units are anticipated to be available throughout the study period of Energy Vision 2020.

TVA recently upgraded the reliability of its combustion turbines, which has reduced the forced outage rate, a measurement of reliability.

NUCLEAR GENERATION

Five nuclear units, located at three sites, are included in TVA's existing inventory of supply resources: Browns Ferry Nuclear Plant Units 2 and 3, Sequoyah Nuclear Plant Units 1 and 2, and Watts Bar Nuclear Plant Unit 1. Total generating capacity of the three operating nuclear units is 3,282 megawatts. Watts Bar Nuclear Plant Unit 1 was granted a license to load fuel and perform low power testing in November 1995. Fuel loading was completed in November, and Watts Bar Nuclear Plant Unit 1 is expected to begin commercial operation in spring 1996. Browns Ferry Nuclear Plant Unit 3 fuel load was completed in October and it is scheduled to return to service in early 1996. These units are considered part of TVA's existing power system for the purposes of Energy Vision 2020.

The two units coming on line in 1996 will provide an additional 2,235 megawatts of generating capacity. Operating Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3 will help meet projected future loads on the TVA power system at a very economically competitive cost. As of March 31, 1995, TVA's undepreciated investment in these two units was approximately $6.8 billion and $1.8 billion, respectively. Both Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3 will be revenue-producing assets when they go into operation. The construction expenditures on these units will be depreciated, and the depreciation costs will be recovered in revenues. Revenues will exceed the depreciation, fuel, and operations and maintenance expense at the plants. Operating the plants will allow TVA to begin earning a return on the agency's investment in the form of generation from Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3.

Compared to purchasing power or meeting demand with coal-fired generation or combustion turbine units, operation of these two nuclear units will be among TVA's lowest cost generating sources. Operating costs for Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3 are projected to be approximately 1.7 cents per kilowatt-hour. In contrast, the operating costs of alternative generating sources would range from 2.0 to 6.0 cents per kilowatt-hour.

TVA's nuclear performance has improved considerably during the past several years. The performance of Browns Ferry Nuclear Plant Unit 2 has been excellent since the plant was restarted in 1990. Performance at Sequoyah, while not reaching the same levels of excellence, has also had significant high points, including being ranked as one of the top nuclear plants in the country for net generation and setting the TVA record for longest continuous run by a large generating station in 1991. The combined capacity factor for TVA's three operating units for fiscal year 1995 was 80 percent.

While TVA has scaled back its nuclear construction program, nuclear generation will continue to play a vital role in helping provide economical power generation.

Detailed information on all of TVA's generating resources, such as plant locations, capacity, and performance and cost characteristics (including decommissioning cost for nuclear) can be found in Volume 2, Technical Document 3, Existing Power System.

How Power Supply Decisions Are Made

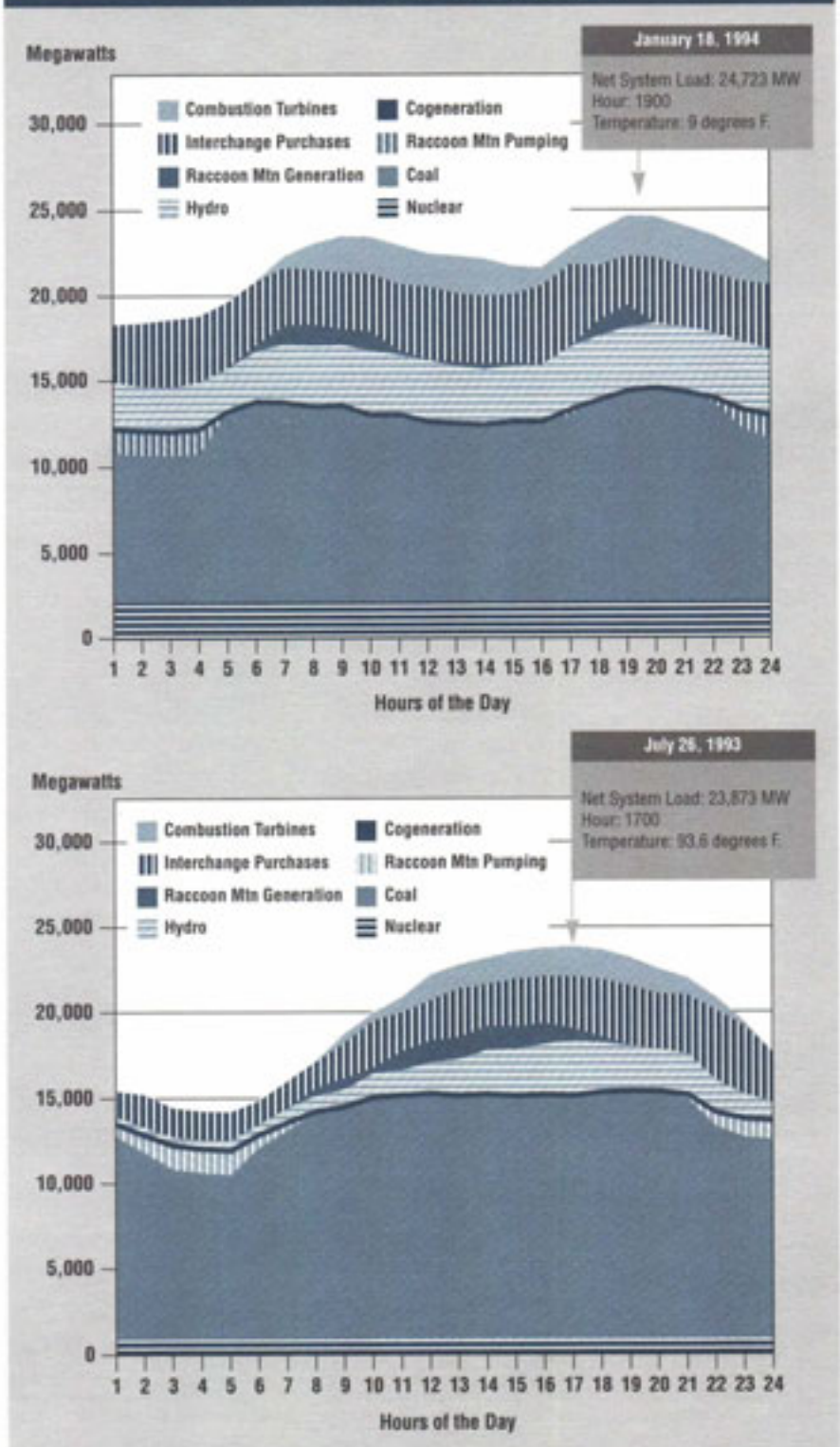
Though TVA has the capacity described in the previous section, the actual use of these energy sources varies depending on costs, weather, customers' needs, and other factors such as operating constraints of a particular power generation source.

Power from TVA's various generation sources is dispatched, or distributed, to meet the demand for electricity at the lowest cost. The primary factor in determining generating mix at any particular time is fuel costs. However, variable operation and maintenance costs (costs that vary with the power output of the various generating units) are added to the fuel costs in dispatching generating units. In addition, beginning in 1995, the economic value of the allowances required to emit sulfur dioxide from some TVA sources is included in making dispatching decisions.

Figures 4-3 and *4-4* show the dispatch of the system for the 24-hour periods of January 18, 1994, and July 26, 1993. These dates represent the all-time winter and summer peak demand on the TVA power system and illustrate how various power production sources are brought on line to meet energy demands.

The hydro resources are the least expensive to operate because they have no fuel costs. Hydro resources provide an economical way to reduce the amount of generation required from other, more expensive generating sources during periods of high demand. Hydro resources are not used continuously because they are limited by the amount of rainfall and runoff into the storage reservoirs or

FIGURE 4-3 & 4-4. **TVA Load and Supply**



Generating resources are brought on line as needed to meet customer demand for electricity. Since power production costs vary, depending on the generating source, plants are brought on line in the most economical sequence. These figures illustrate how the need for power was met during days of winter and summer peak demand.

lakes in the Tennessee Valley. There is significant variation in the amount of hydro output available from week to week and year to year based on the amount of rainfall. Hydro resources also must be operated under constraints to meet the needs of flood control and navigation, and take into account recreation and tourism effects.

Pumped-hydro capacity at the Raccoon Mountain Plant is used to meet peak requirements, as well as to satisfy other system needs such as operating reserve. The operating characteristics of a pumped-storage facility, however, make it a limited resource. The amount of generation is limited by the amount of water in the storage pond at the top of the mountain. This storage pond supports only a set number of hours of operation at full output. In addition, TVA's ability to pump water back into the storage pond may be affected at times by reduced availability of low-cost power to operate the pumps.

Energy production from hydro plants was 20.2 billion kilowatt-hours for fiscal year 1994, accounting for 15.4 percent of TVA's generation. This includes the net pumped-hydro generation from Raccoon Mountain and hydro generation received from the Corps of Engineers and Aluminum Company of America.

Nuclear generation is operated as much as possible, since its fuel costs are relatively low. Another consideration is the physical operating constraints of nuclear plants. Nuclear units are not easily cycled—meaning they cannot be brought on line quickly and the output of energy cannot be adjusted quickly compared to other sources. Hydro is, in contrast, a resource that can respond almost immediately to changes in demands for power. Therefore, nuclear generation is principally used as part of TVA's "base load." Base load is the minimal amount of power that must be available around the clock to meet demand.

Energy produced by TVA's nuclear plants during fiscal year 1994 totaled 18.4 billion kilowatt-hours, or 14 percent of all energy produced by TVA.

Coal-fired generation provides the bulk of TVA's power supply, representing more than 50 percent of the available generating capacity. Coal-fired units do vary in operating costs, depending on the technology at the various plants and the type of coal used by the generating units (high-sulfur coal or low-sulfur coal). In addition, some coal-fired plants, like nuclear units, are not designed to be brought on or off line quickly, and the output of energy is not readily adjustable.

TVA's coal-fired plants supplied 92.1 billion kilowatt-hours during fiscal year 1994, which was 70.4 percent of the total energy supply.

Combustion turbines are relatively high in cost to operate. Combustion turbine units operate on natural gas or fuel oil, both high-cost fuel sources. In addition, TVA's combustion turbines have lower efficiency compared to other types of generating resources. They are used sparingly to meet peak demands.

Energy production from combustion turbines during fiscal year 1994 was 0.2 billion kilowatt-hours, or 0.2 percent of all electricity generated.

1990 Clean Air Act Amendments' Impact on Generating Facilities

The 1990 Clean Air Act Amendments imposed new requirements on the utility industry. The most significant of these requirements derive from the "acid rain" provisions of the amendments, which require the United States electric utility industry to reduce its emissions of sulfur dioxide and nitrogen oxides. Utilities, such as TVA, that burn significant amounts of coal to generate electricity have substantial emission reduction obligations.

SULFUR DIOXIDE CONTROLS

The sulfur dioxide portion of the "acid rain" provisions also introduced on a national scale a new approach to environmental regulation. This approach is intended to reduce the overall cost of achieving the environmental objective by setting a national cap for utility sulfur dioxide emissions and establishing a mechanism to allow emissions reductions to come from the sources that can achieve these reductions at least cost.

The Environmental Protection Agency annually issues to each regulated source a number of sulfur dioxide "allowances" based on the sulfur dioxide annual average emission rate for each fossil unit in 1985 and the amount of coal burned during the baseline period of 1985 through 1987. (One "allowance" gives the source permission to emit one ton of sulfur dioxide.) A source's reduction obligation, the difference between baseline sulfur dioxide emissions and the number of allowances issued by the Environmental Protection Agency, can then be met by either reducing emissions from that source or by ensuring, through allowance transfers, that equivalent reductions are made at another source(s). A source is deemed to be in compliance if, at the end of the year, it holds enough allowances to cover its sulfur dioxide emissions.

Thus, utilities can choose to make "excess" reductions at one or more sources while either (a) making lesser or no reductions at other units on their system that are less economical to control, (b) selling the excess allowances to other utilities, or (c) banking the excess allowances for use in future years. Conversely, a utility could choose to take lesser or no reductions and achieve compliance by buying allowances from others.

Sulfur dioxide emissions are to be reduced in two phases according to the Clean Air Act Amendments. The larger and more polluting utility units are required to reduce sulfur dioxide emissions in Phase I. Phase I sources generally were to be in compliance by January 1, 1995. In Phase II, the remainder of utility sources become subject to sulfur dioxide reductions, and the allowances issued by the Environmental Protection Agency to the Phase I affected sources will be reduced. All sources must be in substantial compliance with Phase II requirements by January 1, 2000.

Twenty-six of TVA's 59 operating coal-fired units are Phase I units. Its remaining coal-fired units are Phase II sources. To date, TVA's approach has been

not to rely on the ability to buy allowances from other sources to achieve its reduction obligations. The TVA system is large enough that it can take advantage of the flexibility available under the allowance program to substantially reduce its cost of compliance.

TVA has already completed the actions necessary to achieve Phase I compliance. Sulfur dioxide emissions control equipment has been installed on TVA's largest Phase I generating units, units 1 and 2 at Cumberland Fossil Plant. This $535 million project included the installation of wet limestone flue gas desulfurization equipment (scrubbers). These scrubbers reduce Cumberland's sulfur dioxide emissions by approximately 95 percent. Other control measures have included the switch to lower sulfur coal at TVA's Allen Fossil Plant in Memphis. Through these actions, TVA will meet its reduction obligations for all 26 affected units through Phase I and have excess reductions banked for use during Phase II.

NITROGEN OXIDES REDUCTION

Utility sources subject to Phase I sulfur dioxide reductions must, in general, also achieve nitrogen oxides reductions during Phase I. There is no national cap and allowance system comparable to the sulfur dioxide reduction program for nitrogen oxides. Nitrogen oxides compliance is based on an allowable emission rate determined by the boiler type. However, flexibility is provided within a utility system to include multiple units within an "averaging plan" that would allow excess reductions at one or more units to offset lesser reductions at others.

Nitrogen oxides reductions are required at 19 of TVA's 26 Phase I units. (The remaining seven units, because of their boiler type, will be subject to reductions during Phase II.) These reductions have already been achieved by installing low-nitrogen oxides burners at 13 of the 19 units. On 4 of these 13 units, separated over-fire air, a supplemental nitrogen oxides control technology, has also been installed to achieve additional reductions. As with sulfur dioxide, TVA will achieve nitrogen oxides compliance on a system-wide basis by using an "averaging plan."

TVA is proceeding to install low-nitrogen oxides burners at many of its Phase II units in advance of the year 2000 regulatory deadline. Installation of burners is either accomplished or planned for the John Sevier, Kingston, and Widow's Creek Fossil Plants. (TVA has a total of 40 generating units that will be subject to Phase II nitrogen oxides reduction requirements.)

COSTS

Total estimated cost for the pollution control measures required for acid rain compliance will be approximately $2.3 billion dollars. By the end of fiscal year 1995, $770 million will have been spent. Operating cost increases associated with these actions will exceed $300 million per year.

OTHER CONSIDERATIONS

TVA has not incurred significant costs or liabilities from other provisions of the 1990 Clean Air Act Amendments. The Nashville/Davidson County area currently exceeds the allowable levels for ambient ozone concentration. The State of Tennessee must develop plans acceptable to the Environmental Protection Agency to reduce ambient ozone concentrations to acceptable levels. This could have required nitrogen oxides reductions from the Gallatin Fossil Plant. (Nitrogen oxides react with other chemicals in the air to form ozone. The Gallatin plant is within the Nashville/Davidson County area.) However, Tennessee has accepted the nitrogen oxides reduction installation at the Gallatin Fossil Plant as meeting the nitrogen oxides reductions required by their plan.

Other ways the 1990 Clean Air Amendments may affect TVA are discussed in Chapter 3, Affected Environment.

Customer Service Programs/Demand-Side Management

Customer service and demand-side management programs have been a part of TVA's energy supply resource mix since the late 1970s. These programs promote energy conservation and the efficient use of electricity. They were initiated in response to the rising cost of energy and the rising cost of building new electric generating units that began in the mid-1970s.

These programs provide benefit to both the end-use consumer through reduced energy costs and to TVA by avoiding the need for additional generating capacity. By 1988, these programs were credited with saving more than 2,300 million kilowatt-hours per year and cutting TVA's system demand by 1,200 megawatts. *Figure 4-5* shows the savings associated with each of these programs, the benefits of which continue today.

Through the years, the economics of TVA's conservation and energy management programs began to change. More than 631,000 Valley homes were weatherized during the 1980s under the Home Insulation Program; this was the backbone of TVA's conservation programs. Building standards for energy efficiency in new homes began to rise as consumers learned of the benefits of improved weatherization techniques. By the late 1980s, TVA was approaching market saturation for its home weatherization program. At the same time, the supply of available power increased, both within TVA and from other utilities, causing TVA to begin a review of its customer service and demand-side management

FIGURE 4-5. **Historical Customer Service Programs**

Program	Units	Millions of Kilowatt-Hours	Megawatts
Sunscreens	5,000	4	-
Heat Pump Water Heater	2,000	5	1
Solar Water Heater	7,000	26	10
Cycle and Save	111,000	0	79
Energy Saver Homes	36,000	116	36
Wood Heaters	16,000	79	55
Heat Pumps	135,000	228	74
Home Weatherization	631,000	1,883	959
TOTAL		**2,341**	**1,214**

TVA served thousands of customers in the decade of the 1980s through programs designed to save energy and increase comfort. For example, 631,000 customers saved a total of 1,883 million kilowatt-hours of energy during the decade through home weatherization and reduced TVA's need for new capacity by 959 megawatts.

FIGURE 4-6 Impacts of Current Demand-Side Management Programs for 1995 – 1996

Program	Units	Millions of Kilowatt-Hours	Megawatts
RESOURCE ACQUISITION (Savings)			
Heat Pump	19,330	51.5	16.5
New Homes	5,857	4.6	1.3
Manufactured Homes	1,230	5.0	1.6
Interruptible Rates		N/A	1,700.0
Direct Load Control	96,850	N/A	69.6
BENEFICIAL ELECTRIFICATION (Sales)			
Heat Pump	10,870	81.7	29.9
New Homes	3,143	21.1	1.4
Manufactured Homes	660	2.6	0

TVA's current programs include energy efficiency programs, a rate program, a direct load control program, and beneficial electrification programs. For example, the heat pump program includes both energy efficiency and beneficial electrification components, and results in a net increase in sales of 30.2 million kilowatt-hours. The interruptible rates and direct load control programs significantly reduce peak demand, but instead of reducing energy requirements, shift energy usage from peak periods to off-peak periods.

programs to make sure that they were still cost-effective for TVA's ratepayers.

As a result of this review, TVA began reshaping its customer service and demand-side management programs during the late 1980s and early 1990s. While the early programs continue to benefit the power system, current initiatives are geared to assist consumers in making electricity a better value through the use of new electric technologies and techniques. Customer service offerings now include an electric heat pump program, a new homes program, a manufactured housing program, and a direct load control program. (This load management program shifts energy use to off-peak hours or periods of low demand for electricity, e.g., the cycling of appliances such as water heaters.) These programs, which are offered through participating distributors of TVA power, are currently scheduled to continue through 1996.

TVA also has rate programs for interruptible power for industrial customers, as discussed earlier in this chapter. This includes Economy Surplus Power (ESP), which is a real-time pricing program for interruptible load. Approximately 1,700 megawatts of industrial load is available for interruption during peak periods. In addition, TVA and participating distributors of TVA power provide a broad range of technical assistance to commercial and industrial customers to help them get the most value for their energy dollar. Some of these services include recommendations on efficient heating and cooling equipment, outdoor lighting systems, power monitor metering, power quality analysis, and preparation of feasibility/application studies for new electrotechnologies that offer opportunities for lower production costs and increased output.

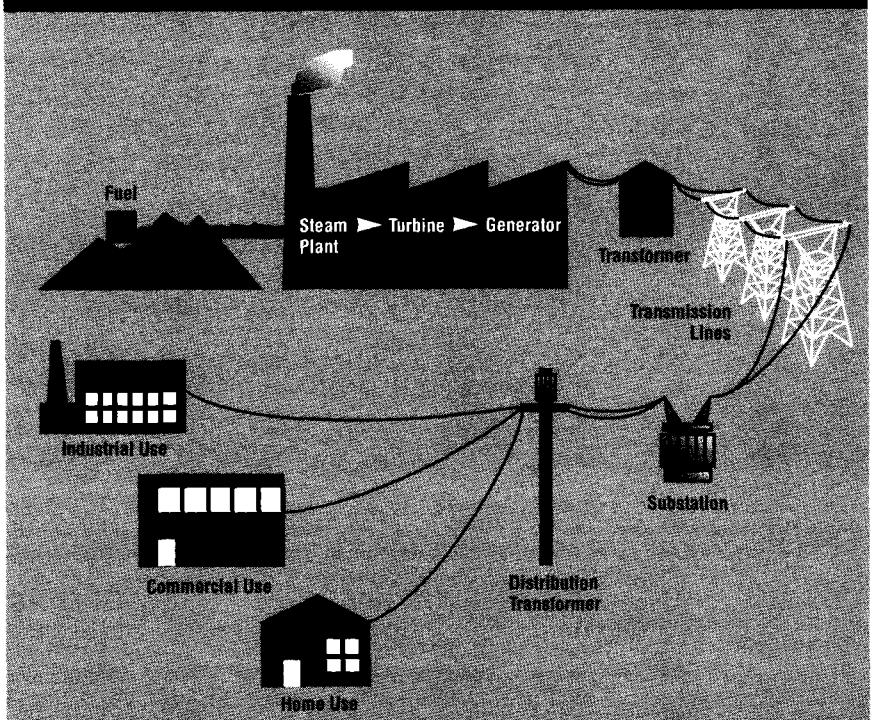
Figure 4-6 shows the impacts of these current demand-side management programs—energy efficiency programs, a rate program, a direct load control program, and beneficial electrification programs. The values in *Figure 4-6* are the impacts occurring only in the year 1996 for the cumulative participation in the program during 1995 and 1996.

TVA's Transmission System

TVA operates an interconnected transmission system capable of carrying power from its 42 generating sites to 750 wholesale delivery points and to 57 points of interconnection with neighboring power systems.

Figure 4-7 illustrates how power is delivered from generating plants to distributors to homes and businesses. Power from generating facilities is produced at low voltages, such as 24,000 volts, which are then generally boosted to 500,000 or 161,000 volts for delivery to wholesale and directly served customers through TVA's transmission system. At delivery points, this high voltage power is reduced at substations to voltages that can be sent through distribution lines to end users, where it is further reduced so that it can be used in homes and businesses.

FIGURE 4-7. **Generation, Transmission, and Distribution**



Electricity is produced at one of TVA's power generating plants and carried over TVA's high voltage transmission system to delivery points of distributors of TVA power. Through a series of substations and transformers, voltage is reduced to appropriate levels for use in homes and businesses.

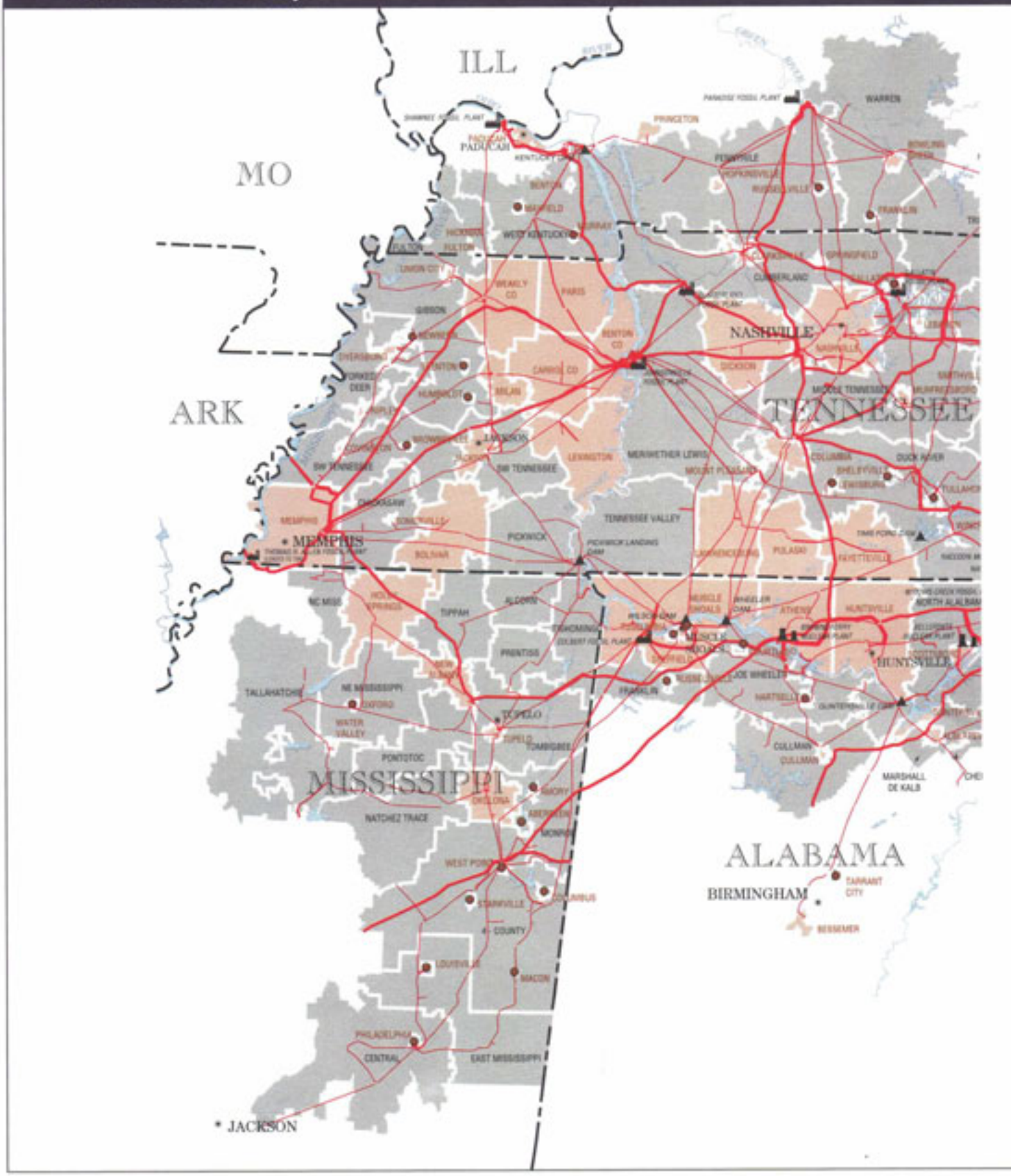
The transmission system includes 12,200 miles of 161,000 and 500,000 volt transmission lines. These two overlaid networks are tied together at 25 locations through 500,000 and 161,000 volt substations located throughout the TVA service area. In addition, 3,800 miles of 69,000 and 46,000 volt lines are operated radially to serve dispersed load centers. Distributors accept power from TVA at voltages ranging from 161,000 to 13,000 volts and, in turn, distribute power at voltages ranging from 161,000 to 120 volts to small industries, commercial customers, and homes.

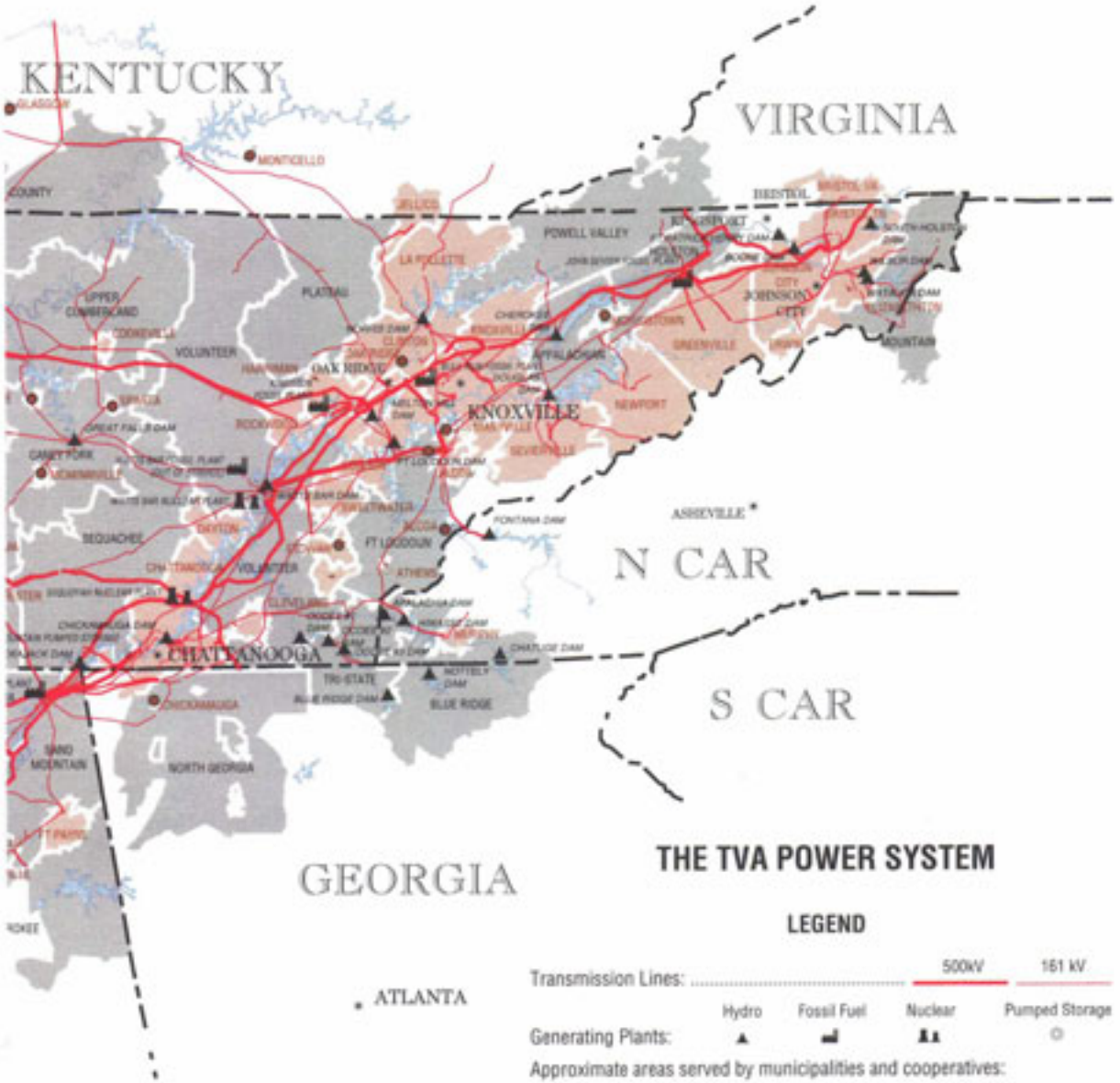
TVA's transmission system is also directly connected to 13 neighboring utilities with interconnection voltages ranging from 500,000 to 69,000 volts. These interconnections allow TVA and its utility neighbors to buy and sell power from each other and to wheel power through their systems to other utilities.

TVA's generation and transmission facilities are self-funded through power revenues. Improvements to the transmission system are planned and implemented to ensure continued reliability and service. The fiscal year 1995 budget for transmission system capital projects is approximately $130 million. These include more than 150 active projects ranging from simple new delivery points ($100-$300 thousand) to major 500,000 and 161,000 volt substations ($30-$40 million) in Mississippi and Alabama.

Figure 4-8 provides an overview of the power system, including the 500,000 and 161,000 volt transmission lines, the generating plants (hydro, fossil fuel,

FIGURE 4-8 **The TVA Power System**





THE TVA POWER SYSTEM

LEGEND

Transmission Lines: ..... 500kV 161 kV

Generating Plants: Hydro ▲ Fossil Fuel Nuclear Pumped Storage

Approximate areas served by municipalities and cooperatives:

Retail distribution by municipalities .....

Retail distribution by cooperatives .....

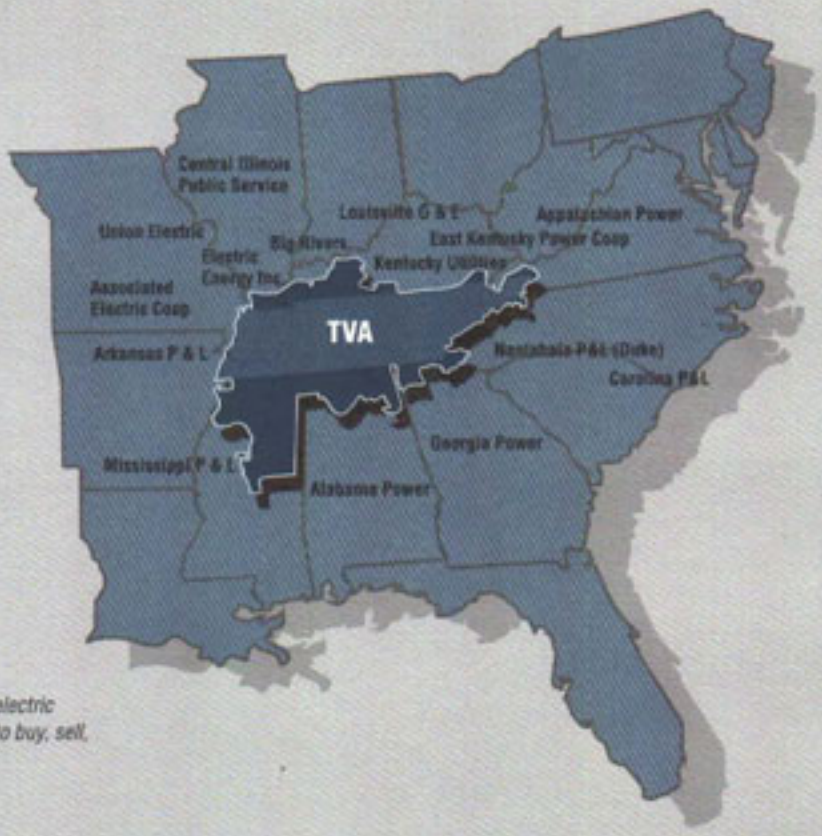
APPROXIMATE SCALE

1994

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE 4-9. **Interconnections with Other Utilities**

- Associated Electric Coop
- Appalachian Power
- Big Rivers EC
- Carolina P&L
- Central Illinois Public Service
- East Kentucky Power Coop
- Electric Energy Inc.
- Entergy Services
  - Arkansas P & L
  - Mississippi P & L
- Kentucky Utilities
- Louisville Gas & Electric
- Nantahala P&L (Duke)
- Southern Company
  - Alabama Power
  - Georgia Power
- Union Electric



TVA has interties with 13 neighboring electric systems, which allows these systems to buy, sell, and wheel power.

and nuclear), and the approximate areas served by the 160 power distributors (municipalities and cooperatives).

Figure 4-9 shows the 13 neighboring utilities that TVA has interconnections with to buy, sell, and wheel power.

TVA's Financial Condition and Results of Operation

Since 1988, actions taken by TVA to reduce its costs and interest expense have allowed it to keep electric rates at the level they were in 1987. The TVA Board approved an eighth year of stable electric rates for TVA customers on September 21, 1994. TVA has been able to do this by refinancing its debt, reducing its workforce, and improving the efficiency of its operations.

FINANCIAL RESULTS OF OPERATION

Revenue

Operating revenues were $5.4 billion for fiscal year 1994. Total energy generated was 134 billion kilowatt-hours for 1994, which was 3.4 percent higher than the previous year. This increase was due to growth in sales to

municipal and cooperative distributors, direct served industries, federal agencies and off-system sales.

Operating Expenses

Operating expenses for fiscal year 1994 were $3.5 billion; fuel expenses accounted for $1.5 billion of this total. Non-fuel operating expenses were $2 billion. Operating and maintenance expenses for 1994 were $1.1 billion, compared to $1.2 billion for 1993. The decrease in operating and maintenance expenses reflects continuing efforts to reduce costs.

Depreciation and amortization costs were $639 million in fiscal year 1994, an increase of $182 million compared to fiscal year 1993. The increase was attributable to the amortization of deferred charges, additions to completed plants, and an increase in the composite depreciation rate.

FIGURE 4-10. **Financial Statement**

	Millions of Dollars		
	1994	1993	1992
OPERATING REVENUES	$5,401	$5,276	$5,065
OPERATING EXPENSES			
Fuel and purchased power, net	1,493	1,401	1,354
Operating and maintenance	1,081	1,174	1,098
Depreciation and amortization of deferred nuclear costs	639	457	505
Tax equivalent payments	248	237	241
Total operating expenses	3,461	3,269	3,198
Operating income	1,940	2,007	1,867
OTHER INCOME AND DEDUCTIONS, net	(59)	23	(87)
Income before interest charges	1,881	2,030	1,780
INTEREST CHARGES			
Interest expense	1,853	1,777	1,695
Allowance for funds used during construction	(123)	(58)	(35)
Net interest charges	1,730	1,719	1,660
NET INCOME	151	311	120

This figure summarizes TVA's income and operating expenses for fiscal years 1992, 1993, and 1994. Net income for fiscal year 1994 was $151,000,000.

Interest Expense

Interest expense for fiscal year 1994 was $1.9 billion, an increase of $76 million compared with 1993. The increase was the result of additional borrowings related to financing TVA's power program. In 1994, TVA refinanced $5 billion of existing long-term debt to save $65 million in annual interest expense. Since refinancing efforts were begun in 1989, TVA has achieved $317 million in interest expense savings.

Earnings

TVA's power program consists primarily of the generation, transmission, and sale of electricity. Net income for fiscal year 1994 was $151 million.

Figure 4-10 summarizes TVA's statement of operations and retained earnings for 1994, 1993, and 1992.

CONTROLLING THE TVA DEBT

Concern about TVA's debt was one of three major issues identified by the public during scoping meetings held as part of Energy Vision 2020. Other major concerns were TVA's nuclear program and TVA's ability to remain competitive.

In the opinion of many TVA customers and members of the public, high debt is generally associated with a poor competitive position. Since the large capital expenditures necessary to complete TVA's nuclear units will increase

TVA's debt, completing these units contributes to a perception that TVA's competitiveness will suffer. With the rapid evolution of the utility industry into a competitive environment, many utilities are trying to improve their debt structure so that the pricing of electricity can be more flexible in response to future uncertainty. Clearly, with the increasing risk of TVA losing customers to other utilities, prudent business practices suggest that debt be carefully managed and controlled.

TVA's debt limit, as set by Congress in the TVA Act, is $30 billion. TVA's current debt is some $3 billion below this debt ceiling. The TVA Board has announced plans to establish a self-imposed debt limit $2-3 billion below the $30 billion allowed by Congress. This internal limit on debt will be formally reviewed periodically to ensure that the limitation meets TVA's continuing business needs. However, one of the major constraints utilized in Energy Vision 2020 was to keep the debt for any feasible resource plan within these limits.

TVA's Electric Rate Structure

The rates for TVA power must be adequate to meet power system needs and be as low as feasible. TVA's rate structure must also respond to customer needs. TVA develops wholesale rates for the distributors (who, in turn, serve most end users) and for large directly served industrial customers.

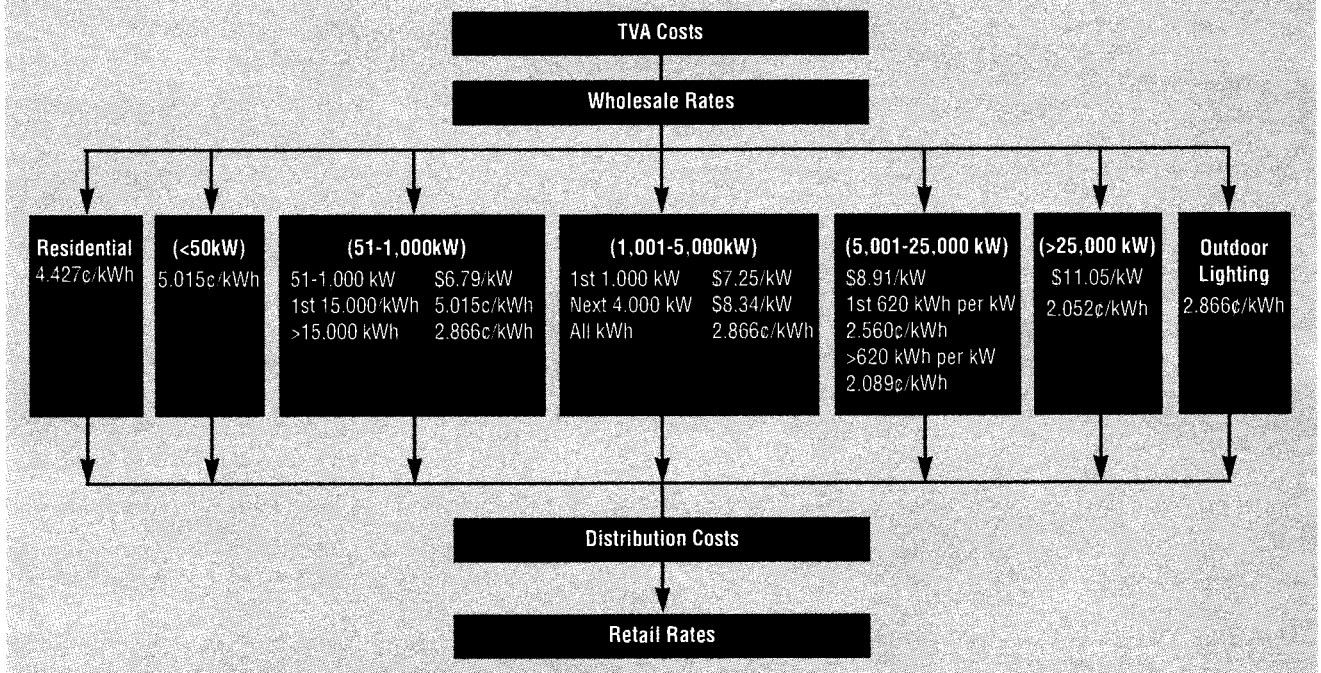
Working with the distributors of TVA power, a major restructuring of TVA's rate design was begun in 1988. This was done in an effort to simplify and improve the way TVA applied power rates.

Specific objectives of the rate restructuring were to:

- Encourage efficient operations
- Provide stable and predictable margins
- Support quality service
- Be competitive
- Be cost-of-service based to ensure equity and avoid discrimination
- Be as simple as possible
- Provide consistent price signals
- Encourage the efficient use of resources
- Encourage economic development of the TVA region as a whole
- Be responsive to changing customer needs

As a result of this restructuring, an "end-use wholesale rate" was developed. This wholesale rate has separate charges for residential and general service end-use groups. General service includes 6 classes of customers: those with demands less than 50 kilowatts, between 51 and 1,000 kilowatts, 1,001 to 5,000

FIGURE 4-11. **TVA Rate Structure**



Wholesale power rates are based on the cost of service for different classes of customers. Distribution cost is added to the wholesale rate by distributors of TVA power to determine the end-use retail price of electricity.

kilowatts, 5,001 to 15,000 kilowatts, 15,001 to 25,000 kilowatts, and demand greater than 25,000 kilowatts. Power rates for large industrial customers with demands greater than 25,000 kilowatts are the same whether they are served by a distributor or directly by TVA. *Figure 4-11* illustrates TVA's rate structure.

As part of the end-use wholesale rate implementation, distributors were provided the flexibility to design retail rates. Distributor retail rates include the end-use wholesale charge paid to TVA, along with the distribution costs for their individual systems.

Even though distributors design their own retail rates, TVA reviews and approves the rates before application. This review is to ensure that the rates are consistent with the requirements of the TVA Act.

Several optional rate arrangements are available for commercial and industrial consumers. These include Economy Surplus Power, an interruptible rate, and the Enhanced Growth Credit, a program that provides power bill credits for new and expanding industries.

Chapter Five

Evaluation Criteria

Chapter Five: Evaluation Criteria

Sound judgments about energy resource options require a way to evaluate cost, benefits, and effects on the environment for each of these options.

Through Energy Vision 2020, TVA developed a comprehensive evaluation system that reflects TVA's goals and objectives, as well as the concerns and values of the public. TVA's evaluation criteria include:

- Long-Run Cost/Value
- TVA Short- and Mid-Term Rates
- Reliability
- Environment
- Economic Development
- Financial Requirements
- Risk Management
- Equity Among Rate Classes

These criteria and associated measures became the quantitative basis for ranking supply-side and customer service options. They were later used in the multi-attribute trade-off analysis to evaluate and improve TVA's strategies.

This Chapter Includes:

- Using the Evaluation Criteria
- Evaluation Criteria and Measurement Descriptions

Evaluation Criteria

TVA's evaluation criteria (listed in *Figure 5-1*) were developed to reflect the values of the public and TVA's goals and objectives. The public's concerns were collected through the public participation process described in Chapter 1. The method by which TVA translated the public concerns and TVA's goals and objectives into measurable criteria for Energy Vision 2020 is described in Chapter 2. These quantifiable measures of public concern and TVA's goals provide the primary guidance for developing the strategies.

Through Energy Vision 2020, TVA developed a comprehensive evaluation system that reflects TVA's goals and objectives, as well as the concerns and values of the public.

Using the Evaluation Criteria

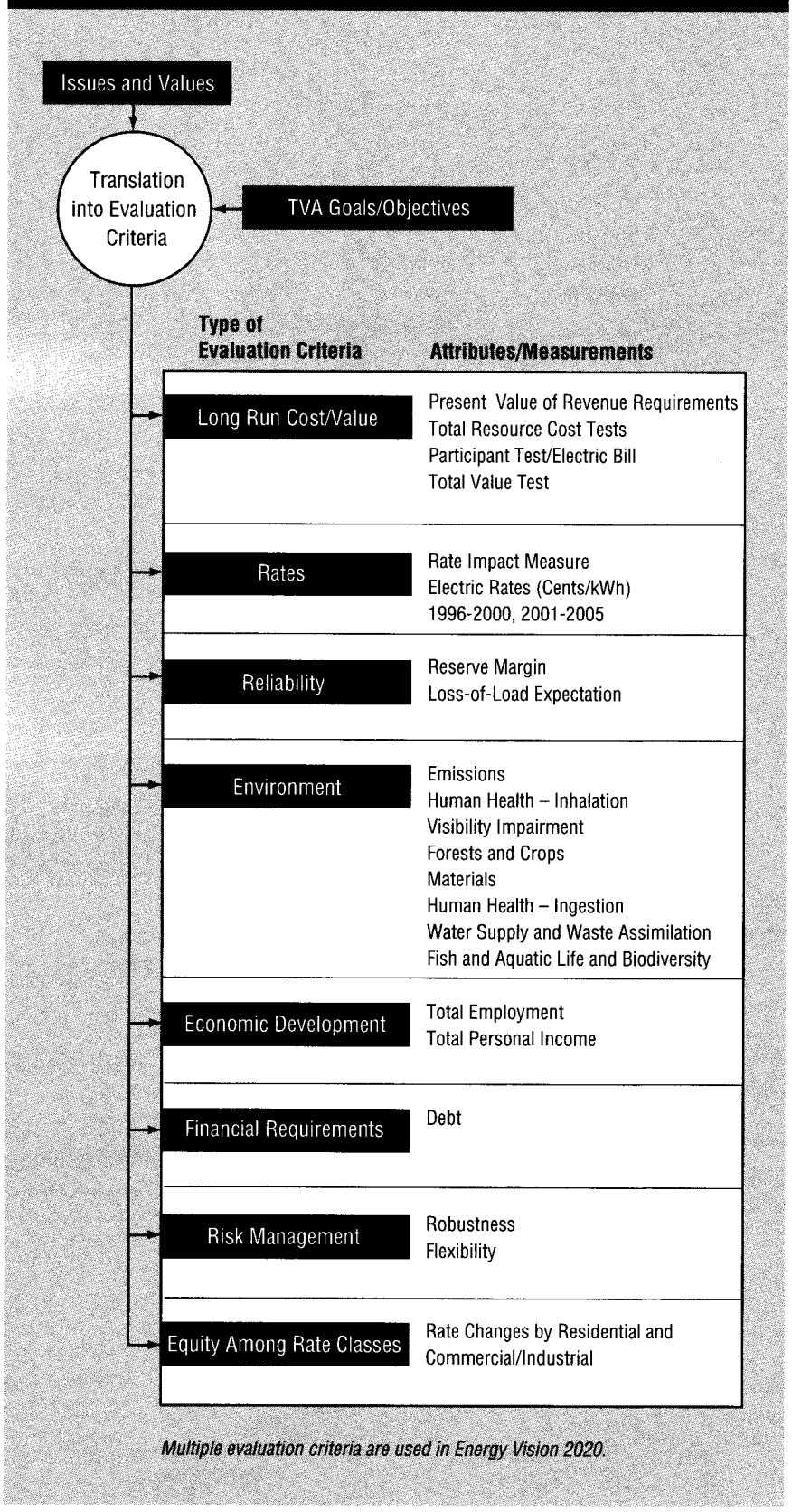
The evaluation criteria and their associated measurements are used at two different points in the integrated resource planning process. First, individual resource options are evaluated and ranked based on appropriate measurements. This ranking is used to prioritize and group individual resource options into possible resource strategies. The evaluation criteria measurements are then used in multi-attribute trade-off analysis to evaluate strategies (for example, short-term rates versus environmental quality measures). By looking at a series of key trade-off plots, the decision-maker is able to see the likely positive or negative consequences of using certain strategies. Additional information about the multi-attribute trade-off analysis used in Energy Vision 2020 is found in Chapter 9.

Evaluation Criteria and Measurement Descriptions

LONG RUN COST/VALUE

The long run cost/value criteria provide a measure of how various resource options and strategies will change TVA's overall cost of doing business and its requirements for revenues over the full 25-year planning period. This, in turn, provides a measure of whether certain options and strategies will add value for TVA's customers. TVA presently uses four different tests to measure long-run cost and benefits.

FIGURE 5-1. **Evaluation Criteria**



Multiple evaluation criteria are used in Energy Vision 2020.

- **Total Resource Cost (TRC) Test** – This test measures whether a resource option or strategy will be cost effective when the net costs and benefits for customers are included in the analysis. The costs include all utility and customer costs for implementing a resource option. The benefits result from the reduction in the cost of producing electricity by implementing the resource option instead of the next best alternative. Choosing options or strategies with the lowest total resource cost is a measure of the least economic cost or highest economic efficiency.
- **Participant Test** – This test is a benefit-cost measurement that evaluates demand-side management programs from the point of view of the customers participating in the programs. The benefits measured include reduction in the participants' utility bills, incentives paid by the utility, and any state, federal, or local tax benefits the participant may receive from participating in the programs. The costs include any additional customer out-of-pocket expenses incurred as a result of participating in the program.
- **Rate Impact Measure (RIM)** – This test measures what happens to electric rates due to changes in utility revenue and operating costs in the long term caused by resource options or strategies
- **Total Value Test** – This test measures not only the total cost of a resource option or strategy from the point of view of TVA and customers as a whole, but also the effects upon the benefits or "value" that participants and ratepayers receive. Value is measured by the

difference between what consumers are willing to pay for a service and what they actually pay. Traditional cost-effectiveness tests are insufficient to capture the full range of benefits that a customer might experience (such as productivity and quality improvements from selecting an option that results in increased electric consumption). The total resource cost test measures value only in terms of cost reductions in electric service. The value test measures value from cost reductions in electric service, other energy services such as natural gas, cost reductions in improvements to industrial processes, and quality improvements in the delivery of energy services. The value test provides an improved measure of economic efficiency.

TVA SHORT- AND MID-TERM RATES

The competitiveness of utilities will be largely based on their rates in the future marketplace. Therefore, all resource options and strategies are measured for their short- and mid-term effect on rates (as well as using the long-term rate impact measurement test described above). TVA has elected to show average short-term impacts for the years 1996-2000 and average mid-term impacts for the years 2001-2005. Electric rates are becoming an increasingly important criterion for resource planning as the industry becomes more competitive and the planning horizon is shortened.

RELIABILITY

To maintain its competitiveness, TVA must not only supply electricity at the lowest possible cost, it must also provide a reliable supply of electricity. For the purposes of Energy Vision 2020, reliability means TVA's ability to provide a continuous supply of electricity to meet its customers' peak demand (expressed in megawatts) and energy requirements (kilowatt-hours). TVA relies on all resources considered in Energy Vision 2020 to meet its reserve requirements, including purchases of power and options to purchase.

The reliability of the TVA power system depends on the performance of TVA's generation and transmission systems. An important consideration in analyzing system reliability is reserve margin and loss-of-load probability. The trigger for adding new generating capacity is generally based on an analysis of loss-of-load probability. Loss-of-load probability can be described as the expected number of hours over a one-year period where TVA's hourly loads are expected to exceed its available supply of power. This is then converted into a reserve margin, or the amount (percentage) of "extra" generation TVA should have in addition to the projected peak load forecast to provide coverage for unexpected outages, scheduled maintenance, etc.

As discussed in Chapter 6, Load Forecast and Need for Power, TVA uses a reserve margin of 15 percent for the years 1996 and 1997 and 13 percent for the years 1998-2010. Since these reliability requirements must be met by all strategies considered in Energy Vision 2020, system reliability is treated as a constraint on each strategy. Therefore, all strategies considered during this process had adequate and comparable levels of reliability.

ENVIRONMENT

Certain environmental costs can be readily identified and included in the total costs of a particular resource option. A good example is the cost for pollution control equipment to reduce sulfur dioxide emissions. It is not always possible, however, to quantify or value all environmental impacts associated with supply-side or electric power generation resources. Nevertheless, these impacts are real and need to be measured and accounted for in the decision-making process to the extent possible. Whenever possible, TVA has analyzed the environmental impacts on the same basis as other evaluation criteria by using the multi-attribute analysis process.

Most of the resource options and strategies being considered in Energy Vision 2020 are generic in nature, rather than being associated with specific projects or sites. For example, integrated coal gasification combined cycle plants are considered in various strategies, but no site is proposed. Without specific sites, TVA is unable to fully evaluate those impacts that are dependent on local conditions. However, TVA does identify differences in strategies, either quantitatively or qualitatively, that reflect air and water pollutant emissions and other indicators such as land use for existing and new resources and their potential for impact on the environment.

TVA's environmental analysis focused primarily on regional or broad-scale environmental impacts and the generic impacts associated with categories of energy options. Site-specific or local impacts of an individual energy resource project will be addressed in detail in future environmental reviews as specific energy projects are developed.

As discussed in Chapter 3, Affected Environment, measurements of individual pollutant emissions or other indicators of potential environmental impacts were combined to form the indices of impacts listed in *Figure 5-2*. More detailed rationales for the various weightings for the measures are in Volume 2, Technical Document 1, Comprehensive Affected Environment.

ECONOMIC DEVELOPMENT

Economic development is a primary mission of TVA and a recognized public concern in the TVA service area. Historically, the residents of the Tennessee Valley have had low levels of per capita personal income compared to national averages. For this reason, all of the states in the Valley place a high value on opportunities to broaden and enhance their economic base.

Alternative strategies for meeting future needs for electricity have different economic impacts. This criterion, like the others, does not override other considerations. Nevertheless, it is necessary and appropriate to evaluate the economic consequences of each proposed resource option and strategy.

Energy Vision 2020 uses two measurements of economic development: (1) total employment created by various resource strategies in the Valley and (2) the effect of these strategies on total personal income for Valley residents.

FIGURE 5-2. Environmental Indices and Weightings

Environmental indices have been developed by weighting environmental emissions. The environmental indices have been developed for air and water impacts. In addition, greenhouse gases are measured in terms of equivalent tons of carbon dioxide.

		IMPACT AREAS							
		Air				Water			
		Environmental Evaluation Criteria							
Environmental Measure	**Units**	Health-Inhalation	Visibility Impairment	Forests and Crops	Materials	Health-Ingestion	Water Supply and Waste Assimilation	Fish and Aquatic Life and Biodiversity	Greenhouse Gases Total Equivalent Carbon Dioxide (Millions of Tons)
Sulfur Dioxide (SO_2) Emissions	Annual Average Tons	0.40	0.70	0.25	0.60				
Nitrogen Oxides (NO_X) Emissions	Annual Average Tons	0.50	0.25	0.75	0.40				
Total Suspended Particulates (TSP) Emissions	Annual Average Tons	0.05	0.05						
Carbon Dioxide (CO_2)Emissions	Annual Average Thousands of Tons								1
Mercury (Hg) Emissions	Annual Average Tons	0.05							
Coalbed Methane Recovered	Annual Average Tons								-21
Natural Gas Methane Emissions	Annual Average Tons								21
Landfill Methane Recovered	Annual Average Tons								-21
Wood Waste Methane Avoided	Annual Average Tons								-21
Wood Waste Carbon Dioxide Avoided	Annual Average Thousands of Tons								-1
Short Rotation Woody Crops Carbon Dioxide Avoided	Annual Average Thousands of Tons								-1
Heat Release to Surface Water	Annual Average Quadrillion BTUs						0.10	0.05	
Water Consumption	Annual Average Trillions of Gallons						0.10		
Water Use	Annual Average Trillions of Gallons							0.03	
Coal Burned	Annual Average Millions of Tons							0.20	
Nuclear Power Production	MWh					0.05		0.02	
Coal Power Production	MWh					0.60		0.05	
Hydro Electric Peaking Production	MWh					0.35	0.80	0.60	
New Power Plants Constructed	Number							0.05	

FINANCIAL REQUIREMENTS

The TVA power program is self-supporting, and its customers ultimately bear all of the costs incurred by the program. The power program receives no federal tax dollars. The TVA Act prescribes certain financial requirements for TVA. For example, TVA is to provide electric power at rates that are as low as possible. Other financial requirements are contained in the covenants of lending documents executed when TVA borrows money for capital improvements.

To address the general public concern over TVA's existing debt, all resource options and strategies were evaluated in terms of impact on TVA's debt. The TVA Act sets a limit on the amount of debt TVA may have outstanding at any one time. An Act of Congress is required to change this limit, which is currently $30 billion. TVA's debt is currently some $3 billion below this debt ceiling. The TVA Board has announced that TVA will limit its debt to an amount about $2 to $3 billion below the Congressionally set limit.

RISK MANAGEMENT

Uncertainties in load growth, fuel prices, capital costs, and regulatory standards have long challenged utility planners. Added to this list of traditional uncertainties is the likelihood of increasing competition, which will make sound resource decisions even more difficult.

Risk management is now considered an essential part of the planning process at TVA. Planners are shifting from simply making resource investments, based on a fixed set of assumptions about the future, to a different mode of planning that accounts for certain levels of uncertainty in future events. Plans must be both robust and flexible to successfully deal with an uncertain future.

A robust strategy is one that performs well relative to the evaluation criteria across a variety of possible futures. A flexible strategy is one that is conducive to being modified as events unfold and near-term futures become more clearly known. More flexible options are likely to be based on smaller units or program sizes. Flexible options would also have short lead times to construct or start, lower capital costs, and low walk-away costs.

Energy Vision 2020 introduces new techniques for analyzing flexibility. These techniques are based on financial options valuation models and extensions of decision analysis models. Financial options valuation models, such as the Black Scholes model, have been adapted by TVA to look at the value of flexibility in the utility industry. Decision analysis models have been extended to incorporate multiple decision points with many possible uncertainties to analyze the value of flexibility.

EQUITY AMONG RATE CLASSES

As in most businesses, utilities establish different classes of customers to tailor their products and services to meet the particular needs of those customers and to assign appropriate costs. The rate structures used by TVA and the distributors of TVA power provide a primary distinction between residential and commercial and industrial customers. Issues of equity among different class-

es of customers arise when a utility offers services to a particular class of customers for its benefit or to achieve social objectives (e.g., energy conservation). Likewise, issues of equity within a rate class can exist between those who participate in a program and those who do not (non-participants).

Typically, customers who participate in special programs or services (e.g., demand-side management) receive most, if not all the benefits. These programs, however, can increase non-participants' electric rates without providing them with corresponding benefits (i.e., reduced electric bills).

Energy Vision 2020 addresses the issues of equity by looking at the rate impacts of each customer service option on the residential and the commercial and industrial rate classes. In addition, equity is evaluated through the Rate Impact Measure (RIM) test. Programs that pass the RIM test benefit all customers through lower power bills for participants and lower rates for non-participants. If a program does not pass the RIM test, implementing the program would cause non-participants' rates to increase—creating a subsidy for participants.

Chapter Six

Load Forecast and Need for Power

Chapter Six: Load Forecast and Need for Power

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.

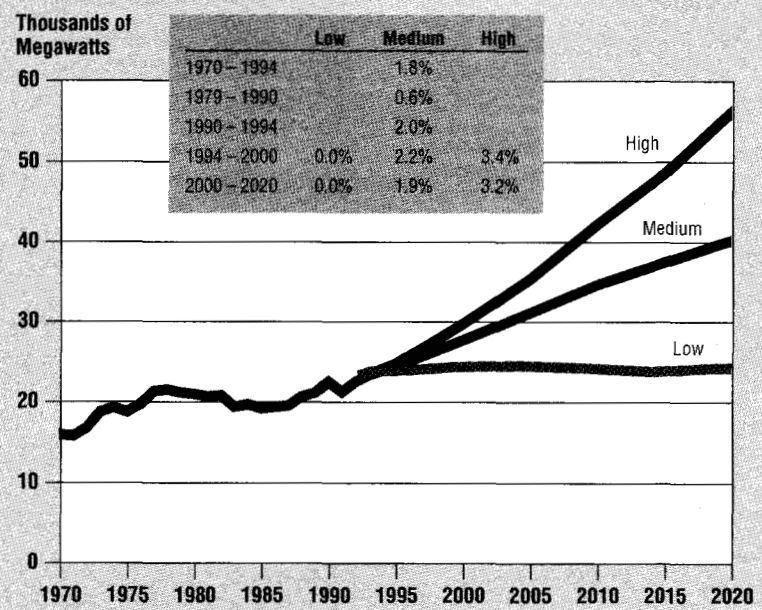
THE RESULTS OF TVA'S LOAD FORECAST

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.

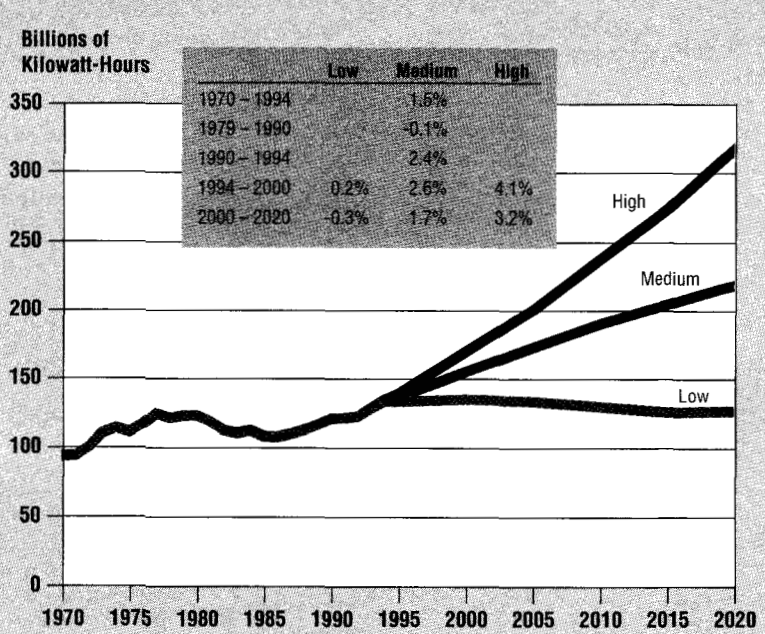
The range of long-term system peak load forecasts developed for Energy Vision 2020 is shown in *Figure 6-1.* For the medium forecast, peak loads are expected to increase 2.2 percent per year through 2000 and 1.9 percent per year from

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



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**



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.

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.

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

2. Price of Electricity

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

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

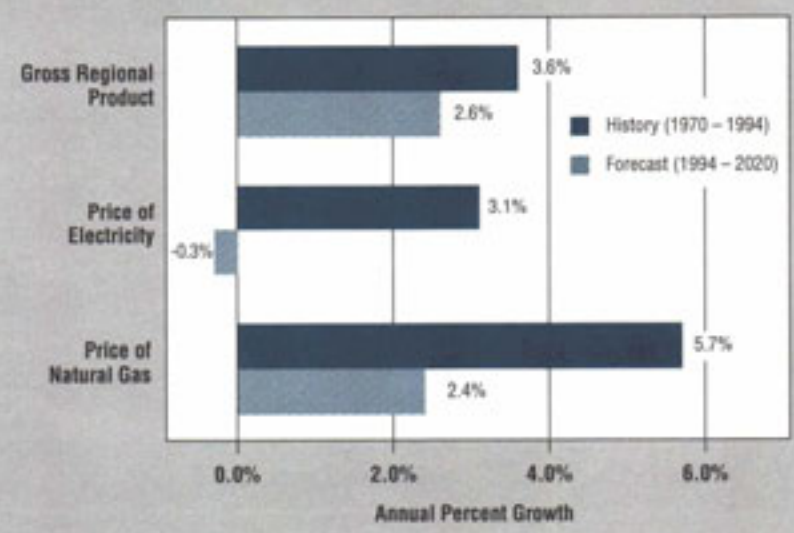
The load forecast is the basis for planning decisions, such as construction of power plants and implementation of demand-side management. Since the implementation of resource decisions can require many years and enormous financial obligation, state-of-the-art load forecasting is necessary. Key elements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

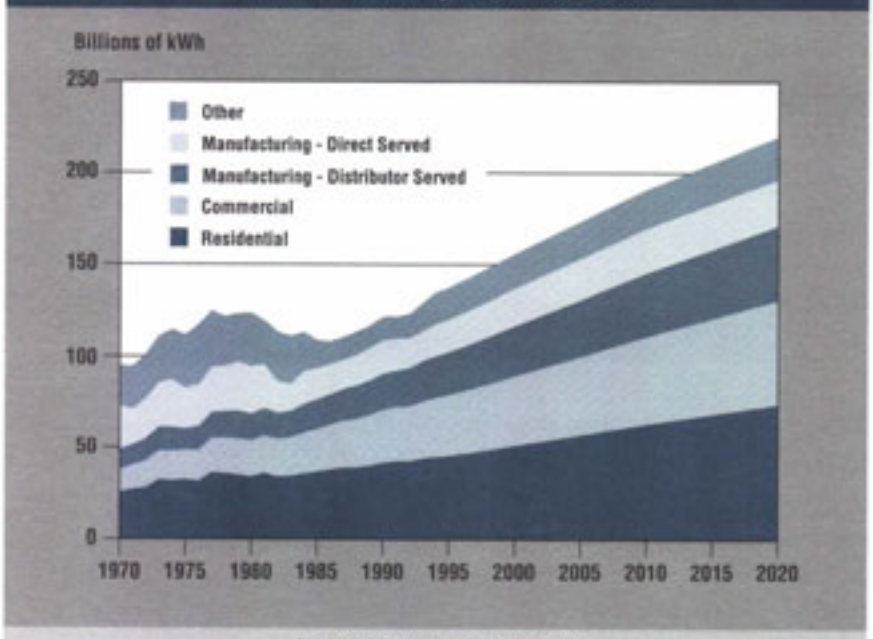
Three types of models are used:

- 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.

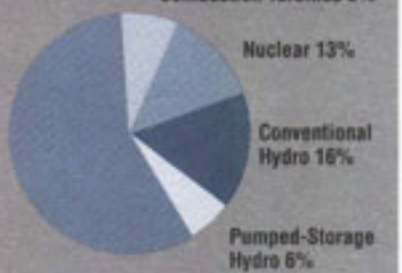
3. Producing a Range of Forecasts to Deal with Uncertainty

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.

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.

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

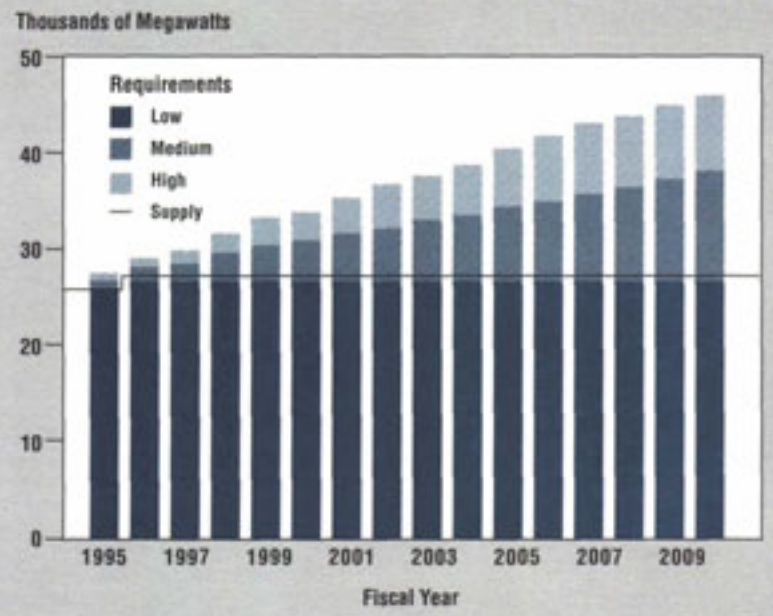
the contracted power is available for interruption due to variations in contracts. Approximately 1,700 megawatts of the 2,500 megawatts of industrial load is available for interruption during peak periods through 2002. After 2002, the availability of interruptible power is expected to drop to 1,500 megawatts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

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.

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.

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.

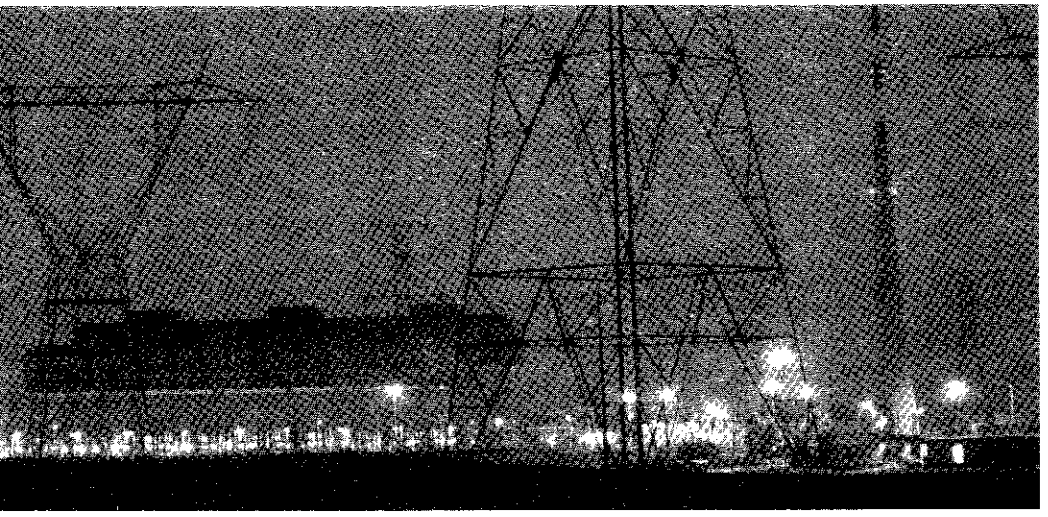
The reserve margin proposed by TVA is in alignment with reserve margins established by other entities in the utility industry. Among members of the North American Electric Reliability Council, of which TVA is a member, forecast reserve margins range from 13.5 percent to 22.3 percent for 1995 and projections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

Chapter Seven

Supply-Side Options



Chapter Seven: Supply-Side Options

Existing TVA plants will continue to be the backbone of TVA's power supply system for the Energy Vision 2020 planning period. However, TVA's load forecasting indicates that its customers' future needs for electricity will exceed its current generating capacity.

With four nuclear units in various stages of construction, a near-term decision was needed on whether to continue these projects. Several options were developed that involved completion, conversion, or cancellation of these nuclear projects.

TVA also created an extensive list of other generating options to meet new peaking, intermediate, base-load, and storage power supply needs through the year 2020. These included traditional technologies (e.g., coal plants, combustion turbines), as well as potential renewable and advanced technology facilities.

In addition, TVA identified options that would give TVA greater flexibility. These include the purchase of competitively priced power from other suppliers (e.g., independent power producers, cogenerators), options on future power delivery, and business partnering arrangements.

TVA characterized all of the supply-side options under consideration, describing their performance, cost, and relevant environmental emissions.

This Chapter Includes:

- Defining Supply-Side Options
- Identifying Supply-Side Options
- Characterization of Supply-Side Options

Supply-Side Options

TVA's load forecasting indicates that its customers' future electricity needs will exceed its current generating capacity. Two broad resource alternatives—energy conservation or energy generation from additional sources—are available to TVA to meet this increased demand. The best solution will probably include elements from both alternatives.

This chapter defines and identifies the broad range of supply-side options that TVA considered in Energy Vision 2020 and explains how these options are characterized according to their performance, cost, and environmental factors.

Existing plants will continue to be the backbone of TVA's power supply in the future; however, a broader definition of supply-side options captures the diverse range of possibilities open to power suppliers—like TVA—today.

Defining Supply-Side Options

Historically, electric utilities have generated, transmitted, and distributed power. Resources that generate or transmit electricity are referred to as supply-side options.

Like most utilities, TVA has satisfied most of its customers' growing electricity demand by either adding new plants to its system or increasing the amount of electricity produced at existing facilities. New generating plants are not the only way to satisfy increased customer demand, but they remain an important option for the future.

Existing plants will continue to be the backbone of TVA's power supply in the future; however, a broader definition of supply-side options captures the diverse range of possibilities open to power suppliers—like TVA—today. A more workable definition of "supply-side option" is "the actions a power supplier can take to increase the amount and reliability of power available for its customers." With this broader definition, options now include power purchased from other producers, power produced by joint ventures, and transmission system improvements. More options add opportunities for TVA to increase the value of power provided to its customers.

MEETING NEEDS FOR POWER

Demand for electricity changes constantly, which increases the need for different generating technologies. The four types of power generators are:

- **Peaking units** can respond quickly to changes in power demand, but normally operate only when demand for power is very high and not for extended periods. A gas-fired combustion turbine is an example of a peaking unit.

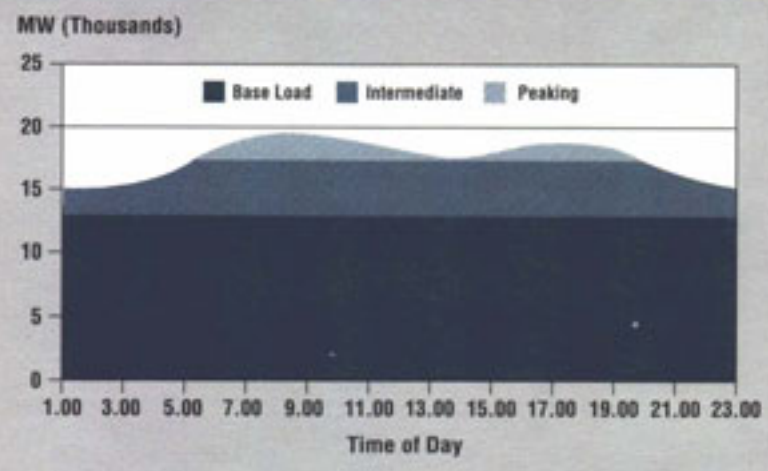
- **Intermediate units** operate to meet the next highest level of power demand. They have some of the same characteristics of peaking units; they must start and stop often and generate a wide range of power outputs. A gas-fired, combined cycle plant is an example of an intermediate unit.
- **Base-load units** meet a largely constant level of power demand and tend to be cycled on and off far less frequently than peaking or intermediate units. A nuclear power plant is an example of a base-load unit.
- **Storage units** usually serve the same power supply function as peaking units, but use low-cost off-peak electricity to store energy for generation later at peak times. An example of a storage unit is a hydro pumped-storage plant that pumps water to a reservoir during periods of low demand and releases it to generate electricity during periods of need. Consequently, a storage unit is both a power supply source and an electricity user.

Figure 7-1 illustrates the use of peaking, intermediate, and base-load generators. Although these categories are useful, the distinction between them is fuzzy. For example, a peaking unit may be called on to run continuously for some time period like a base-load unit, although it is less economical to do so. Similarly, many base-load units are capable of operating at different power levels, giving them some of the characteristics of an intermediate or peaking unit. Energy Vision 2020 considers strategies that take advantage of this range of operations.

The differences among the types of power generation can be characterized by their capital and operating costs. Peaking units generally have low capital costs and high operating costs. Base-load units usually have high capital costs and low operating costs. Costs for intermediate units tend to fall in the middle.

Figure 7-2 illustrates the costs for typical supply-side options as a function of capacity factor. As the figure shows, all options become less expensive the more they are operated. At low capacity factors, peaking units have lower costs than base-load units due to the peaking units' low capital costs. At higher capacity factors, base-load units have lower costs due to their lower operating costs.

FIGURE 7-1. **Representative Winter Day Load Profile**



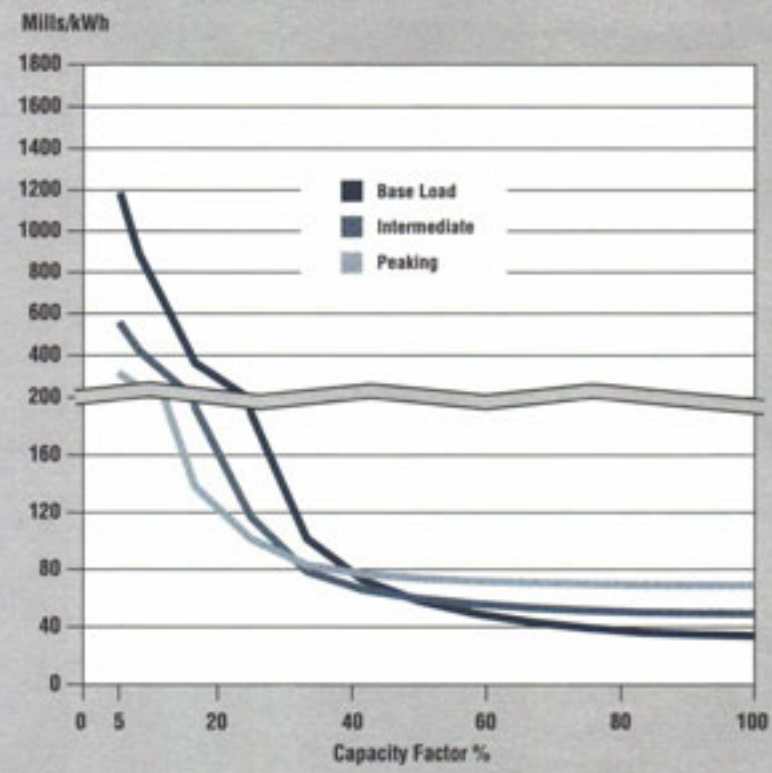
Different types of power generators are needed to meet variations in TVA's load demand.

CENTRALIZED AND DECENTRALIZED GENERATION

Most older generating plants are located in large power supply centers, or central stations, providing between several hundred and several thousand megawatts of capacity. Many available generating technologies are best suited for this type of application.

Other technologies offer the chance to locate the generation facility closer to the end user, a concept referred to as "distributed generation." Both central station and distributed generation technologies are included in the group of supply-side options considered in Energy Vision 2020. For Energy Vision 2020, however, TVA has included additional distributed generation technologies with low power levels (less than 20 megawatts) in the customer service options discussed in Chapter 8. These technologies tend to be closely tailored to customer needs, even though they satisfy the definition of a supply-side option.

FIGURE 7-2. **Cost of Producing Electricity as a Function of Capacity Factor**



While all options become less expensive when operated more, the "least cost" option changes. This characteristic, driven by the relationship between fixed and variable costs, defines whether an option is viewed as peaking, intermediate, or base load. (Capacity factor is the ratio of the actual energy output for a power plant over a certain period of time—typically one year—to the maximum achievable output over the same period of time.)

Identifying Supply-Side Options

TRADITIONAL SUPPLY-SIDE OPTIONS

Some supply-side options are traditional power supply technologies, such as the pulverized coal and natural gas-fired combustion turbine options. Other options involve projects that are unique to TVA. These include completing or converting the Bellefonte Nuclear Plant and increasing the capacity of the Raccoon Mountain pumped-storage facility. Still other options reflect ongoing research and development into new technologies including solar power, wind power, fuel cells, and some of the more advanced combustion technologies.

In developing its supply-side options, TVA faced the challenge of investigating a broad spectrum of options while keeping the total to a manageable number for Energy Vision 2020.

With four nuclear units in various stages of construction, the nuclear completion, conversion, and cancellation options were all included since near-term decisions regarding these projects are needed. (More information on these options can be found in Volume 2, Technical Document 8, Resource Integration.)

Traditional options were included because a number of these technologies are still viable—other utilities are still constructing plants using these technologies today.

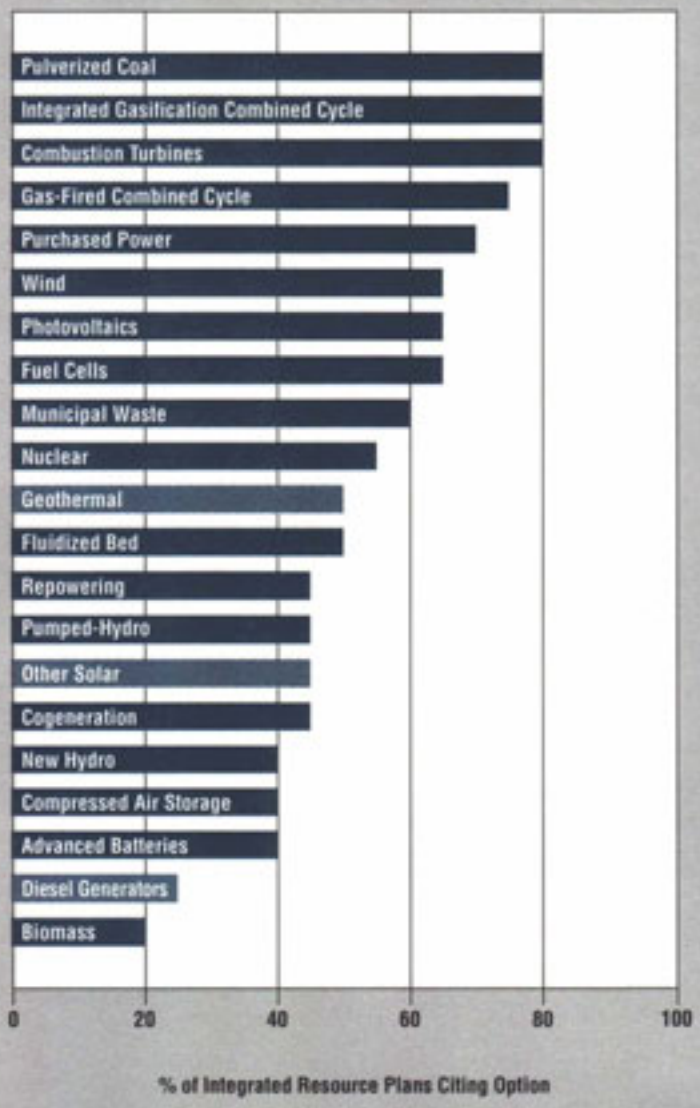
Even within the category of more traditional options, many variations are possible. Plant reliability (availability) can be increased, but usually at additional cost.

Similarly, environmental impacts can be limited to predetermined levels by using different fuels or by adding or altering environmental control equipment. The supply-side options included in Energy Vision 2020 generally include only representative projects for each technology.

TVA reviewed 20 other utility integrated resource plans to verify that its list of options was comprehensive. The treatment of supply-side options differed considerably in the plans examined, ranging from detailed option descriptions in some cases to a listing of only the most promising options in others. No clear, standard set of options emerged from this review. Nevertheless, a comparison of TVA's option list with other lists confirmed that TVA's list is comprehensive.

As shown in *Figure 7-3*, with the exception of geothermal options, large solar collectors and diesel generators, the TVA list is comparable to those in other utilities' integrated resource plans. With regard to the exceptions, TVA has not identified sufficient geothermal resources in the region to support geothermal energy options; large solar collectors are not economical compared with other solar options (i.e., photovoltaics); and diesel generators have been analyzed with customer service options.

FIGURE 7-3. **Comparison with Options Cited in 20 Other Integrated Resource Plans**



The TVA supply-side options list is comparable to those in other integrated resource plans with the exception of geothermal options, large solar collectors, and diesel generators.

RENEWABLES

Several renewable resource options are included as supply-side options. These include several biomass technologies, wind turbines, photovoltaics, landfill and coalbed methane recovery, and technologies that burn garbage as a fuel. Many of these technologies have characteristics that are beneficial compared to some of the other supply-side technologies. These characteristics include small modular size, the possibility of dispersed locations, and low environmental emission rates.

POWER FROM OTHER SUPPLIERS

The purchase of power from cogenerators and independent power producers has become a common practice in the utility industry. Contracts for outside power usually are procured through a bidding process after a utility has defined its needs (in terms of capacity type, amount of energy, and dates when power is needed). Proposals from a TVA bidding process (explained below) and certain unsolicited proposals were reviewed in Energy Vision 2020. Over the years, TVA has received a number of unsolicited proposals for power supply. TVA used these proposals as the basis for defining representative cogeneration and independent power producer projects for the supply-side options list.

OPTION PURCHASE AGREEMENTS

In July 1994, TVA issued a request for proposals for option purchase agreements. Option purchase agreements provide a means for TVA to secure reliable, competitively priced power. These agreements offer flexibility and could enhance TVA's ability to conduct business effectively in a competitive environment.

TVA asked potential suppliers to propose flexible contracts to supply peaking, intermediate, and base-load power. TVA indicated that it was interested in securing up to 2,000 megawatts of peaking capacity for the period from 1997 to 2006 and up to 2,000 megawatts of base-load capacity for the period from 2000 to 2006.

TVA solicited two kinds of option purchase agreements: a call option and a put option. With a call option, TVA pays the seller a price (premium) that gives TVA the right, but not the obligation, to purchase power from the seller at a given price at some specified time in the future.

A put option is the reverse. The seller of the power pays TVA a premium for the right, but not the obligation, to sell power to TVA at a given price at some specified time in the future. In this case, if the owner of the put option chooses to sell the power, TVA is obligated to buy it. Therefore, the put option increases the uncertainty that TVA must consider in planning future supply capacity, but TVA receives an upfront payment as compensation.

In its request for proposals, TVA explained that it would accept proposals from other electric systems, marketers and brokers, demand-side management projects, and developers. Any company could bid, thus opening the process to a variety of services.

In addition to proposals for call and put options, TVA also accepted proposals for forward contracts. A forward contract is not an option purchase agreement. It is simply a firm contract for TVA to buy power from a seller at a specified price at a future date.

TVA received 138 proposals from the request for proposals. These represent 9,800 megawatts of peaking capacity and 12,200 megawatts of base-load capacity.

Proposals received by TVA have been evaluated on the basis of their price, flexibility, and transmission capabilities, as well as their financial, technological, environmental, and economic development attributes. From the results of these

evaluations, the proposals were ranked, and TVA developed a "short list" of the best candidates. TVA will negotiate the price, amount of capacity, and premiums with these candidates.

A full description of the option selection process can be found in the document "Request for Proposal for Option Purchase Agreements," dated July 8, 1994, and a supplement, dated September 22, 1994.

FIGURE 7-4. **Typical Project Implementation Schedule**

Project Phase	Typical Duration
Site Selection, Environmental Studies, & Permitting	2 years
Contracting, Engineering, & Procurement	2 years
Construction & Startup	3 years
Total	7 years

The typical implementation schedule for an option involves three phases.

FLEXIBLE SUPPLY-SIDE OPTIONS

While Energy Vision 2020 outlines the amount and time frame of TVA's need for power, each supply-side option has its own lead time (time required for its implementation). Typically, the implementation of an option involves three phases. During the first phase, the preferred site for the option is identified (and possibly secured), environmental studies are performed, and environmental permits are obtained. During the second phase, engineering analysis and design are completed, and contracts for construction are placed. During the final phase, the plant is constructed and begins operation. While some overlap is reasonable, these phases generally are viewed as sequential activities. *Figure 7-4* provides a typical project implementation schedule, which is applicable to a number of options.

Overall project schedules can be shortened by selecting sites and performing environmental studies prior to making the decision to commit to the project. Although the usefulness of such studies can be limited, they usually remain valid for at least 5-10 years. In Energy Vision 2020, TVA considered the desirability of identifying sites and performing environmental studies for some options in order to shorten their lead times. This provided additional flexibility for some of the options.

POWER FROM OTHER UTILITIES

TVA also can buy power from other utilities. For the next few years, some utilities in the region are expected to have excess generating capacity. This excess capacity is expected to be depleted by the early 2000s. After that, power purchases from other utilities will still be possible, but prices will likely reflect the cost of adding new capacity.

TECHNOLOGIES NOT CURRENTLY COMMERCIALLY AVAILABLE

Identifying new technologies presented a challenge. Ongoing research and development are continuing to produce new technologies as well as significant improvements in existing applications. No one can predict the full range of options that will become available over the next 25 years.

Research and development efforts are underway for many potentially attractive new technologies, ranging from ideas on the drawing board to prototype technologies that have been tested but are not yet commercially available. It was neither feasible nor necessary to include every conceivable new technology in Energy Vision 2020. To be considered an option in Energy Vision 2020, a new technology had to be sufficiently well developed that its date of commercial availability, cost, and performance could be credibly estimated.

TVA identified these options through public comments, its own research and development, and utility industry research provided by the Electric Power Research Institute.

Forecasting cost and performance characteristics for a new technology includes many uncertainties. Nevertheless, some important trends in technology development have been observed. Estimates of cost and performance can be overly optimistic until prototypes have been tested and their detailed designs completed. Cost and reliability estimates improve as more units are built, although unforeseen problems may occur at any time.

Some promising new technologies are now being used outside the TVA region where climate and other conditions are favorable. This is true for wind turbines and solar photovoltaic cells. Since industry research and development are continuing to improve both the cost and performance of these options, they are included as supply-side options in Energy Vision 2020.

The costs for each supply-side option in Energy Vision 2020 include two ranges of uncertainty: one for the developmental status of the technology and another reflecting the accuracy of the cost estimate. Appropriately, both ranges are wide for technologies in early stages of development, allowing for either innovative breakthroughs or future problems. Both ranges narrow as development proceeds toward a standard commercial product, and costs become less uncertain.

NON-TRADITIONAL BUSINESSES AND BUSINESS ARRANGEMENTS

Conventional power plants owned and operated by utilities are not necessarily the ideal solution for obtaining additional capacity in the TVA region. By the same token, conventional power purchase agreements may also not be ideal. The changing competitive environment in the utility industry provides several new alternatives to consider.

Conventional power supply options typically use one of two approaches. A utility or independent power producer primarily generates power as a business and may make some minor side products. Alternately, a cogenerator may use a manufacturing process that generates small quantities of power as a byproduct. As technology advances, opportunities for more closely aligning manufacturing or chemical processes with power production appear increasingly attractive. TVA is exploring such arrangements, which are referred to as coproduction. At this time, the best opportunities for such an arrangement are associated with coal gasification technologies.

Finally, conventional utility projects have relied on utility ownership and financing. Although financing by a single entity remains feasible, partnership arrangements may also be beneficial. TVA is considering two partnership options for the Bellefonte Nuclear Plant—either complete it as a nuclear plant or convert it to a coal gasification plant. For the nuclear completion partnership option, TVA would invest no capital beyond that which it has already invested. For the coal gasification partnership option, additional capital may be required for equipment.

Other partnership opportunities may also be beneficial, particularly as a means of minimizing TVA's debt.

The rapid changes occurring in the utility industry will continue to challenge planners to look beyond conventional options for supplying power in a cost-effective, environmentally responsible way. In some cases, these opportunities may take the form of different business arrangements for implementing technologies that are already included in the supply-side option list (for example, a Bellefonte partnership). In others, new technologies or combinations of existing technologies may arise.

BELLEFONTE CONVERSION

One of the options being considered in Energy Vision 2020 is the conversion of the Bellefonte Nuclear Plant to an integrated gasification combined cycle plant that generates power and makes chemical products. Doing this as a partnership arrangement is also being considered.

The concept for the integrated gasification combined cycle with coproduction and partners is the same as for a conventional integrated gasification combined cycle, with the addition of chemical coproduction capability. Some of the syngas is diverted from the combustion turbines for use as a feedstock in a chemical process plant. The studies to date have indicated that methanol and some of its derivatives represent the most feasible coproduction alternatives. Under one scenario, the ultimate facility is assumed to consist of four 3,000 ton-per-day gasifiers providing syngas to fuel two combustion turbines plus the coproduction plant. The facility will be able to generate approximately 484 megawatts with the capability to produce 6,600 tons per day of methanol and associated products. It is also assumed that the gasification and coproduction plants are owned and operated by partners. TVA would own and operate the power block only. The chemical coproducts were assumed to be shipped to the Gulf Coast area by barge for sale to markets in that region.

The construction schedule for this concept is based upon a multi-phase installation. The integrated gasification combined cycle option described above is based on the successful demonstratoin of the use of integrated gasification combined cycle technology. An effort is under way to demonstrate at Bellefonte the feasibilty of integrated gasification combined cycle technology through the use of Department of Energy Clean Coal Technology funding. The demonstration facility will consist of one 3,000 ton-per-day gasifier and a combustion turbine combined cycle repowering of one of the Bellefonte nuclear units with a capacity of 400 megawatts. (The Department of Energy has tentatively approved resiting the Combustion Engineering Clean Coal II Springfield project to Bellefonte.) Approvals for construction of the demonstration plant are expected to be obtained by October 1997. Operation of the demonstration plant will occur in the latter part of 2000. Subsequent gasifiers could go into operation after a two-year demonstration period, as determined by economic considerations. Construction of the chemical coproduction facilities could proceed in parallel with the construction of these future gasifiers, as economically justified.

The concept is sufficiently flexible to allow several alternatives for the development of Bellefonte. TVA will be conducting an 18 to 24 month study to eval-

uate the various long-term conversion options. Meanwhile, the Department of Energy demonstration project will proceed on a schedule agreed to by both TVA and the Department of Energy. To meet this schedule, planning for the demonstration unit is under way.

Subsequent expansion could follow several different scenarios. The steam turbines at Bellefonte are sufficiently large to allow connection of several combustion turbine combined cycle units. For example, initial installations could consist of phased combined cycle units fueled by fuel oil or natural gas (if available) starting as peaking combustion turbines, then converted later to combined cycle operation. These units could then be updated to syngas operation by the construction of additional gasifiers as economics dictate.

TRANSMISSION OPTIONS

Consistent with a broader definition of supply-side options, TVA also considered the following two transmission system improvement options:

- A series of transmission system capital improvements would reduce transmission losses on the TVA system. Since TVA continually evaluates projects that reduce losses, those projects are not explicitly evaluated as a part of each strategy in Energy Vision 2020.
- The location of future generation in the western part of the power system can reduce losses and improve transfer capacity on transmission interfaces with other utilities. The loss reduction would be equivalent to about 45 megawatts per 1,000 megawatts of capacity and would mean a savings of $30 to $50 million.

ENVIRONMENTAL CONTROL OPTIONS

Compliance with the 1990 Clean Air Act Amendments' Phase II requirements for sulfur dioxide reduction is another consideration in Energy Vision 2020. Compliance is a dynamic activity that requires ongoing consideration of changes in fuel markets, sulfur dioxide allowance markets, cost of pollution control equipment, opportunities for power purchases, etc. Thus, defining a detailed strategy in Energy Vision 2020 is not feasible. However, TVA established a general approach to Phase II compliance from which appropriate strategies will emerge.

The capital and operating costs of sulfur dioxide emissions reduction options vary widely. Emissions control options include scrubbers and the use of low sulfur coal. Energy supply options include switching to an alternative fuel such as natural gas, converting a facility to a technology with lower emissions (i.e., repowering), or replacing coal-fired units with low emission generation capacity. Demand-side management or conservation options can also reduce sulfur dioxide emissions by reducing usage of existing facilities or avoiding the need for new capacity. Purchasing allowances from other regulated sources that exceed their emissions reduction requirements is also an option.

The costs of implementing any of these options depend on timing. For example, emissions reductions taken earlier than required or exceeding minimum requirements may be less expensive at one TVA source and delay the need for equivalent reductions at another source in the TVA system. The relative costs of

FIGURE 7-5. **Alternative Phase II Acid Rain Control Options**

Reference Case	Minimum Capital Borrowing	Repowering – Minimum Carbon Dioxide (CO_2) Impact
Wet flue gas desulfurization (scrub) at Paradise Unit 3 in 2002 and add coal reburn in 2000	Switch Paradise Unit 3 to 100% powder river basin coal in 2006	No scrubbers at Paradise Unit 3
Wet flue gas desulfurization at Allen Units 1-3 in 2004 and add coal reburn in 2000	Switch Allen Units 1-3 to 100% natural gas in 2000; no coal or gas reburn	Repower Allen and Johnsonville Units 1-10 with gas-fired combined cycle in 2004
Switch to eastern low sulfur coal at selected plants	Switch to medium and low sulfur coal at selected plants	Switch to low sulfur coal at selected plants
Build up allowance bank in Phase I; buy and sell allowances in Phase II	Sell excess allowances in Phase I; buy and sell allowances in Phase II	Build up allowance bank in Phase I; buy and sell allowances in Phase II

Energy Vision 2020 considers 3 alternatives to comply with the Clean Air Act: (1) a Reference Case, (2) Minimum Capital Borrowing, and (3) Repowering—Minimum Carbon Dioxide (CO_2) Impact.

achieving emissions reductions from TVA sources will depend on future environmental regulations, future costs of alternative fuels, and the development of new emissions control technologies.

Typical Phase II environmental control options can be formulated to address TVA's Energy Vision 2020 criteria. For example, a control option to minimize impacts on rates would include sulfur dioxide scrubbers, while a control option to minimize debt would minimize capital expenses and use extensive fuel switching. Other examples include control options that not only reduce sulfur dioxide emissions, but also minimize carbon dioxide emissions and maximize the use of new technologies for emissions controls and repowering.

The precise operational details of a control option must be worked out in response to future events (e.g., new regulations, generation demands). Prior to deploying specific pollution control projects, further environmental reviews would be conducted. *Figure 7-5* shows Phase II acid rain control options that are being considered in Energy Vision 2020.

In Energy Vision 2020, additional carbon dioxide mitigation was represented through options for cofiring biomass fuel at TVA's existing coal-fired plants. For the first option, it was assumed that the overall amount of biomass fuel would be 0.3 percent and in the second option, 1.3 percent.

Many of the options considered in Energy Vision 2020, such as repowering and demand-side management, could also help TVA comply with the Clean Air Act.

Characterization of Supply-Side Options

All of the supply-side options that TVA identified for consideration in Energy Vision 2020 were characterized using data describing their performance (e.g., capacity, heat rate), cost (e.g., capital cost, operation and maintenance

FIGURE 7-6A. **Conventional Supply-Side Options—Performance Characteristics**

Option Name	Status	Duty Cycle	Net Full Load Capacity (MW)	Net Full Load Heat Rate (Btu/kWh)	Fuel	Total Schedule (Yr)	Coproducts
Supercritical Pulverized Coal Plant (4x300 MW)	Mature Commercial	Base Load	1,200	9,522	High Sulfur Coal	8	None
Simple Cycle Combustion Turbine (1x150 MW)	Mature Commercial	Peaking	150	10,500	Natural Gas	5	None
Natural Gas-Fired Combined Cycle (1x470 MW)	Mature Commercial	Intermediate	470	7,000	Natural Gas	5	None
Compressed Air Energy Storage with Humidification (3x337 MW)	Initial Commercial	Peaking	1,011	5,874	Natural Gas	7	None
Integrated Gasification Combined Cycle (IGCC) (3x245 MW)	Initial Commercial	Base Load	740	7,230	High Sulfur Coal	8	Sulfur
Integrated Gasification Cascaded Humidified Advanced Turbine (G Series CT) (2x420 MW)	Large Scale Demo	Base Load	840	8,200	High Sulfur Coal	8	None
Landfill Methane (1x2 MW)	Pilot Scale	Intermediate	2	6,450	Landfill Gas (Methane)	3	Waste Heat, Steam
Hydro Generation: Modernization at Existing Projects	Mature Commercial	Peaking	3,864	NA	NA	11	None
Bellefonte (BLN) Repowering – IGCC with Coproduction with Partners (2x242 MW)	Initial Commercial	Base Load	484	7,200	Syngas	8	Multiproducts
Generic Natural Gas Combined Cycle Independent Power Producer (1x150 MW)	Mature Commercial	Intermediate	150	7,500	Natural Gas	5	None
Wind - 39 Meter Variable Speed Advanced Wind Turbine (444x0.45 MW)	Pilot Scale	Intermediate	200	NA	Wind	6	None
Power Purchase - Peaking	Mature Commercial	Peaking	300	12,000	NA	0	None

Figures 7-6A-E. Supply-Side Options – Conventional, Flexible, and Option Purchase Agreements. These figures show performance (7-6A), cost (7-6B), and environmental characteristics (7-6C) for some of the supply-side options. The flexible options (7-6D) are different than the conventional options in their schedules and costs (all other characteristics remain the same). By doing some work upfront, such as site identification and permitting, before a final decision is made to put an option in place, the total schedule can be significantly reduced. The accelerated schedule, the upfront cost to complete this preliminary work, and the remaining cost to complete the option are shown for the flexible options.

cost, fuel cost), and environmental emissions (e.g., air, water, solids).

Selected conventional supply-side options, characterized by performance, cost, and environmental emissions, are shown in *Figures 7-6A, 7-6B,* and *7-6C.* Flexible TVA-built options are shown in *Figure 7-6D,* and option purchase agreements are shown in *Figure 7-6E.* These supply-side options are shown because they are included in the final set of strategies evaluated in Energy Vision 2020.

A complete list of the supply-side options identified for consideration in Energy Vision 2020 and their characteristics can be found in Volume 2,

FIGURE 7-6B. Conventional Supply-Side Options—Cost Characteristics

Option Name	Base Capital ($/kW)	Fuel Cost ($/MMBtu)	Base Fixed Operating &Maintenance ($/kW-Yr)	Base Variable Operating &Maintenance (Mills/kWh)	Base Fixed Additions &Improvements ($/kW-Yr)
Supercritical Pulverized Coal Plant (4x300 MW)	$1,345	$1.00	$20.0	1.3	$13.6
Simple Cycle Combustion Turbine (1x150 MW)	$360	$2.48	$2.0	2.6	$0.0
Natural Gas-Fired Combined Cycle (1x470 MW)	$655	$2.48	$4.7	1.25	$4.5
Compressed Air Energy Storage with Humidification (3x337 MW)	$315	$2.48	$2.2	2.5	$0.0
Integrated Gasification Combined Cycle (IGCC) (3x245 MW)	$1,524	$1.00	$20.8	1.2	$12.0
Integrated Gasification Cascaded Humidified Advanced Turbine (G Series CT) (2x420 MW)	$1,126	$2.48	$18.6	0.9	$13.2
Landfill Methane (1x2 MW)	$1,034	$1.29	$9.8	1.7	$40.0
Hydro Generation: Modernization at Existing Projects	$52	NA	$6.9	0.0	$10.8
Bellefonte (BLN) Repowering - IGCC with Coproduction with Partners (2x242 MW)	$465	$3.59	$4.7	1.3	$4.5
Generic Natural Gas Combined Cycle Independent Power Producer (1x150 MW)	$0	$2.48	$86.7	17.16	$0.0
Wind - 39 Meter Variable Speed Advanced Wind Turbine (444x0.45 MW)	$958	NA	$15.0	0.0	$0.0
Power Purchase - Peaking	$0	NA	$33.6	31.8	$0.0

Fuel cost data are in 1995 dollars. Other cost data are in 1994 dollars.

FIGURE 7-6C. Conventional Supply-Side Options—Environmental and Other Characteristics

Option Name	Sulfur Dioxide (lb/MMBtu)	Nitrogen Oxides (lb/MMBtu)	Carbon Dioxide (lb/MMBtu)	Thermal Discharge (MMBtu/MWh)	Solid Waste (lb/MMBtu)	Economic Development (Annual Average Employment)
Supercritical Pulverized Coal Plant (4x300 MW)	0.3	0.1	210	0	24.0	918
Simple Cycle Combustion Turbine (1x150 MW)	0	0.08	115	0	0	20
Natural Gas-Fired Combined Cycle (1x470 MW)	0	0.08	115	0	0	128
Compressed Air Energy Storage with Humidification (3x337 MW)	0	0.03	115	0	0	130
Integrated Gasification Combined Cycle (IGCC) (3x245 MW)	0.05	0.035	205	0	9.5	610
Integrated Gasification Cascaded Humidified Advanced Turbine (G Series CT) (2x420 MW)	0.05	0.01	205	0	9.5	569
Landfill Methane (1x2 MW)	0	0.16	-798	0	0	1
Hydro Generation: Modernization at Existing Projects	0	0	0	0	0	619
Bellefonte (BLN) Repowering - IGCC with Coproduction with Partners (2x242 MW)	0.03	0.08	131	0	9.5	108
Generic Natural Gas Combined Cycle Independent Power Producer (1x150 MW)	0	0.08	115	0	0	15
Wind - 39 Meter Variable Speed Advanced Wind Turbine (444x0.45 MW)	0	0	0	0	0	108
Power Purchase – Peaking	0	0.1	115	0	0	0

FIGURE 7-6D. **Flexible TVA Supply-Side Options**

Option Name	Original Schedule (Yr)	Accelerated Schedule (Yr)	Cost to Obtain Accelerated Schedule ($/kW)	Cost Remaining ($/kW)
Simple Cycle Combustion Turbine (1x150 MW)	5	1.5	$22	$338
Natural Gas-Fired Combined Cycle (1x470 MW)	5	2	$14	$641
Integrated Gasification Combined Cycle (IGCC) (3x245 MW)	8	3.5	$18	$1,506
Integrated Gasification Cascaded Humidified Advanced Turbine (G Series CT) (2x420 MW)	8	3.5	$15	$1,111
Landfill Methane (1x2 MW)	3	1.5	$205	$829
Bellefonte Repowering – IGCC with Coproduction with Partners (2x242 MW)	8	3.5	$20	$445

The schedule for the landfill methane option is constrained by the commercialization of the fuel cell technology upon which it is based. Thus, an accelerated schedule would not reduce the timing of the initial availability of the option.

FIGURE 7-6E. **Option Purchase Agreements**

Option Type	Schedule (Yr)	Availability	Option Price ($/MW-Yr)	First Year Charges ($/MWh)
Base Load - Call	3	85 – 100%	100 – 65,000	$24 – 52
Peaking - Call	2	95 – 100%	150 – 1,346	$40 – 250

Technical Document 6, Supply-Side Options. A brief description of each option, identifying the primary source of data for characteristics of the option, is also found in Volume 2, Technical Document 6, Supply-Side Options.

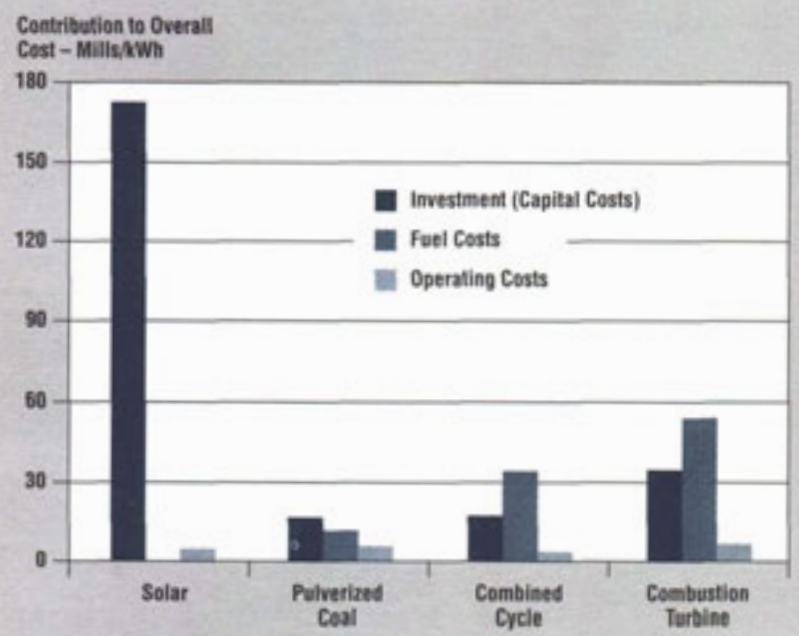
In developing Energy Vision 2020, TVA considered whether to use a single source or multiple sources of data to characterize the options. A single source provides better data consistency across options; however, multiple sources provide the advantage of a broader range of data and more recent data. TVA elected to use multiple sources, recognizing that this approach could introduce some differences in how costs are allocated in different categories and how critical factors such as contingencies are treated. In many cases, Electric Power Research Institute's Technical Assessment Guide was used as a source. This guide provides the most comprehensive assessment of supply-side options available. In other cases, option descriptions reflect information from proposals or other specific studies available only to TVA.

COST, PERFORMANCE, AND ENVIRONMENTAL CHARACTERISTICS

A review of *Figure 7-6* reveals the broad range of performance attributes, cost factors, and environmental emissions associated with the supply-side options. Comparing options across this full range is a daunting task, but some general guidelines can help.

Figure 7-7 shows the sensitivity of overall cost to various cost factors for four typical supply-side options. As shown in *Figure* 7-7, the magnitude of different cost factors varies considerably among different options; however, for most options either capital costs or fuel costs (or both) dominate.

FIGURE 7-7. **Cost Factor Sensitivities**



The relative magnitude of the contributing cost factors varies considerably among different options based on expected operating capacity factors.

While the cost of power is an important consideration for the selection of supply-side options in Energy Vision 2020, other factors are also significant. Environmental emissions differ dramatically depending on fuel type and technology. Each option also requires different capital investments, which will affect TVA's overall debt. TVA considers these effects within the framework of Energy Vision 2020. In general, the broad range of supply-side options support strategies that perform well from the perspectives of cost, environmental factors, rates, and debt.

SITING CONSIDERATIONS

Supply-side option costs and benefits are site-specific. Since Energy Vision 2020 is programmatic in nature, site-specific decisions will be made later. Therefore, for many supply-side options, TVA evaluated generic locations. Where specific conditions are necessary to conduct the review, such as for estimating transmission costs and effects, TVA considered a location at milepost 160 on the Tennessee River, which is in the western part of the TVA system.

Some options can only be implemented at a single location (for example, the completion of Bellefonte Nuclear Plant or its conversion to use of another fuel). For these options, the actual location was considered in estimating the effects on the transmission system and determining likely fuel costs.

Chapter Eight

Customer Service Options

Chapter 8: Customer Service Options

Customer service options are actions consumers can take on their side of the electric meter to obtain energy efficiencies and provide load management options for utilities. Customer service options also include actions consumers can take to use electricity to improve their productivity and quality of life.

TVA's catalog of customer service options contains traditional demand-side management (i.e., energy efficiency and load management), self-generation, beneficial electrification, and rate options. TVA designed the options to take advantage of existing and emerging technologies that could be effectively integrated into programs to meet varying customer and TVA needs.

These options were ranked by total resource cost as well as other evaluation criteria and combined into blocks of options suitable for analysis with power supply options. TVA's long- and short-term resource plans will include those customer service options that integrate well with desirable supply-side options and meet TVA's evaluation criteria.

This Chapter Includes:

- Range and Effects of Options
- Customer Objectives
- Key Areas for Customer Service Options
- Summary of All Customer Service Options
- Option Development Process
- Programs Used to Overcome Market Barriers
- Key Variables and Assumptions
- Results of Analysis
- Summary

Customer Service Options

Range and Effects of Options

The customer service options developed by TVA cover a wide range of technologies and pricing strategies. They also include other activities that change the way customers use electricity, providing both direct benefits to customers and resource benefits for the power system. These options would be implemented by TVA in partnership with distributors of TVA power for the benefit of end-use customers.

The integrated resource planning process also considers the indirect effects associated with customer service options; these include economic development, electricity prices, customer value, productivity, and the environment.

One of the primary goals of Energy Vision 2020 is to provide benefits to customers.

Customer Objectives

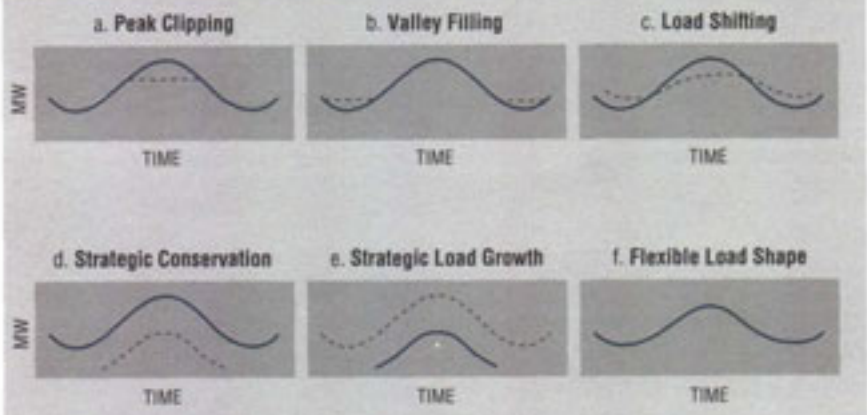
One of the primary goals of Energy Vision 2020 is to provide benefits to customers. In developing customer service options, TVA gave special consideration to the following objectives:

- **Minimum Rates** – Options that help TVA maintain competitive rates
- **Low Cost** – Options that are cost-effective for both the customer and the utility
- **Large Impacts** - Options that can quickly produce significant energy and capacity savings
- **Diversity** – Options that address all end uses (devices that use electricity) and improve the flexibility of the power system
- **Environmental Benefits** – Options that have important environmental benefits associated with them
- **Customer Service** – Options that create value for the customer by increasing productivity or lowering the costs of energy services
- **Social Equity** – Options that provide all ratepayers with an equal opportunity to participate in customer service programs and minimize the potential rate subsidies between one customer class and another

Customer service options are also associated with six different load shape objectives, as shown in *Figure 8-1.* A load shape shows the pattern of

electricity consumption in a utility's service territory over a period of time. One of demand-side management's objectives is to smooth the shape of energy demand to achieve a flatter load shape. A flatter load shape allows the utility to use generating facilities that have lower operating and fuel costs per unit of electricity produced and avoid the use of higher-cost peaking alternatives.

FIGURE 8-1. **Customer Service Options Load Shape Objectives for the Power System**



Different load shape objectives for the power system suggest the need for a variey of customer service options.

FIGURE 8-2. **Load Shape Objectives for Customer Service Options**

Load Shape Objectives	OPTION TYPE: Energy Efficiency	Load Management	Beneficial Electrification	Self-Generation	Rates
Peak Clipping	•	•		•	•
Valley Filling		•	•	•	•
Load Shifting		•			•
Strategic Conservation	•			•	•
Strategic Load Growth			•	•	•
Flexible Load Shape	•	•	•		•

Customer service technologies and options that can meet various load shape objectives include energy efficiency (high-efficiency heat pumps), load management (water heater cycling), beneficial electrification (electric arc furnaces), self-generation (customer backup generation dispatched to optimize the power system), and rates (real time pricing options to flatten the load shape).

Key Areas for Customer Service Options

TVA developed customer service options in four key areas:

- Traditional demand-side management, which includes conservation and load management
- Self-generation
- Beneficial electrification
- Rates

Figure 8-2 shows which of the load shape objectives can be achieved by the different customer service options.

DEMAND-SIDE MANAGEMENT

Demand-side management options include energy efficiency measures such as insulation, building construction designs, and the use of more efficient appliances and equipment. Demand-side management is also achieved through load management options, where the utility controls the heating cycle for water heaters, the use of other appliances, or encourages customers to modify their pattern of energy use by using storage technologies in order to reduce demand during peak hours.

SELF-GENERATION

Self-generation options refer to relatively small decentralized power systems that customers can use to meet a portion of their energy needs and also improve reliability. Utilities can encour-

age use of these options through financing rate programs or partnerships to provide benefits to the power system. Self-generation systems include both fossil and renewable technologies.

BENEFICIAL ELECTRIFICATION

Beneficial electrification options promote the use of electricity by identifying new, efficient uses of electricity or by substituting it for other fuels to increase productivity and product quality. Beneficial electrification can also provide increased convenience for the customer or environmental benefits. Electric buses, microwave heating, and electric lawn mowers are examples of potentially valuable new uses of electricity.

RATE OPTIONS

Rate options refer to changing the level and structure of charges for electricity use by customers. These charges include a customer charge, a demand charge, and an energy charge. The customer charge is based on the non-energy-related costs of serving each customer. Non-energy-related costs include administrative costs. The demand charge is based on the quantity of generating capacity required to serve a customer. Finally, the energy charge is based on the variable production costs of each unit of electricity. Fuel costs are a large component of the energy charge. As shown in *Figure 8-2*, rate options can achieve all load shape objectives. Rate options also include charges based on time of use in order to reduce demand during hours of peak use.

FIGURE 8-3. **Customer Service Options Summary – Impacts for 2010**

Resource Acquisition (Saving)	Options	Megawatts
Energy Efficiency & Load Management	39	5532
Self-Generation	8	281
Rates (Time-of-Day)	3	892
Load Growth (Sales)	**Options**	**Megawatts**
Beneficial Electrification	14	205
Rates(Declining Block)	3	169

Values are the impacts occurring only in the year 2010 for the cumulative participation in the program to that date. The customer service options identify a potential to save 6,705 megawatts of alternative capacity. Beneficial electrification and declining block rates would increase the required electricity production capacity by 374 megawatts.

Summary of All Customer Service Options

Figure 8-3 summarizes the customer service options developed for consideration in Energy Vision 2020. In the demand-side management area, TVA has developed 39 options (23 for residential customers and 16 for commercial and industrial customers). There are 14 beneficial electrification options spanning all sectors of the economy. Eight self-generation options were developed for commercial and industrial customers. TVA also developed two rate options for each sector of the economy.

These options can change both the need for new generating capacity and the level of electricity sales that TVA would be required to provide. *Figure 8-3* shows that in 2010, more than 5,500 megawatts of electricity could be saved if all of the proposed energy efficiency options were adopted regardless of their cost-effectiveness. Small-scale self-generation could reduce direct demand on the TVA system by more than 280 megawatts.

Time-of-day rates for residential, commercial, and industrial sectors could reduce demand by 892 megawatts in 2010. Time-of-day rates charge customers more for energy use during hours when electricity must be produced

by the power plants that are the most expensive to operate. A declining block rate option, which charges a lower price for electricity use when use exceeds a certain amount, provides a benefit for customers who use large amounts of electricity. The declining block rate option could increase electricity demand by 169 megawatts. Beneficial electrification could increase demand by 205 megawatts.

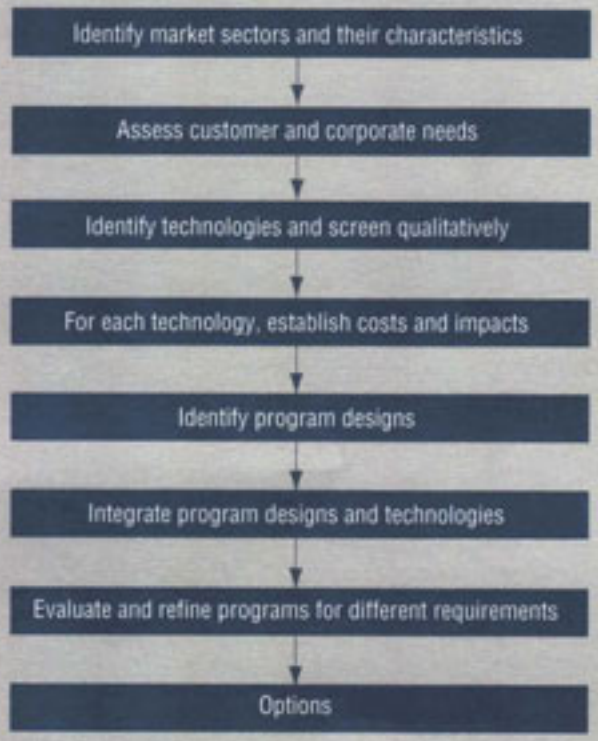
Option Development Process

TVA followed a specific process to develop and evaluate the initial set of customer service options. *Figure 8-4* illustrates the process used to develop customer service options, including energy efficiency, load management, self-generation, beneficial electrification, and to a limited extent, rate options.

IDENTIFY MARKET SECTORS AND ASSESS CUSTOMER NEEDS

TVA identified different market sectors and their characteristics to assess customer needs and to understand the kinds of technologies and programs that would be most effective in addressing those needs. TVA also met with distributors of its power to obtain their input for promoting energy-efficient technologies to end-use customers.

FIGURE 8-4. **Process for Development of Customer Service Options**



Customer service options use specific technologies delivered through a variety of program designs to meet customer needs and improve energy efficiency.

IDENTIFY AND QUALITATIVELY SCREEN TECHNOLOGIES

To ensure that a wide range of options was developed for analysis in Energy Vision 2020, TVA identified a large variety of efficient technologies. TVA then eliminated those with no potential application in the Valley. For example, evaporative air conditioners were dismissed because they are not compatible with the Valley's humid climate. Considerable care was taken not to eliminate technologies prematurely and to carry forward as many technologies as possible to the next stage of the analysis.

ESTABLISH AND RANK TECHNOLOGY COSTS AND IMPACTS

For all selected technologies, TVA gathered information on costs, energy requirements, and impacts on its capacity. This information was stored in a detailed database. Engineering simulations, as well as data from other utilities, technology vendors, and TVA field tests all contributed information to the

database. Once the database was developed, it was reviewed by a number of technology experts from the public and private sectors.

For each market segment, TVA ranked energy efficiency technologies from a total resource cost perspective. To ensure that TVA would have a comprehensive set of options, some technologies with benefits lower than the cost of the technology were included in one or more program options. Beneficial electrification measures were ranked according to their impact on average electricity prices. This ranking identified the technologies to be included in one or more of the beneficial electrification options.

IDENTIFY PROGRAM DESIGNS

A critical step in the process was the design of programs that would encourage customer acceptance, meet economic and financial objectives, and provide options for all customer classes. TVA reviewed other programs to identify strategies that would meet TVA, distributor, and customer objectives. Past and present TVA programs and other utility programs were examined to find best practices and program characteristics providing the greatest chance for success.

Programs included in TVA's customer service options were designed to:

- Increase energy efficiency by overcoming obstacles to the adoption of a new technology
- Increase customer value
- Promote market transformation and changes in consumer behavior

Programs providing customer value, such as microwave heating or laser cutting options, address environmental concerns and increase productivity. These factors often have a greater impact on business profits than do energy costs.

INTEGRATE PROGRAM DESIGNS AND TECHNOLOGIES

For customer service options, TVA combined technologies with delivery strategies to provide the most economical, efficient, and convenient services to customers. Technologies were integrated with program designs based on likely distribution channels, customer needs, and the characteristics and economics of the different technologies.

EVALUATE AND REFINE OPTIONS TO MEET DIFFERENT REQUIREMENTS

TVA compiled a wide variety of different customer service options to ensure diversity and comprehensiveness. TVA evaluated each option to determine its likely impact on the utility, its customers, and society. Delivery of technologies through a variety of program designs ensures that customer needs are met.

FIGURE 8-5. **Objectives Satisfied by Program Designs**

	PROGRAM OBJECTIVES					
Program Concepts	Minimum Rates	Low Cost	Large Impact	Diversity	Customer Service	Social Equity
Financing/Leasing	•			•	•	
Technical Assistance					•	
Assistance with O & M					•	
Rebates			•	•		•
Direct Install			•		•	•
Audit	•	•		•	•	
Mail Order		•	•			•
Rates	•	•		•		
Custom Programs			•	•	•	
Shared Savings	•	•		•	•	

Customer service options use different program delivery mechanisms or concepts that best satisfy the range of customer objectives.

Programs Used to Overcome Market Barriers

Figure 8-5 lists the program concepts or delivery mechanisms that were used to develop the customer service options and shows the customer objectives that can be satisfied by these programs. Some programs are more technology-specific, while others are designed to assist customers in identifying efficiency opportunities unique to their home or business. These programs provide value to customers by making technologies more accessible to them and by overcoming obstacles that prevent customers from adopting energy efficiency measures on their own.

The obstacles to adopting energy-efficient technologies, often referred to as market barriers, can be classified into five types:

- Inadequate information
- Inconvenience and hassle
- Excessive risk
- Financial barriers
- Availability

Figure 8-6 shows how different program designs can overcome the market barriers identified above. Some program designs are more technology-specific than others.

Programs such as the following can be used to overcome these market barriers:

Financing/Leasing – Financing is offered to utility customers or alternatively, the utility owns the technology itself and leases it to customers.

Technical Assistance – Architectural and engineering firms, utility personnel, equipment vendors, or manufacturers assist customers with the new technologies.

Operating and Maintenance Assistance – Customers receive ongoing assistance in operating and maintaining equipment.

Rebates – Customers, equipment installers, or manufacturers receive monetary incentives for high-efficiency energy systems.

Direct Install – Customers receive high-efficiency equipment and direct installation at no charge or at a reduced charge.

Audit – Customers are offered help in determining the most cost-effective energy efficiency options for their homes or businesses. Tools and information also may be given to facilitate a self-audit.

FIGURE 8-6. **Market Barriers Overcome by Program Designs**

	MARKET BARRIERS				
Program Designs	Information	Inconvenience & Hassle	Risk	Financial	Availability
Financing/Leasing		•	•	•	
Technical Assistance	•		•		
Assistance with O & M	•	•	•		
Rebates			•	•	
Direct Install	•	•	•	•	•
Audit	•				
Mail Order	•	•	•	•	•
Rates				•	
Custom Programs	•		•	•	
Shared Savings			•	•	
Market Transformation	•	•			•

Program designs incorporate a variety of delivery mechanisms to overcome market barriers and deliver more energy-efficient technologies to customers.

Mail Order – Catalogs are distributed to promote appliances that are not widely available on a commercial basis, in order to discount cost and provide information for customers. Catalogs are most appropriate for smaller, easily installed items. This program is particularly attractive to people in rural or remote areas and to the elderly.
Rates – Customers get a special electricity rate that encourages use of various equipment or influences energy use patterns.
Custom Programs – Customers receive site-specific assistance to identify and install energy efficiency measures or make changes that will save energy.
Shared Savings – Utilities provide financing and assistance in implementing an efficiency program and share the savings with the customer.
Market Transformation – Utilities provide programs and support to activities that induce lasting structural or behavioral changes in the market that result in increases in the adoption and penetration of energy-efficient technology and practices.

Key Variables and Assumptions

TVA described and characterized the customer service options in terms of costs and benefits. To provide a reasonable estimate of the potential for energy efficiency, load management, small-scale self-generation, and beneficial electrification in the Valley, TVA used a number of assumptions to estimate the effects of these technologies on electricity use.

CUSTOMER ACCEPTANCE

Distributor and customer participation are critical in determining how an option will penetrate the market. Participation by both distributors and customers is assumed to be voluntary. Because of varying circumstances and needs, it is assumed that not all distributors and customers will participate in a given program. Participation rates for distributors and customers for each option can be found in Volume 2, Technical Document 7, Customer Service Options.

TECHNOLOGY ASSUMPTIONS

The energy savings of high-efficiency equipment depend on the average energy consumption of currently installed equipment and the number of units that might be replaced. TVA used surveys of residential and commercial customers to determine existing market shares of end-use equipment. For the industrial sector, TVA used equipment shares based on regional and national estimates, along with customer billing data.

The start date for options was assumed to be 1996 for the purpose of modeling program effects; however, any option or program could actually be started whenever needed. The number of participating customers and the impacts of many options could be scaled up or down, depending on how aggressively the options are pursued.

The Energy Vision 2020 load forecast includes a significant number of efficiency improvements driven by market and other forces. These forces include an underlying rate of technological innovation, price-driven efficiency improvements, and federal and state initiatives to improve appliance standards and building codes.

The options incorporate only those technologies that exceed the efficiency levels in existing or scheduled codes and standards. Emerging technologies may offer even greater efficiencies during the Energy Vision 2020 planning horizon. To the extent that data was available, TVA has included emerging technologies in its analysis.

FUTURE UNCERTAINTIES

There are a number of uncertainties in many of the key variables and assumptions in the customer service options development process. However, TVA's analysis indicates that some factors are more important than others in determining the cost-effectiveness of the various customer service options. TVA's current analysis indicates that the cost of energy saving technologies, the degree of customer acceptance, and the impact on the power system are the most significant factors influencing the cost-effectiveness of options. In order to test the sensitivity of the customer service options to these factors, TVA constructed both optimistic and pessimistic scenarios for the options. Optimistic scenarios assumed greater customer acceptance and lower costs for each technology, while pessimistic scenarios assumed the opposite.

Results of Analysis

DEMAND-SIDE MANAGEMENT

Using the process described earlier, TVA developed energy efficiency and load management options for residential, commercial, and industrial sectors. Together, these 39 options represent an energy savings potential of more than 23.0 billion kilowatt-hours and a peak demand reduction potential of 5,532 megawatts in the year 2010. These options are described below by sector.

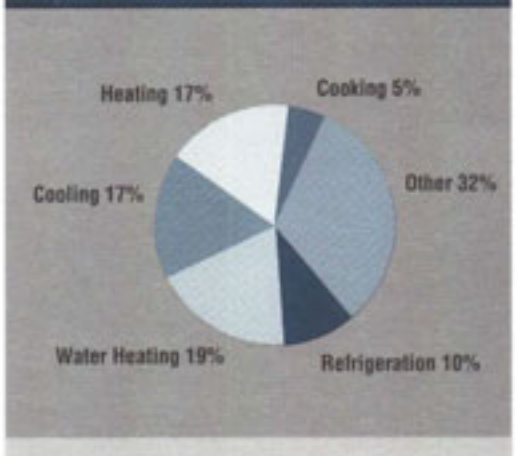
Residential Sector

Residential Sector Overview

The TVA service area includes approximately 3 million residential households. Residential customers in the Valley purchase about 45 billion kilowatt-hours of electricity per year, which accounts for about 35 percent of all TVA sales. Residential electricity use can be categorized as shown in *Figure 8-7*. The combination of heating, ventilating, and air conditioning (HVAC) accounts for 34 percent of residential electricity use, while water heating accounts for 19 percent. Refrigeration and cooking use about 15 percent of residential electricity, with the remainder of residential electricity consumed by lighting and other appliances.

Eighty-five percent of Valley residents have central or window air conditioning. Electric water heaters are present in 77 percent of all homes, and electric space heaters are present in 47 percent. TVA identified options that can increase the efficiency of energy use for these end uses, as well as others.

FIGURE 8-7. **Residential Uses of Electricity**



The percentage of residential electricity uses for water heating, space heating, and cooling suggests customer service options should focus on these end uses.

Evaluation of Residential Technologies

TVA considered 107 residential efficiency measures and technologies, evaluating them in four end-use categories: heating, ventilating, and air conditioning; water heating; appliances; and lighting. *Figure 8-8* shows the number of technologies considered and those included in options by end-use category. Of the original 107 technologies that TVA considered, 42 are included in the residential options evaluated in Energy Vision 2020. Volume 2, Technical Document 7, Customer Service Options, lists the technologies evaluated in the residential option development process.

Residential Sector Option Features

TVA incorporated 42 technologies into program designs to create 23 residential options. The options use a variety of delivery systems and program features to overcome market barriers and to meet customer objectives (for example, low cost, equity, minimum rates). TVA included the following types of programs in the residential options.

Financing. TVA developed loan and leasing options for high-efficiency heat pumps and heat pump water heaters. Financing helps to overcome the relatively high initial cost of these technologies. When combined with financing of insulation measures, maintenance contracts, and strict efficiency and installation standards for the equipment, these options can provide significant energy savings and customer service benefits.

Direct Installation. This approach provides materials and equipment at no cost to participants. TVA developed such options for residential low-income home owners and rental properties. Measures include compact fluorescent lighting, low-cost water heating, air infiltration control measures, and attic insulation. When combined with a walk-through energy audit and an education session, TVA can save customers energy and money and reduce the need to generate power.

Rebates/Cash Incentives. TVA also developed options that would offer rebates for large appliances such as high-efficiency dishwashers, refrigerators, freezers, room air conditioners, horizontal axis clothes washers, and condensing clothes dryers. All appliance rebates would be offered at the retail level in cooperation with key trade allies (manufacturers,

FIGURE 8-8. **Technologies Considered for Residential Options**

End Use	Included in Options	Emerging Technology	Total Considered
HVAC	18	2	48
Water Heating	11	1	20
Appliances	10	11	31
Lighting	3	2	8
TOTAL	42	16	107

TVA considered technologies for all building types for those residential end uses which consume the majority of the sector's total electricity use.

engineering firms, construction contractors, etc.). Rebate levels range from 50 to 75 percent of the difference in cost between the more efficient and the less efficient appliances.

Another appliance option provides a savings bond to residential customers for turning in each working refrigerator or freezer to TVA or the distributor. These appliances would be properly disposed of, and appropriate materials would be recycled.

Options targeting the new construction and new manufactured housing markets provide cash incentives to home builders, as well as mobile home manufacturers and dealers who meet or exceed TVA's energy efficiency standards.

Mail Order. TVA could offer energy-efficient lighting products, programmable thermostats, and low-cost heating and hot water savings measures through a mail order catalog at low introductory prices. This option targets customers in rural or remote areas and typical mail-order shoppers.

FIGURE 8-9. **Residential Energy Efficiency Options – Impacts for 2010**

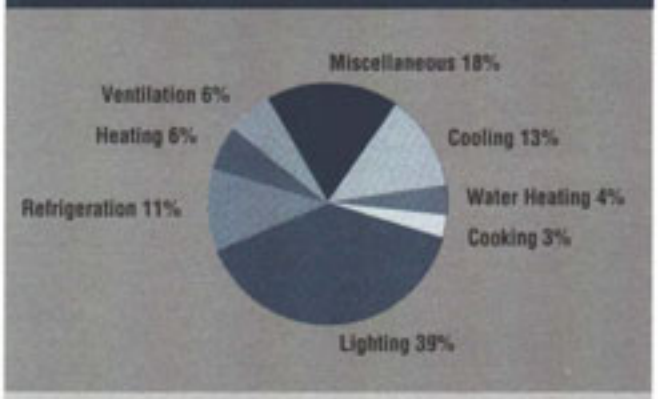
Energy Efficiency	Winter Megawatts	Summer Megawatts	Million Kilowatt-Hours	Thousands of Units	Total Resource Cost (1995 Cents/Kilowatt-Hour)
Heat Pump Loans	433	469	1347	254	5
Heat Pump Financing/Leasing	581	518	1688	266	1.6
Heat Pump Rebates	627	527	1787	375	3.3
Ground Source Heat Pump Leasing	58	62	179	26	8.1
Efficient Air Conditioning	0	133	233	124	7.6
New Homes	402	184	1142	118	3
Manufactured Housing	164	53	358	131	4.4
Low Income Weatherization	12	6	36	10	12.9
Low Income	165	75	467	251	2.8
Direct Install	845	386	2399	1163	2.3
Heat Pump Water Heater Leasing	262	103	995	452	3.2
Solar Water Heater	11	4	41	15	22.1
Efficiency Products Catalog	234	107	665	714	1.4
Lighting Retail Component	225	103	639	687	2.5
Appliance Rebates	39	41	304	1518	9.1
Refrigerator Turn-In	10	13	93	91	3.5
Student Self-Audit	53	23	150	1235	4.3
Self-Audit	42	19	120	102	2.6
Load Management					**1995 Dollars/Kilowatt**
Load Management - Air Conditioning	0	53	21	39	58
Load Management - Water Heater	212	84	0	158	55
Load Management - Storage Water Heater	100	39	0	75	934
Load Management - Supervisory Control and Data Acquisition	0	0	0	67	140
Load Management - New Technology	0	0	0	276	2039

Values are the impacts occurring only in the year 2010 for the cumulative participation in the program to that date. TVA developed 23 residential sector options for evaluation in Energy Vision 2020 with applications for all major end uses of electricity and for all types of housing.

Energy Audits/Education. Some options combine do-it-yourself energy audits for secondary school students or home owners. TVA or distributors would provide technical support with materials and analysis.

Load Management. Five load management options include TVA's control of air conditioners and water heaters using FM radio, SCADA systems (supervisory control and data acquisition systems), and new two-way communication systems that are under development at many utilities in partnership with the telecommunication companies. TVA could offer customers cash incentives or service packages under these options.

FIGURE 8-10. **Commercial Use of Electricity**



In the commercial sector customer service options targeted toward lighting, refrigeration, cooling, and heating should have the largest impact.

Residential Sector Results

Figure 8-9 summarizes projected costs and load and energy impacts for all residential energy efficiency and load management options. This figure shows that in 2010, more than 12.7 billion kilowatt-hours of energy savings and 3,002 megawatts of summer capacity savings could be achieved if all of the proposed options were implemented. Savings from energy efficiency options can be obtained at resource costs ranging from 1.4 to 22.1 cents per kilowatt-hour. In the process of ranking options, these costs can be compared to the alternative costs of generating electricity from a power plant and to the average residential retail rate of 5.95 cents per kilowatt-hour.

Commercial and Industrial Sectors

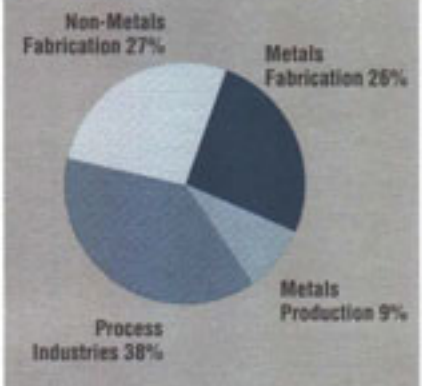
Commercial and Industrial Sector Overview

TVA and the distributors of its power serve about 486,750 commercial and industrial customers. These customers account for more than 4 billion square feet of floor space and consume almost 48 billion kilowatt-hours of electricity per year. Electricity is used to provide cooling in 70 percent of all commercial buildings, heating in 35 percent, and water heating in 45 percent. Industrial customers use electricity to operate all motor drives, to drive electrolytic processes that produce chemicals and primary metals, for lighting, and for a small fraction of the heat required in manufacturing processes.

Commercial customers use electricity in a variety of ways, as shown in *Figure 8-10.* Lighting accounts for 39 percent of energy use in the commercial sector, while heating, ventilation, and cooling use a total of 25 percent. The miscellaneous category, which includes office equipment, consumes 18 percent of electricity used and represents a rapidly growing load in the commercial sector. The remaining 18 percent is used in water heating, cooking, and refrigeration.

Figure 8-11 shows electricity use in the industrial sector by industry type. Process industries (e.g., paper-making) use 38 percent of the electricity in the

FIGURE 8-11. **Industrial Electric Market**



Energy efficiency opportunities in the industrial sector are concentrated in motors, drives and overall manufacturing process improvement.

industrial market, while non-metals fabrication (e.g., rubber gloves) uses 27 percent, and metals fabrication (e.g., iron foundries), 26 percent. Metals production (e.g., tin refining) consumes 9 percent of the electricity used in the industrial market.

Figure 8-12 shows how electricity is consumed in each industrial subsector and in the industrial sector as a whole. In the industrial sector, 67 percent of electricity is used for motors, 16 percent for electrolytic production and electrotechnologies (such as microwave drying), 8 percent for heat used in the manufacturing process, and 9 percent for lighting and other end-uses (eg., space heating and cooling).

Evaluation of Commercial and Industrial Technologies

In commercial markets, TVA identified and evaluated energy-efficient technologies for 10 different building types: offices, restaurants, retail stores, groceries, warehouses, schools, colleges, hospitals, lodgings, and miscellaneous commercial buildings.(eg. churches) TVA determined the energy and demand impacts of weather and schedule-sensitive technologies (e.g., office lighting) by performing simulations that modeled electricity consumption in each type of building.

For each type of building, TVA considered several technologies for each end use (e.g., heating, cooling, lighting, etc.).

For industrial markets, TVA investigated technologies such as high-efficiency motors and adjustable-speed drives; however, many industrial technology applications are unique to a particular industry. In such cases, program options examine whether various technologies are appropriate and cost-effective for a specific site. *Figure 8-13* lists the number of technologies that were included in the options for both the commercial and industrial sectors. Volume 2, Technical Document 7, Customer Service Options, lists the technologies considered.

Commercial and Industrial Option Features

TVA combined 62 technologies with various delivery strategies to form 16 commercial and industrial program options. The options are designed to overcome different market barriers and to address the needs of the different market segments or types of businesses within the commercial and industrial sectors. Some of these options promote specific technologies that have widespread application in commercial and industrial markets. Other options address customers' financial, productivity, or environmental needs and provide customized applications of energy-efficient technologies. The following programs were incorporated in the commercial and industrial options.

FIGURE 8-12. **End Uses as a Percent of Total Industrial Electric Use**

	Process Heating	Motor Drives	Electrolytics	Lighting & Other
Process Industries	< 1%	79%	11%	10%
Non-Metals Fabrication	15%	27%	53%	5%
Metals Fabrication	20%	69%	2%	9%
Metals Production	6%	83%	0%	12%
Total	8%	67%	16%	9%

Most electricity provided to the industrial sector is currently used to power motor drives.

Technology Rebates. Rebate options promote energy-efficient lighting; heating, ventilating, and cooling; water heating; refrigeration; and cooking technologies in the commercial sector. Rebates are also provided for high efficiency motors, adjustable-speed drives used in manufacturing equipment, and efficiency improvements for industrial customers producing compressed air. These options encourage customers to select higher-efficiency equipment by providing educational information and rebates. Rebate levels range from 50 to 75 percent of the additional cost of the high-efficiency equipment.

FIGURE 8-13. **Technologies Considered for Commercial and Industrial Options**

End Use	Included in Options	To Be Considered for Custom Applications	Emerging Technologies	Total Considered
Lighting	20	1	13	38
HVAC	16	15	5	39
Water Heating	8	2	2	12
Refrigeration	4	5	1	16
Industrial Process	5	3	2	10
Building Shell	6	1	-	10
Appliances	2	3	5	18
Miscellaneous	1	3	-	7
Total	62	33	28	150

Lighting, heating, ventilation, and air conditioning (HVAC), and water heating represent more than half of the technologies considered for the commercial and industrial sectors.

Comprehensive Measure Financing. This option provides financing for large commercial customers who retrofit buildings with comprehensive sets of energy-saving measures. Low-interest loans or shared-savings arrangements are offered with this option. These cover the cost of the energy-efficient investment and overcome the initial-cost barrier of these investments. Customers repay the loan with electric bill savings, which would also yield a positive cash flow for customers. Under a shared savings arrangement, customers pay a percentage of their energy savings in exchange for the service provided by TVA. By recovering program costs from the program participants, financing options could minimize the rate impact of energy efficiency programs or non-participants.

Comprehensive Measure Rebates. This option uses the same process as the Comprehensive Measure Financing option to identify comprehensive sets of energy-saving measures for buildings. It uses rebates to increase participation and thus obtains more energy savings.

Technical Assistance. Technical assistance is combined with rebates and financing for new construction in the large commercial sectors. In new construction, technical assistance provided to customers includes incentives for architects and engineers to include energy-efficient systems in building design. Building commissioning (a careful tuning of all building energy systems) is also included for new construction to ensure that energy-efficient systems operate optimally. For older, large commercial buildings, technical assistance helps identify the optimal set of energy efficiency measures for the whole building, often with the use of customized technology applications.

Direct Installation. This program is for small commercial businesses and provides the installation of low-cost energy-efficient measures at no cost to the customer. While on site, the program calls for TVA to perform an audit to identify

additional cost-effective energy savings opportunities. Participants are then introduced to other programs offered by TVA.

Operation and Maintenance. This heating and cooling program is directed at small commercial businesses and other commercial customers who do not have building maintenance staffs. The customer's heating and cooling system is maintained for a small monthly charge included in the customer's electric bill. The program maintains the optimal operation of heating and cooling equipment to reduce electricity use.

Load Management. Three load management options were developed for the commercial sector. Two options encourage the adoption of thermal storage technologies for use with chillers or rooftop cooling units by offering rebates and technical assistance to design the installation. The other option provides the customers with bill credits for curtailing electricity use when notified to do so by the utility. Customers could choose the load reduction strategy that best fits their business operations. To participate in this option, customers must be able to reduce load or make arrangements to join with other customers in reducing load at times of high demand for TVA electricity.

Process Efficiency Improvements. Most of the energy savings potential in the industrial sector involves changing the actual nature of the various production processes. Customized applications of energy-efficient technologies include high-efficiency motors, adjustable-speed drives for manufacturing equipment, and other electric technologies. This program provides customers with technical assistance to identify cost-effective energy efficiency opportunities and to quantify any additional non-energy benefits related to a proposed project. Incentives include rebates for demand reduction or for energy savings.

Commercial and Industrial Results

The 16 program options for the commercial and industrial sectors provide ways to promote energy-efficient technologies. *Figure 8-14* summarizes the projected costs and impacts of these options in the year 2010.

The commercial and industrial options shown in *Figure 8-14* could account for more than 10.5 billion kilowatt-hours of energy savings and 2,530 megawatts of summer peak demand reduction in the year 2010 if all of these options were implemented. Energy savings in the commercial and industrial markets can be obtained at a resource cost of between 2 cents per kilowatt-hour to 13.7 cents per kilowatt-hour. This compares to the average commercial retail rate of 5.73 cents per kilowatt-hour and distributor industrial rate of 4.28 cents per kilowatt-hour. The demand reduction potential of all the options shown in *Figure 8-14* would be 17 percent of the total commercial and industrial sector demand in the year 2010. Similarly, potential energy savings are about 10 percent of the forecast energy use in these two sectors in the same year.

SELF-GENERATION AND RENEWABLE GENERATION

Overview

TVA used a set of customer characteristics and needs to identify the specific market segments most suitable for fossil fuel and renewable energy self-generation. These characteristics include:

- Industrial production processes generating byproducts or waste material that can be used to power a self-generation system.
- Facilities with a relatively constant high heating requirement. Waste heat from a cogeneration system could support the facility's heating needs.
- Situations where electrical outages or disturbances could result in excessive lost production or business for the customer, create a hazardous situation, or cause a violation of environmental standards.
- Customers having a high peak demand and paying a high rate for peak demand electricity.
- Customers having access to renewable fuels or creating a renewable fuel as a byproduct of its manufacturing process.

FIGURE 8-14. **Commercial and Industrial Options Summary – Impacts for 2010**

Option Name	Winter Megawatts	Summer Megawatts	Million Kilowatt-Hours	Units (Million sq.ft.)	Total Resource Cost (1995 Cents/Kilowatt-Hour)
COMMERCIAL TECHNOLOGY REBATES					
Lighting Rebates	265	511	2845	1626	2.0
Heating, Ventilation, and Air Conditioning Rebates	255	223	670	630	7.7
Appliance Rebates	40	69	364	501	3.2
New Construction	124	188	762	360	4.4
New Construction - Renewables	94	40	159	30	7.4
SMALL COMMERCIAL SECTOR					
Retrofit-Direct Install	65	98	465	315	3.1
Heating, Ventilation, and Air Conditioning Maintenance	38	26	87	236	13.7
LARGE COMMERCIAL SECTOR					
Comprehensive Measures Financing	120	170	713	284	4.9
Comprehensive Measures Rebates	242	311	1278	449	4.9
COMMERCIAL LOAD MANAGEMENT					
Commercial Cool Storage	0	93	3	44	167 [1]
Rooftop Cool Storage	0	120	13	59	453 [1]
Commercial Group Load Curtailment	244	242	227	2240 [2]	169 [1]
INDUSTRIAL PROGRAMS					
Industrial Technology Rebates	21	24	167	2100 [2]	3.2
Industrial Process Energy Efficiency - Direct Serve	149	169	1057	11226 [3]	4.1
Industrial Process Energy Efficiency - Distributor Serve	167	190	1325	8420 [3]	4.0
Energy Efficient Rates (opt-out)	50	56	394	2504 [3]	3.2

[1] Cost in $/kW
[2] Number of participants
[3] Participant defined as industrial customer with one million kWh of energy use

Values are the impacts occurring only in the year 2010 for the cumulative participation in the program to that date. TVA developed commercial and industrial options for evaluation in Energy Vision 2020 with applications for all major uses of electricity and for all types of buildings.

Based on these characteristics, TVA identified four industrial and seven commercial market segments as candidates for self-generation systems. The industrial candidates are the food, wood, pulp and paper, and chemical industries. The commercial market segments are transportation, supermarkets, restaurants, finance and insurance, hotel/motel, hospitals, and nursing homes. TVA also identified the potential for customer-owned generation using landfill gas, wood waste, and small head hydro systems. Photovoltaic options (power produced from sunlight) were also considered, but current technology costs limit their use to highly specialized or remote applications.

Evaluation of Self-Generation and Renewable Generation Technologies

TVA examined technologies limited to the 100 kilowatt to 20 megawatt range. Units of this size, which are appropriate for the markets considered above, are used either as self-generation units or as emergency power units. Technologies that have suitable designs, commercial availabilities, and costs for integration with the power system are:

- Reciprocating Engine Systems (100-kilowatt to 3-megawatt systems)
- Gas Turbine Systems (4-megawatt to 21-megawatt systems)
- Coal-Fired Steam Turbine Systems (20-megawatt systems)
- Fuel Cells (2-megawatt systems)
- Wood Waste-Fired Steam Turbine Systems (800-kilowatt systems)
- Small Head Hydro Systems (various sizes)

Installation costs for these systems range from $988 per kilowatt for a 10.7-megawatt gas turbine to $2,557 per kilowatt for a 100-kilowatt reciprocating engine system. Photovoltaic options currently cost approximately $5,000 per kilowatt, but are predicted to drop in price in the near future. Consequently, TVA studied the potential impacts of photovoltaics if the technology cost were to fall below $3,000 per kilowatt.

Self-Generation and Renewable Generation Option Features

Options were developed for the following markets:

New Industrial Systems

TVA or distributors would contract to purchase excess power from commercial or industrial customers or would pay customers for generating their own power during times of peak demand. An incentive payment would be paid each year per kilowatt of capacity provided.

New and Existing Commercial Systems

TVA or distributors would contract to purchase excess power from the customer or pay the customers incentives each year for each kilowatt generated during times of peak demand for TVA power.

FIGURE 8-15. **Renewables and Self-Generation Options Summary – Impacts for 2010**

Option Name	Winter Megawatts	Summer Megawatts	Million Kilowatt-Hours	Number of Participants	Total Resource Cost 1995 Cents/Kilowatt-Hour
RENEWABLE GENERATION PROGRAMS					
Landfill Gas - Fuel Cells	74	74	585	36	6.0
Small Head Hydro	5	5	29	5	5.9
Biomass: Wood Waste	54	54	374	62	3.6
Photovoltaics	1	1	5	1975	33.0
Photovoltaics - Technology Advancements	3	3	11	4600	19.0
CUSTOMER-OWNED COGENERATION					
Commercial Existing Cogeneration	95	95	118	416	7.7
Commercial New Cogeneration	18	18	51	84	12.1
Industrial New Cogeneration	30	30	17	208	8.8

Values are the impacts occurring only in the year 2010 for the cumulative participation in the program to that date. The greatest potential for self-generation is from landfill gas, wood wastes, and existing commercial cogeneration.

Renewable-Based Energy Systems

Customers would be offered incentives for generating energy with combustible renewable resources such as wood or other renewable products. For non-combustible renewable resources, such as hydroelectric power and photovoltaics, customers would be offered an incentive for each kilowatt-hour produced. The incentives would cover the higher costs and higher uncertainties associated with energy produced from renewable resources and reflect the environmental benefits of renewable and non-combustible resources. As part of this option, information on the cost and performance of renewable resources would be gathered and documented to better assess the applicability of these technologies to the TVA system.

TVA would provide technical assistance to vendors and customers to ensure project feasibility and proper installation as well as synchronization between local distribution systems and the customer's facility. Payments to participants for their power would be based on capacity and energy savings (e.g., avoided costs) for TVA. Incentives for renewable resources would be higher to encourage investment in these emerging technologies.

Self-Generation and Renewable Generation Results

TVA has developed eight self-generation/renewable generation options for the commercial and industrial sectors. *Figure 8-15* summarizes the estimated participation in these options, the options' projected costs, and their potential energy and peaking capacity savings in the year 2010. In 2010, more than 1.1 billion kilowatt-hours of energy savings and 281 megawatts of capacity savings are projected for these proposed options.

FIGURE 8-16. **Technologies Considered for Beneficial Electrification**

Sector	Technologies Considered	Included in Option
Residential	12	11
Commercial	13	13
Industrial	87	35
Transportation	5	3
TOTAL	117	62

More than half of the technologies considered were in the industrial sector. Heating, ventilation, and cooling were important technologies considered in the residential and commercial sectors.

BENEFICIAL ELECTRIFICATION

Overview

Beneficial electrification options include technologies that take advantage of the unique characteristics of electricity (such as ease of control, flexibility of application, and high energy efficiency) and improve productivity and quality. The use of an electrotechnology (such as microwave drying) in manufacturing or using electric vehicles for transportation could also reduce adverse environmental impacts. Generally, electrotechnologies limit environmental pollutants to those produced by an electric generating plant. In this case, the pollutants are more easily controlled so there is less harm to the public or the environment. These beneficial electrification options address transportation and electric manufacturing technologies, as well as commercial and residential options for cooking, heating, security lighting, and water heating.

Evaluation of Beneficial Electrification Technologies

TVA evaluated 117 beneficial electrification technologies and measures for four market sectors. *Figure 8-16* lists the number of technologies considered in each sector. Currently, 43 beneficial electrification technologies are included in the Energy Vision 2020 options. More than half of the technologies TVA considered and included in beneficial electrification options come from the industrial sector. Volume 2, Technical Document 7, Customer Service Options, lists the technologies and measures evaluated.

Beneficial Electrification Option Features

TVA integrated technologies with programs to form 14 beneficial electrification options covering the 4 major sectors as follows:

Industrial Electrotechnologies

Seven options cover process heating, melting, curing and drying, and specific applications in the chemical, metals, food, and textile industries. Industrial electrotechnology options do not use any program rebates or direct financial incentives. Technologies would be promoted on their own merits. These include the enhancement of the customer's competitiveness through reduced operating and maintenance costs, increased productivity, improved product quality, increased operating flexibility, and contributions toward long-term environmental compliance. TVA's primary role would be to provide information and technical assistance in conjunction with consultants and trade allies.

Commercial Sector

TVA developed two options for the commercial sector. Suitable commercial buildings would be targeted for high-efficiency air-source and water-source heat pumps, as well as heat pump water heaters. Restaurants, hotels, and other commercial facilities would be targeted for high-efficiency electric cooking and

security lighting equipment. These options would use the same efficiency standards and incentives as the commercial energy efficiency options.

Residential Sector

The first of two residential options targets customers replacing natural gas, oil, propane, and wood space heating or water heating. It encourages these customers to use high-efficiency electric heat pumps and heat pump water heaters. Incentives and efficiency standards would reflect those for the residential energy efficiency options. The second option would promote electric lawn mowers to customers in non-attainment areas (environmentally sensitive because of dirty air) and security lighting to customers in high crime areas.

Transportation Sector

The three electric transportation options target electric buses, fleet vehicles (vans, carts, forklifts), and cars. These options focus on the benefits of electric transportation in urban non-attainment areas. Options would be limited to technologies that could penetrate the market without state or federal mandates. The beneficial electrification options developed for Energy Vision 2020 do not use any direct financial incentives such as rebates or special rates.

FIGURE 8-17. **Beneficial Electrification Options Impacts in 2010**

Option Name	Units	Millions Kilowatt-Hours	Megawatts
INDUSTRIAL SECTOR			
Process Heating	228	609	87
Melting	29	549	79
Food Processing	29	368	53
Textiles	64	19	3
Chemicals & Metals	49	37	5
Curing and Drying	425	123	18
Environmental Technology	140	227	33
COMMERCIAL SECTOR			
Institutional Facilities	30300	294	21
Cooking & Security Lighting	10917	112	25
RESIDENTIAL SECTOR			
HVAC & Water Heating	101256	374	-119
Security Lighting/Lawn Mowers	236407	51	0
TRANSPORTATION			
Electric Buses	259	9	0
Fleet Vehicles	503	4	0
Electric Autos	1774	6	0
TOTAL		2782	205

Values are the impacts occurring only in the year 2010 for the cumulative participation in the program to that date. The industrial sector options have the most impact in beneficial electrification. Commercial institutional facilities (primarily heating and cooling) and residential heating and cooling are also significant.

Beneficial Electrification Results

Figure 8-17 summarizes the potential impacts of all beneficial electrification options in the year 2010. This figure shows that in 2010, these options would be responsible for more than 2.7 billion kilowatt-hours of increased electricity use and an increase in electricity demand of about 200 megawatts. Industrial electrotechnology options account for 70 percent of the projected increase in electricity use and the need for additional generating capacity.

RATES

The bulk of TVA's revenue is generated from the wholesale rate that TVA charges the 160 power distributors that purchase power for resale to end-use customers. The wholesale rate structure presumes the wholesale rates for different types of service will be the foundation for the associated retail rates. Each distributor applies retail rates that reflect the appropriate TVA wholesale charges, distributor losses in transmitting power to the end-use customer, and distributor-specific distribution costs.

FIGURE 8-18. **Alternative Rate Impacts - Impacts for 2010**

Option Name	Summer Megawatts
Time-of-Day Rates	892
Declining Block Rates	169

Time-of-day rates would save 892 megawatts of electricity, while declining block rates would increase sales by 169 megawatts.

In accordance with this principle, TVA has developed a set of wholesale and retail time-of-day rate options. These options have charges that vary according to TVA's cost of generation and distribution, by time of day and season. The cost of producing electricity is greatest during times of peak demand for TVA electricity, such as summer afternoons, and lower in off-peak periods such as evenings and weekends.

Retail time-of-use rates are designed to give end-use customers price signals to curtail use during peak periods and to shift electricity consumption to off-peak periods. Wholesale time-of-use rates can encourage distributors to offer programs or to participate in TVA programs to shift electricity use from peak to off-peak periods.

A set of declining block rate options was also developed. Declining block rates have higher charges for initial electricity usage with progressively lower charges for higher levels of usage. Declining block rates can encourage the use of electrical products over competing alternatives. *Figure 8-18* shows the potential impact of these two rate options in 2010.

FIGURE 8-19. **Customer Service Options Blocks for Energy Efficiency and Load Management (Impacts for 2010)**

Block 1 1,482 Megawatts

PROGRAM
- Commercial Cool Storage
- Rooftop Cool Storage
- Commercial Group Load Curtailment
- Residential Load Management – Air Conditioning
- Residential Existing Load Management – Air Conditioning
- Residential Existing Load Management – Water Heaters
- Residential Heat Pump Financing/Leasing
- Residential Efficiency Products Catalog
- Industrial Technology Rebates – High-Efficiency Motors
- Residential Lighting Products – Retail Component
- Comprehensive Measures Financing
- Residential Ground Source Heat Pump Leasing

Block 2 1,264 Megawatts

PROGRAM
- Residential Self-Audit
- Residential New Homes
- Commercial Lighting Rebates
- Residential Low Income Program
- Residential Load Management – Water Heaters
- Commercial New Construction
- Commercial Appliance Rebates
- Refrigerator Turn-In
- Residential Student Self-Audit
- Small Commercial Retrofit

Block 3 1,497 Megawatts

PROGRAM
- Residential Load Management – Supervisory Control and Data Acquisition
- Comprehensive Measures Rebates
- Industrial Energy Efficiency – Distributor Serve
- Industrial Energy Efficiency – Direct Serve
- Industrial Technology Rebates – Adjustable Speed Drives
- Energy Efficient Rates
- Residential Heat Pump Water Heating Leasing
- Residential Direct Install
- Commercial HVAC Rebates
- Residential Manufactured Housing Program

Block 4 1,289 Megawatts

PROGRAM
- Residential Load Management – New Technology
- Commercial HVAC Maintenance Program
- Residential Heat Pump Loans
- Residential Efficient Air Conditioning
- Residential Heat Pump Rebates
- Residential Load Management – Storage Water Heaters
- Industrial Technology Rebates – Compressed Air Efficiency
- Residential Appliance Rebates Program
- Residential Low Income Weatherization Program
- Residential Solar Water Heater Program
- Commercial New Construction – Renewables

Summary

For consideration in Energy Vision 2020, TVA has more than 60 customer service options that address all relevant sectors and end uses in the Valley economy. TVA has developed options to smooth system load shape using traditional demand-side management (energy efficiency and load management), self-generation, beneficial electrification, and rate options.

The costs and impacts of the options are interdependent. Option costs depend on the market penetration rate and number of technologies that are required to achieve specific energy and capacity savings.

FIGURE 8-20. **High and Low Impact Blocks for Beneficial Electrification**

High Beneficial Electrification	Low Beneficial Electrification
INDUSTRIAL SECTOR	
Process Heating	Process Heating
Melting	
Food Processing	Food Processing
Textiles	
Chemicals & Metals	
Curing and Drying	Curing and Drying
Environmental Technology	Environmental Technology
COMMERCIAL SECTOR	
Institutional Facilities	
Cooking & Security Lighting	
RESIDENTIAL SECTOR	
HVAC & Water Heating	HVAC & Water Heating
Security Lighting/Lawn Mowers	
TRANSPORTATION	
Electric Buses	
Fleet Vehicles	
Electric Autos	

High beneficial electrification included all options. Low beneficial electrification included those options that had a low total resource cost and reduced rates the most.

CUSTOMER SERVICE OPTION BLOCKS

The customer service energy efficiency and load management options were placed into blocks of approximately 1,000 to 1,500 megawatts of capacity savings in the year 2010. Customer service options were placed in these blocks to simplify their integration with supply-side technologies that are generally much larger than any single customer service option. Different numbers of blocks were then incorporated into the strategies that were evaluated in Energy Vision 2020. Options were placed in the blocks, as shown in *Figure 8-19*, based on the following criteria, in order of importance:

- Resource cost
- Impact on rates
- Equity (opportunity for all customers to participate)
- Competitiveness (preservation of long-term customer relationships)
- Other evaluation criteria used in Energy Vision 2020

Thus, programs included in Block 1 are low cost, have minimal effects on TVA rates, and rank high on the other evaluation criteria that have been identified for Energy Vision 2020. For example, program options in Block 1 provide energy savings at an average total resource cost of 2.7 cents per kilowatt-hour and, as discussed later in the chapter on integration, have only a small impact on TVA rates. Programs in Block 1 would be the first to be selected by TVA for implementation in Energy Vision 2020 because of their low cost and low rate impacts.

The energy savings in Block 2 can be obtained at a total resource cost of 2.8 cents per kilowatt-hour, but the constituent programs have a greater impact on TVA rates than those in Block 1. The average total resource cost of ener-

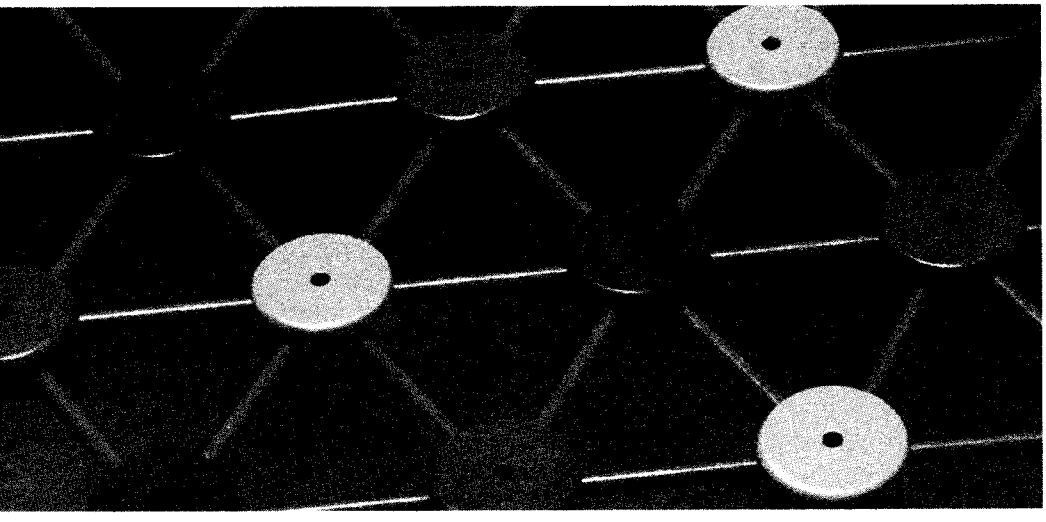
gy savings associated with options in Block 3 is 3.9 cents per kilowatt-hour while in Block 4 the average cost is 5.2 cents per kilowatt-hour. Blocks 3 and 4 also have larger impacts on TVA rates than do Blocks 1 and 2.

Peak demand savings potential in the year 2010 from Block 1 represents 4.7 percent of the forecast summer peak demand, and energy savings constitute 2.5 percent of total projected system sales in 2010. For Blocks 1 and 2 combined, the peak demand savings potential in the year 2010 is 8.7 percent of the forecast summer peak demand, and projected energy savings are 6.3 percent of total projected system sales. For all four blocks, peak demand savings potential in the year 2010 is 15.9 percent of forecast summer peak demand, and associated energy savings are 12.8 percent of total projected system sales.

The beneficial electrification options also were separated into two blocks, shown in *Figure 8-20*, according to the criteria discussed previously. Likewise, the self-generation and renewable generation options in *Figure 8-15* were placed in a separate block option. Different combinations of the four blocks of energy efficiency and load management options, one of the blocks of beneficial electrification options, the self-generation options, and rate options can be integrated with various supply options to form different resource strategies for Energy Vision 2020. Each of these different strategies is then evaluated using TVA's multi-attribute trade-off process in order to identify the best strategies for meeting future energy needs. This process is discussed in Chapter 9.

Chapter Nine

Resource Integration / Alternative Strategy Comparisons



Chapter 9: Resource Integration/ Alternative Strategy Comparisons

The resource integration phase of Energy Vision 2020 identified over 2,000 strategies using various mixes of supply-side and customer service options. From an extensive series of evaluations, several strategies emerged that offer competitive electricity for TVA's customers.

Seven strategies produce low cost, low electric rates, low debt, and low environmental impacts. At the same time, these strategies increase customer value and opportunities for economic development.

Options and strategies were also evaluated for several key uncertain events in the future (e.g., load growth, natural gas prices). These evaluations have identified several strategies, which provide flexibility to adapt to uncertain events.

The overall results of the resource integration are summarized in the long-term plan at the end of this chapter.

Much of the material in this chapter describes the results of computer analyses of many variables related to planning the power system. As such, some of the material is quite complex. For this reason, graphical charts have been included to show many of the key results that have been considered for future resource decisions.

Readers interested in a more qualitative summary of the results can review this Chapter's Final Evaluation section and the last section, which deals with the long-term plan.

This Chapter Includes:

- What Does Integration Mean?
- Review of Criteria and Options
- Uncertainties and Futures Development
- Strategy Development
- Decision on Nuclear Power
- Final Strategy Evaluation
- Environmental Consequences
- Managing Risk – Hedging Uncertainties
- Final Evaluation
- The Long-Term Plan – Preferred Alternative

Resource Integration/ Alternative Strategy Comparisons

What Does Integration Mean?

Energy Vision 2020 has its own language. Integration means combining options to create strategies and combining uncertainties to create futures. Strategies and futures are then combined to create scenarios. These scenarios are then evaluated against the plan's criteria.

As discussed in Chapter 2, Energy Vision 2020 uses multi-attribute trade-off analysis to integrate strategies, futures, and evaluation criteria. This integration process is summarized in *Figure 9-1*. Input from the public and TVA employees was a starting point for Energy Vision 2020. TVA received more than 1,300 comments, which were translated into evaluation criteria, resource options, and uncertainties.

One of the primary goals of Energy Vision 2020 is to develop a long-term plan that provides flexibility.

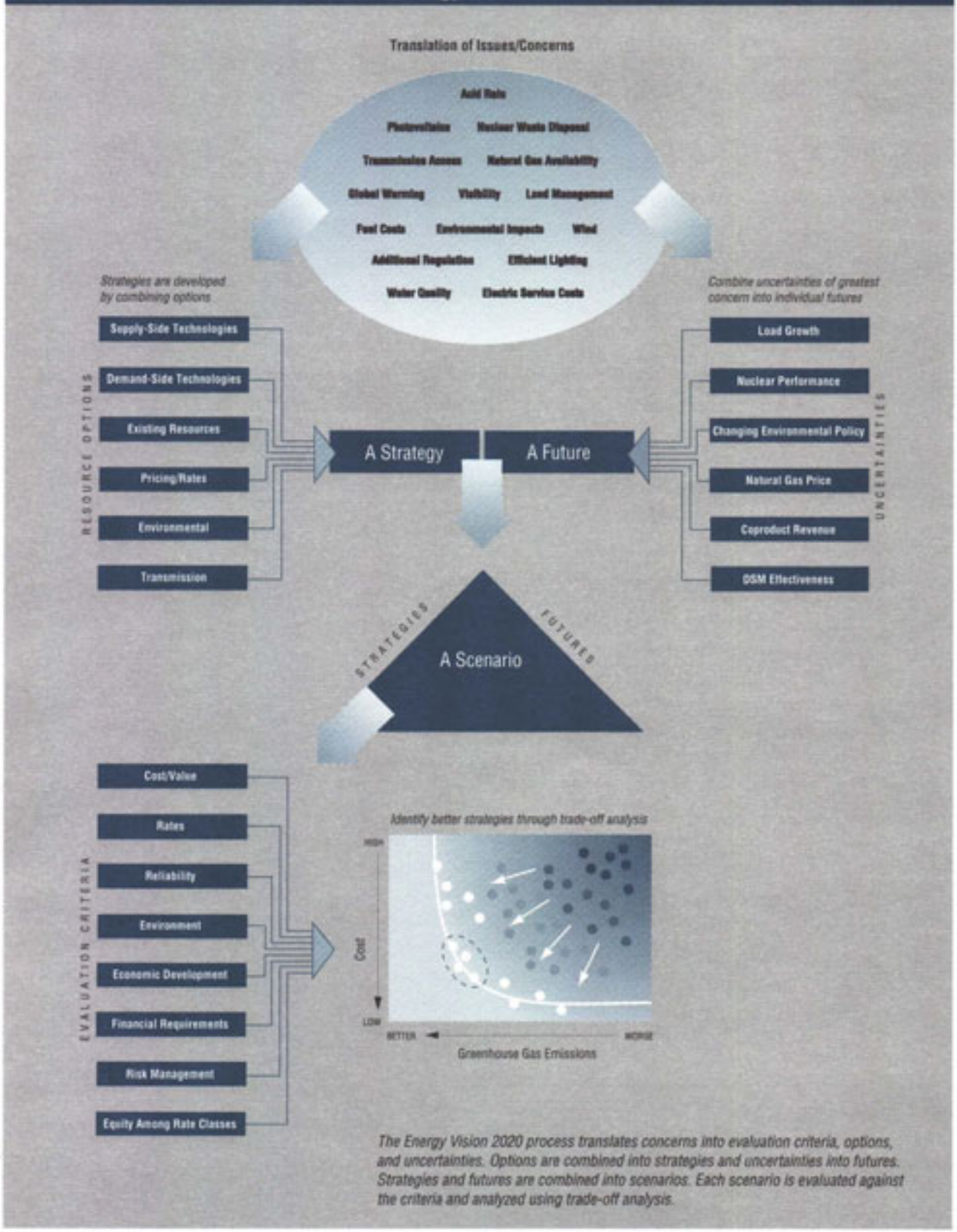
Evaluation criteria are based on values people hold; they are used to define and judge different resource plans or strategies. As indicated in *Figure 9-1*, criteria were identified in eight areas: cost and value, electric rates, reliability, environment, economic development, financial requirements, risk management, and equity among rate classes.

Strategies are based on actions TVA can control and are largely based on supply-side options, demand-side technologies, existing resources, and environmental control options. Several pricing or electric rate options and transmission options were considered, but not to the extent of the other resource options.

Each strategy was designed to meet the capacity requirements for either the low, medium, or high load forecast. Beginning with the existing coal, nuclear, and other power resources, new resource options were added to meet the capacity requirements. These options included peaking and base-load supply-side and demand-side resources as well as environmental control technologies to reduce pollutants such as sulfur dioxide, nitrogen oxides, and carbon dioxide.

From the public input, uncertainties were identified and combined into futures. Futures are largely outside of TVA's control. The key uncertainties are load growth, nuclear performance, changing environmental policy, natural gas prices, the price or revenue from chemical coproducts and the effectiveness of demand-side management programs. The futures create a highly uncertain environment that creates cost, electric rate, and other risks to TVA's customers. These risks must be managed in order to create a desirable strategy.

FIGURE 9-1. **Energy Vision 2020 Process**



The Energy Vision 2020 process translates concerns into evaluation criteria, options, and uncertainties. Options are combined into strategies and uncertainties into futures. Strategies and futures are combined into scenarios. Each scenario is evaluated against the criteria and analyzed using trade-off analysis.

Strategies and futures are combined into a scenario—thus, one strategy and one future produces one scenario. Since each scenario is evaluated using the same criteria, all strategies and resource options—supply or demand—are evaluated on a level playing field.

Since each scenario contains a strategy for a given future, the strategies can be judged or evaluated on all the criteria.

To evaluate these strategies, TVA uses a number of custom and off-the-shelf computer applications. One of these applications, MIDAS, is a program tailored for TVA by the Electric Power Research Institute. The MIDAS computer application can take 30 years of power demand forecasts and simulate how the TVA power system would be run. At the same time, MIDAS also estimates financial results under various assumptions. These assumptions deal with such variables as load growth, the price of fuel, or a change in rates. As assumptions change—for example, load growth increasing from 2 percent a year to 3 percent—a new simulation is run. Each simulation provides forecasts of future capacity, type of capacity, generation, and financial forecasts of cost, debt, and electric rate measures.

The results of the evaluations produce estimates for each of the 42 criteria. The estimates of the criteria are provided for each possible combination of strategies and futures. The process produces thousands of data elements that must be analyzed.

The large volume of results is analyzed systematically using the trade-off analysis. This trade-off analysis is necessary because more than one evaluation criterion or measurement is relevant to evaluating the strategies.

The purpose and nature of trade-off analysis are shown graphically in *Figure 9-1*. The axes of the graph identify two evaluation criteria or attributes. In this example, the cost of electricity ($/kilowatt-hour) is on the vertical axis and greenhouse gas emissions (tons) are on the horizontal axis. The results for each strategy are plotted on the graph for various futures.

If there were only two criteria that TVA had to consider, the ideal strategy would be located closest to where the two axes meet (in the lower left hand corner). In this example, strategies within the dotted line would be those with the lowest electricity costs and the lowest greenhouse gas emissions.

Once trade-offs are analyzed, strategies are modified and improved where possible to move them closer to the corner. In cases where an unavoidable trade-off exists, the decision-maker must choose between strategies. As an example, if there is no strategy with both the lowest costs and the lowest greenhouse gas emissions, the decision-maker may have to choose one over the other. After extensive reviews of different trade-offs, those strategies that, in the opinion of the decision-maker, best meet the criteria and provide flexible choices are developed into the long-term resource plan.

The result of this integration is a plan that can be interpreted objectively. It sounds complicated, but it is not so difficult when broken down step by step. It is TVA's intention to ensure every possibility is reviewed to provide a better tomorrow for the Tennessee Valley. This process creates a valuable management tool for TVA's decision-making during the next 25 years.

Review of Criteria and Options

As explained in Chapter 5, TVA established 42 criteria in the early stages of the Energy Vision 2020 process. Of these, 8 are related to cost and rates, 2 are related to debt, 2 are related to economic development in the Valley, and the remaining 30 are related to the environment. These criteria represent stakeholder values and are used to evaluate strategies.

Of the 188 resource options considered, 120 are supply-side options, 60 are customer service options, 2 are rate options, 4 are environmental control options, and 2 are transmission options. Chapter 7 explains how supply-side options were developed, and Chapter 8 covers customer service options. Discussions about environmental control options are also found in Chapter 7.

TVA sorted and ranked all 188 options according to selected criteria. The rankings were used as an aid in developing strategies. Ranking results are found in Volume 2, Technical Document 8, Resource Integration.

Uncertainties and Futures Development

Uncertainties also were evaluated. As explained in Chapter 2, uncertainties are those concerns that impact the Valley's energy future and are beyond TVA's control. For example, the future level of natural gas prices is an uncertainty and is significant because natural gas is a source of fuel for several supply-side options.

TVA identified 40 uncertainties, which were reduced to the 7 most important: load growth, nuclear cost and performance, greenhouse gas (carbon dioxide) regulations, air and water quality regulations, price of natural gas, revenue from chemical coproducts, and effectiveness of demand-side management. A description of how TVA accounted for uncertainty is found in Volume 2, Technical Document 8, Resource Integration. The uncertainties identified in the plan are shown in *Figure 9-2.*

TVA combined the seven uncertainties in every imaginable combination to produce possible futures. For example, one future included high electricity sales growth, high cost of natural gas as a fuel, and increased regulation of greenhouse gases. This exhaustive process produced 972 futures.

FIGURE 9-2. **Range of Values of Key Uncertainties**

	Low	Medium	High
1. LOAD GROWTH (Peak)			
• 1994-2000	0.0%	2.2%	3.4%
• 2000-2020	0.0%	1.9%	3.2%
2. NUCLEAR ISSUES			
• Capacity Factor	55%	67%	86%
• O&M (94$) all escalate at 4.5%	55 $/kW	69 $/kW	83 $/kW
• Capital Cost ($m)			
– Bellefonte Unit 1	1311	2622	3470
– Bellefonte Unit 2	912	1824	2420
– Browns Ferry Unit 1	1187	2374	3150
– Watts Bar Unit 2	1097	2194	2910
3. CARBON DIOXIDE COMPLIANCE (94 $) (Control cost over 1990 level)	0 $/Ton	5 $/Ton	10 $/Ton
4. AIR & WATER CONTROLS (94 $) (Add to existing coal units 2004)	0 $/kW	150 $/kW	250/425 $/kW
5. PRICE OF NATURAL GAS			
• Price (2000 $)	256 ¢/MBtu	342 ¢/MBtu	418 ¢/MBtu
• Escalation	2.4%	5.3%	7.9%
6. COPRODUCT REVENUE (2000 $)	91 $/Ton	262 $/Ton	320 $/Ton
7. DSM EFFECTIVENESS (MW peak reduction in 2010)	3124	5494	8219

Over 40 uncertainties were evaluated, and the 7 uncertainties with the greatest impact on the criteria are shown in this figure. For each uncertainty, low, medium, and high values are shown.

Strategy Development

In developing strategies, TVA attempted to identify ones that best addressed the evaluation criteria and uncertainties. Using the ranking process, TVA combined the customer service options into four demand-side management blocks and two beneficial electrification blocks, as explained in Chapter 8. The supply-side options were combined into 31 categories, including coal, gas, nuclear, renewables, and independent power production. These 31 categories were used to create diverse strategies to address the established criteria and uncertainties. There were three environmental control options, two electric rate options, and two transmission option. Each strategy contained short- and long-term supply-side options, customer service options (demand-side management or beneficial electrification), environmental control options, electric rate options, or transmission options.

From the 6 customer service blocks, 31 categories of supply-side options, 3 environmental control options, 2 electric rate options, and 2 transmission options, over 2,000 strategies were produced. Each strategy was further subdivided into a short-term period, 1996-2005, and a long-term period, 2006-2020.

TVA examined all of these strategies using the multi-attribute trade-off analysis described earlier in this chapter and in Chapter 2. In these early evaluations each strategy was evaluated for each criterion. This process created over 40,000 estimates of the evaluation criteria.

From these early evaluations many strategies were eliminated and new strategies were created. Strategies were eliminated based on the evaluation criteria. Strategies were generally eliminated only if there were clearly superior strategies. These evaluations resulted in 7 strategies emphasizing the evaluation of customer service options, 14 strategies relating to supply-side options including nuclear options, and 16 strategies that were mixed strategies or combinations of supply, customer service, environmental control, pricing, and transmission options. These 37 strategies best addressed the evaluation criteria and uncertainties.

These strategies were combined with futures, then scenarios were evaluated using the multi-attribute trade-off analysis. This process produced another set of thousands of estimates of evaluation criteria for the different futures.

The evaluation of 37 strategies was reviewed with the stakeholder Review Group at its January meeting. As the analysis continued, some strategies were eliminated, while others were refined to make new strategies. These new strategies were reviewed at the February and March meetings of the stakeholder Review Group.

During these three rounds of reviews, additional analysis concentrated on two areas. First, during the January review, there were no strategies with both low rates and low environmental emissions, particularly carbon dioxide (CO_2) emissions, in the 37 strategies evaluated. (Carbon dioxide is generally a good indicator of the air quality performance of all strategies.) In subsequent rounds, low cost renewables—which have few emissions—were given a more prominent position, and the rates/environment trade-off improved. The stakeholder Review Group recommended several strategies to improve on this trade-off.

Second, changes in the electric utility industry are creating additional uncertainty. Increasing competition increases the uncertainty in load growth and the future price of electricity. Since both load growth and price uncertainty create cost and electric rate risks to customers, TVA developed a set of resource options that provide the flexibility to adapt to these uncertainties. These resource options permit TVA to manage the risk associated with uncertain load growth and electric prices.

As described in Chapter 7, these flexible resource options are similar to call options found in financial markets. Based on a request for proposals, hundreds of call options for purchasing power were identified. In addition, TVA identified flexible internal options. These options are largely based on traditional supply- and demand-side options, but with the flexibility to stop or start construction on a project or program.

These flexible resource options, along with the traditional resource options, were evaluated using new techniques. These techniques are based on financial options valuation models and extensions of decision analysis models.

Approximately 400 flexible resource options were evaluated. From these evaluations, the best flexible resource options were identified and strategies containing these options were developed.

The three rounds of evaluations and the additional analysis performed during the period resulted in 21 strategies. These 21 strategies were reviewed by the stakeholder Review Group in March. These strategies are identified in *Figure 9-3.*

For purposes of comparison, TVA also retained Strategy D. Strategy D is the reference or "No Action" strategy for Energy Vision 2020. The "No-Action" strategy was to identify those resource options that TVA would most likely have employed to meet demand in the absence of the information and analysis produced as a result of the Energy Vision 2020 process. Taking into account the difficulties TVA has encountered in completing the nuclear units that it has had under construction, it was determined that TVA would likely have looked to some mix of combined cycle combustion turbines, new coal-fired units, and limited amounts of purchased power. These became the core elements of the Energy Vision 2020 "No Action" strategy and formed the reference strategy for purposes of analysis and benchmarking integration results across alternative strategies.

Decision on Nuclear Power

During the course of Energy Vision 2020, TVA's staff performed a review of issues involving unfinished or inoperative nuclear units and their impacts on rates, debt, long-term costs, and flexibility for meeting future power needs. This review was based on the more than 2,000 strategies evaluated using the multi-attribute trade-off analysis.

The three major concerns identified by TVA stakeholders—debt, competitiveness, and nuclear power—are interrelated. In the opinion of many stake-

FIGURE 9-3. **Characteristics of Energy Vision 2020 Strategies**

No./Name	Supply-Side Characteristics	Customer Service Characteristics	Environmental Controls	Pricing
STRATEGY A Minimum CO_2 - Natural Gas Repowering of Existing Coal	Supply-side expansion relies on low emission options • Natural gas combined cycle repowering of several existing coal units • Combustion turbines • Combined cycle • Fuel cells • Hydro modernization	Maximum use of DSM (three blocks) reduces need for generation	SO_2 • Gas repowering of some existing coal • Switching to lower sulfur coals CO_2 and other fossil emissions • CO_2 penalty added to assumed cost of generation options to shift generation to lower emission sources • Moderate level of biomass (waste wood) cofiring (1.3%) at existing fossil units	No special pricing policy is used
STRATEGY B Minimum CO_2 - Natural Gas Repowering of Existing Coal and Renewables	Supply-side expansion relies on low emission options and renewables • Natural gas combined cycle repowering of several existing coal units • Combustion turbines • Landfill and coalbed methane • Wind • Refuse-derived fuel repowering of an idled coal plant • Biomass-fueled plants • Fuel cells • Hydro modernization	Maximum use of DSM (three blocks) reduces need for generation	SO_2 • Gas repowering of some existing coal • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • CO_2 penalty added to assumed cost-of-generation options to shift generation to lower emission sources • Moderate level of biomass (waste wood) cofiring (1.3%) at existing fossil units	No special pricing policy is used
STRATEGY C Low-Cost Producer (Coal-Based)	Supply-side options emphasize coal for all base-load options • Combustion turbines • Small pulverized coal plant at existing site (Shawnee 11) • Pulverized coal with scrubbers • Clean coal technologies • Hydro modernization	Maximum use of DSM (one block) reduces need for generation	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing fossil units	Time-of-day rates reduce peak demand growth
STRATEGY D Combined Cycle, Purchased Power, Coal (Reference)	Supply-side options emphasize a blend of TVA-built, IPPs, and cogenerators to reduce production cost and debt • Combustion turbines • Combined cycle • IPP and cogeneration natural gas combined cycle • IPP coal • Clean coal technologies	Low-price block of DSM (block one) reduces demand with minimum rate increase	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing fossil units	No special pricing policy is used

FIGURE 9-3. **Characteristics of Energy Vision 2020 Strategies** *CONTINUED*

No./Name	Supply-Side Characteristics	Customer Service Characteristics	Environmental Controls	Pricing
Strategy E Maximum Customer Value Index - Off-System Sales, High Beneficial Electrification, Declining Block Pricing	Supply-side options mix emphasizes coal expansion for low production cost • Combustion turbines • Small pulverized coal plant at existing site (Shawnee 11) • Clean coal technologies • Pulverized coal with scrubbers • Hydro modernization	Attempt to increase customer value (low rates and low-cost services) by a combination of: • Low-price block of DSM (block one) reduces demand with minimum rate increase • High level beneficial electrification provides services and increases power sales • Off-system sales	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • A level of biomass (waste wood) cofiring of 0.3%	Declining block pricing promotes electricity use
Strategy F Low Total Resource Cost/High DSM	Supply-side options mix emphasizes coal expansion and low-cost renewables for low production cost • Combustion turbines • Clean coal technologies • Landfill and coalbed methane • Pulverized coal with scrubbers • Hydro modernization	Maximum use of DSM (three blocks) reduces need for generation	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used
Strategy G Maximum Sales	Supply-side options mix emphasizes coal expansion and low-cost renewables for low production cost • Combustion turbines • Clean coal technologies • IPP coal plant • Pulverized coal with scrubbers • Hydro modernization • Compressed air energy storage • Combined cycle • Small pulverized coal plant at existing site (Shawnee II)	No DSM High-level beneficial electrification Off-system sales	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing fossil units CO_2 and other fossil emissions • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used

FIGURE 9-3. **Characteristics of Energy Vision 2020 Strategies** *CONTINUED*

No./Name	Supply-Side Characteristics	Customer Service Characteristics	Environmental Controls	Pricing
Strategy H Maximum Capacity Diversity	Supply-side options mix emphasizes many diverse smaller options • Combustion turbines • Combined cycle • IPP and cogeneration combined cycle • IPP coal plant • Clean coal technologies • Compressed air energy storage • Landfill and coalbed methane • Wind • Fuel cells • Biomass (short rotation woody crop) plant • Refuse-derived fuel stoker plant • Hydro modernization	Low-price block of DSM (block 1) reduces demand with minimum rate increase Low-level beneficial electrification provides improved rate impact	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • Moderate level of biomass (waste wood) cofiring (1.3%) at existing fossil units	No special pricing policy is used
Strategy I Bellefonte Nuclear Partnership	Supply-side options include traditional expansion options with a Bellefonte Nuclear Partnership • Combustion turbines • Combined cycle • IPP and cogeneration combined cycle • IPP coal plant • Clean coal technologies • Bellefonte nuclear partnership	Low-price block of DSM (block 1) reduces demand with minimum rate increase	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • Moderate level of biomass (waste wood) cofiring (1.3%) at existing fossil units	No special pricing policy is used
Strategy J Bellefonte Coproduct, Renewables, IPPs	Supply-side expansion features an integrated coal gasification plant that produces a high-value chemical coproduct, projected for siting at Bellefonte Nuclear Plant • Combustion turbines • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • IPP combined cycle • Landfill and coalbed methane • Clean coal technologies • Hydro modernization	Low-price block of DSM (block 1) reduces demand with minimum rate increase	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used

FIGURE 9-3. **Characteristics of Energy Vision 2020 Strategies** *CONTINUED*

No./Name	Supply-Side Characteristics	Customer Service Characteristics	Environmental Controls	Pricing
Strategy K Defer and Build BFN 1 and WBN 2 with Reference Expansion	Supply-side expansion features completion of two nuclear units and traditional expansion options • Combustion turbines • BFN 1 and WBN 2 • IPP and cogeneration combined cycle • Combined cycle • Clean coal technologies • IPP coal plant	Low-price block of DSM (block 1) reduces demand with minimum rate increase	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units	No special pricing policy is used
Strategy L Minimum CO_2 with Less DSM (a variation of Strategy B)	Supply-side expansion relies on low emission options and renewables • Natural gas combined cycle repowering of several existing coal units • Combustion turbines • Combined cycle • Landfill and coalbed methane • Wind • Refuse-derived fuel repowering on an idled coal plant • Biomass fueled plant • Fuel cells • Hydro modernization	Low-price and low-cost DSM (two blocks) reduces need for generation	SO_2 • Gas repowering of some existing coal • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • CO_2 penalty added to assumed cost of generation options to shift generation to lower emission sources • Moderate level of biomass (waste wood) cofiring (1.3%) at existing fossil units	No special pricing policy is used
Strategy M Combined DSM and Off-System Sales (a variation of Strategy F)	Supply-side options mix emphasizes coal expansion and low-cost renewables for low production cost • Combustion turbines • Pulverized coal at an existing plant • Clean coal technologies • Landfill and coalbed methane • Pulverized coal with scrubbers • Hydro modernization	Low-price and low-cost DSM (two blocks) reduces need for generation Off-system sales	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used
Strategy N Decentralized Generation with More Renewables	Supply-side options mix emphasizes many diverse options • Combustion turbines • Combined cycle • IPP and cogeneration combined cycle • IPP hydro plant • Landfill and coalbed methane • Wind • Fuel cells • Refuse-derived fuel stoker plant • IPP coal plant	Low-price block of DSM (block 1) reduces demand with minimum rate increase	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units	No special pricing policy is used

FIGURE 9-3. **Characteristics of Energy Vision 2020 Strategies** *CONTINUED*

No./Name	Supply-Side Characteristics	Customer Service Characteristics	Environmental Controls	Pricing
Strategy O Bellefonte Coproduct, More DSM, More Off-System Sales (a variation of Strategy J)	Supply-side expansion features an integrated coal gasification plant that produces a high-value chemical coproduct, projected for siting at Bellefonte Nuclear Plant • Combustion turbines • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • IPP combined cycle • Landfill and coalbed methane • Clean coal technologies • Hydro modernization	Low-price and low-cost block of DSM (two blocks) reduces need for generation Off-system sales	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used
Strategy P Low-Cost Renewables, Low-Price DSM, Repowering	Supply-side expansion relies on low emission options and renewables • Natural gas combined cycle repowering of several existing coal units • Combustion turbines • IPP combined cycle • Clean coal technologies • Compressed air energy storage • Landfill and coalbed methane • Wind • Pulverized coal • Refuse-derived fuel repowering of an idled coal plant • Hydro modernization	Low-price block of DSM (block 1) reduces demand with minimum rate increase	SO_2 • Gas repowering of some existing coal • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • CO_2 penalty added to assumed cost of generation options to shift generation to lower emission sources • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used
Strategy Q Flexible Strategy with External Options	Supply-side expansion features purchase options with rights, but not obligations, to purchase power • Combustion turbines • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • IPP combined cycle • Purchase of peaking capacity • Flexible base capacity purchase • Flexible peaking capacity purchase • Landfill and coalbed methane • Clean coal technologies • Hydro modernization	Low-price block of DSM (block 1) reduces demand with minimum rate increase Low-level beneficial electrification provides improved rate impact Off-system sales	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used

FIGURE 9-3. **Characteristics of Energy Vision 2020 Strategies** *CONTINUED*

No./Name	Supply-Side Characteristics	Customer Service Characteristics	Environmental Controls	Pricing
Strategy R Flexible Strategy with Internal Options	Supply-side expansion features preplanning, design, and siting work to support flexible start dates of TVA-built options • Combustion turbines • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • IPP combined cycle • Combined cycle • Purchase of peaking capacity • Flexible base capacity purchase • Landfill and coalbed methane • Clean coal technologies • Hydro modernization	Low-price block of DSM (block 1) reduces demand with minimum rate increase Low-level beneficial electrification provides improved rate impact Off-system sales	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used
Strategy S Low Cost, Low Rates, Improved Environment (a variation of Strategy O)	Supply-side expansion features an integrated coal gasification plant that produces a high-value chemical coproduct, projected for siting at Bellefonte Nuclear Plant • Combustion turbines • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • IPP combined cycle • Landfill and coalbed methane • Clean coal technologies • Hydro modernization	Low-price block of DSM (block 1) reduces demand with minimum rate increase Low-level beneficial electrification provides improved rate impact Off-system sales spread fixed cost over more sales	SO_2 • Scrubbers are added at several existing units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used
Strategy T Low-Cost Renewables, Low-Price DSM, Repowering, Bellefonte Coproduct Partnership (a variation of Strategy P)	Supply-side expansion relies on low emission options, renewables, and an integrated coal gasification plant that produces a high-value chemical coproduct, projected for siting at Bellefonte Nuclear Plant • Natural gas combined cycle repowering of several existing coal units • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • Combustion turbines • IPP combined cycle • Clean coal technologies • Compressed air energy storage • Landfill and coalbed methane • Wind • Pulverized coal • Hydro modernization	Low-price block of DSM (block 1) reduces demand with minimum rate increase	SO_2 • Gas repowering of some existing coal • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • CO_2 penalty added to assumed cost of generation options to shift generation to lower emission sources • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used

FIGURE 9-3. **Characteristics of Energy Vision 2020 Strategies** *CONTINUED*

No./Name	Supply-Side Characteristics	Customer Service Characteristics	Environmental Controls	Pricing
Strategy U Low-Cost Renewables, More DSM, Repowering, Bellefonte Coproduct Partnership (a variation of Strategy P)	Supply-side expansion relies on low emission options, renewables, and an integrated coal gasification plant that produces a high-value chemical coproduct, projected for siting at Bellefonte Nuclear Plant • Natural gas combined cycle repowering of several existing coal units • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • Combustion turbines • IPP combined cycle • Clean coal technologies • Compressed air energy storage • Landfill and coalbed methane • Wind • Pulverized coal • Fuel cells • Hydro modernization	Low-price and low-cost DSM (two blocks) reduces need for generation	SO_2 • Gas repowering of some existing coal • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • CO_2 penalty added to assumed cost of generation options to shift generation to lower emission sources • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used

holders, high debt is generally associated with a poor competitive position. Since the large capital expenditures necessary to complete TVA's nuclear units would increase TVA's debt, the possibility of completing these units contributes to a perception that TVA's competitiveness will suffer.

The question of how to proceed with four nuclear units—Bellefonte Nuclear Plant Units 1 and 2, Watts Bar Nuclear Plant Unit 2 and Browns Ferry Nuclear Plant Unit 1—is critically important to TVA and the region it serves. The total cost to complete or restore them to service as nuclear units is estimated to be about $9 billion—unquestionably a major investment by TVA's customers. But in addition to these costs, TVA considered these factors:

- Need for power in the future
- Cost and operating performance of other options that could replace the nuclear units
- TVA's long-term costs
- TVA's rising debt
- Impact of any decision on short- and long-term rates
- Environmental effects of various resource options

After receiving the staff's review, TVA's Board of Directors announced that TVA will not fund the completion of Bellefonte Units 1 and 2 and Watts Bar Unit 2 as nuclear units. In addition, Browns Ferry Unit 1 will continue in its current inoperative status. TVA will keep open alternatives for these units that would minimize short-term rates, increase long-term flexibility, minimize long-term costs, and limit debt.

Alternatives to completing these units as nuclear units include:

- Converting the units to another technology such as natural gas or coal gasification with a chemical coproduct
- Replacing these units with different types of supply- and demand-side resource options

The nuclear power report is found in Volume 2, Technical Document 8, Resource Integration.

Final Strategy Evaluation

The 21 strategies that remained following the third round of evaluation were compared using the evaluation criteria.

TVA used the 42 criteria to quantitatively compare the strategies. Several were selected as representative of the 42 criteria. These include a customer value test; total resource cost; impact on short-term rates; impact on total debt; emissions of carbon dioxide, sulfur dioxide, and solid waste; and annual average income in the TVA region.

Strategies were combined with futures to develop 20,000 scenarios. The scenarios were then evaluated against all 42 of the criteria, creating more than 850,000 data points. Each of these data points represents the numerical value for one criteria and one scenario.

In Energy Vision 2020, TVA used multi-attribute trade-off analysis extensively as an evaluation tool. Five trade-off graphs appear as illustrations in this section. These trade-off graphs provide a comparison of the 21 strategies for representative criteria for a mid-range future. This mid-range future consists of:

- Medium load growth
- Medium natural gas price
- Medium chemical coproduct price
- Medium nuclear performance
- Medium demand-side management effectiveness
- No additional environmental regulations
- No additional carbon dioxide regulations

(Medium values are identified with the list of uncertainties in *Figure 9-2.*) This mid-range future is judged to be one of the more probable futures and is used in the initial evaluations.

Figures which follow show trade-off graphs in which the 21 strategies are evaluated against debt, long-term costs, short-term rates, carbon dioxide

emissions, economic development, and customer value. Trade-off graphs are plotted such that the best performing strategies (relative to the other strategies) appear in the lower left corner of the graphs. Best performing strategies have the lowest (or highest) value for the two criteria plotted on the chart. Strategies in this area are enclosed within a box. A discussion of the strategies within the box that will be carried forward for further analysis follows:

Debt in Year 2001 Versus Total Resource Costs

Nine strategies result in low debt and low long-term costs (long-term costs to customers over the 25-year period are identified as total resource costs [TRC]). These 9 are Strategies F, J, M, O, Q, R, S, T, and U. (See *Figure 9-4*.) One of the major concerns identified by the public is TVA's debt, i.e., the current level of debt and the prospects of the growth in debt if TVA would have completed the unfinished nuclear plants.

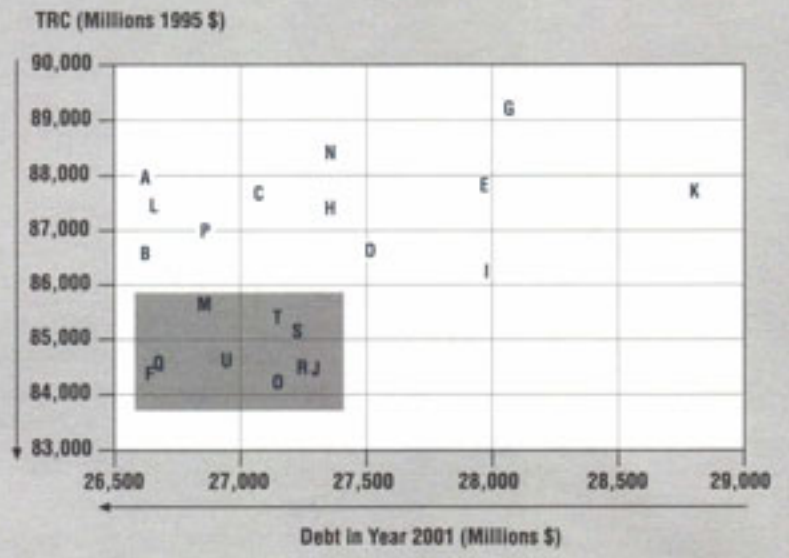
The amount that TVA borrows in the future adds to the debt. TVA borrowings are generally equal to TVA capital expenditures on existing and new plant and equipment less any internal funds that are generated for reinvestment in existing or new plant and equipment. Internal funds for reinvesting in plant and equipment are largely based on depreciation or amortization charges for existing plant and equipment.

All of the strategies identified in *Figure 9-4* indicate that TVA, by itself, will not complete Bellefonte Units 1 and 2, Watts Bar Unit 2, or restore Browns Ferry Unit 1 as nuclear plants. Reducing expenditures on the capital-intensive nuclear plants is one of the major reasons that the projected debt level in 2001 remains below $28 billion.

In addition, the nine low-cost and low-debt strategies include the completion of Watts Bar Unit 1 and Browns Ferry Unit 3 in 1996. These revenue- producing units require relatively small capital expenditures to complete and will be depreciated when the units go into service, thereby providing internal funds to manage debt.

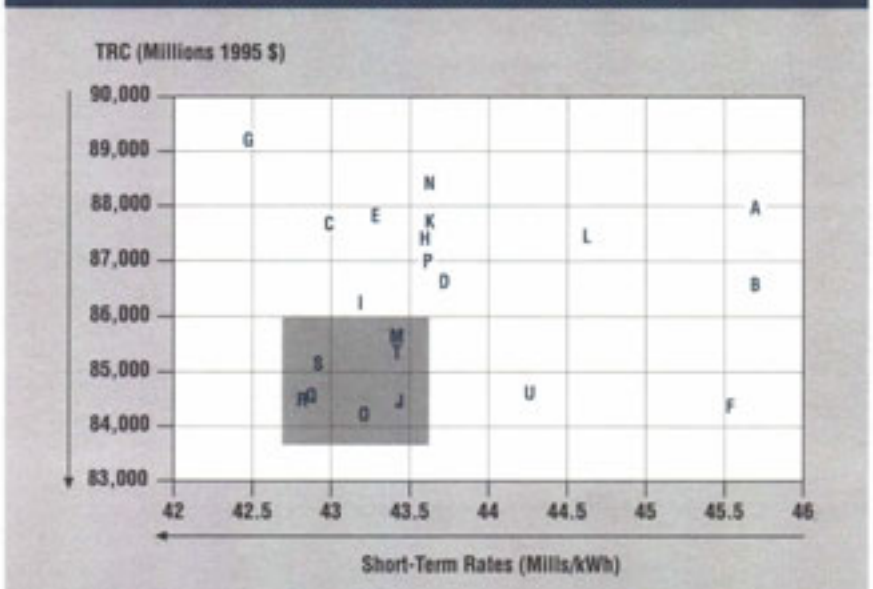
Peaking capacity needs beginning in 1998 and base-load capacity needs in 2001 are met by low capital cost and small-size combustion turbines and combined cycle plants, purchased power from other utilities or purchases of options on future power delivery, demand-side management, and other low-capital cost resource options. These resource options result in lower capital expenditures and help maintain the TVA debt level

FIGURE 9-4. **Strategy Trade-Off for Debt in Year 2001 vs. Total Resource Costs**



The nine strategies within the box have relatively low debt and low costs.

FIGURE 9-5. **Strategy Trade-Off for Short-Term Rates vs. Total Resource Costs**



The seven strategies within the box have relatively low short-term rates and low costs.

below the $30 billion statutory limit.

TVA also closely scrutinizes, monitors, and controls capital expenditures on existing plant and equipment. Most capital expenditures other than for safety or regulatory compliance are subjected to cost-effective tests to maintain low costs and electric rates, as well as reduce TVA's need to borrow additional money.

Thus, the strategies identified in *Figure 9-4* indicate that TVA can manage its debt by controlling capital expenditures on existing and new plants. By controlling capital expenditures, these expenditures will not exceed the amount of internal funds and therefore require little or no new borrowing. Without borrowing additional money, TVA can maintain or lower the level of debt.

Most importantly, TVA's Board of Directors indicated that TVA would limit its debt. This limit on debt would be less than TVA's statutory limit of $30 billion. These strategies result in debt that is $2 to $3 billion less than TVA's statutory limit of $30 billion. Long-term costs are in a range of $84 to $86 billion or a range of 2.4 percent.

Short-Term Rates Versus Total Resource Costs

Seven strategies result in low short-term rates and low long-term costs. These are Strategies J, M, O, Q, R, S, and T. (See *Figure 9-5.)* Strategies F and U have high rates but low costs. Strategy G has high costs but low short-term rates.

All of the strategies that are low cost, with the exception of Strategies M and F, contain the Bellefonte conversion to a coal gasification plant with the production of both electricity and a chemical coproduct.

The Bellefonte conversion option alone reduces the total resource costs approximately $1,500 million. The Bellefonte conversion option reduces both costs and electric rates. Costs and rates are reduced because the sale of the chemical coproduct provides benefits that reduce the cost of electricity. In addition, this option minimizes electric rates because much of the existing plant at Bellefonte can be used in the conversion that reduces the potential write-off of unused plant and equipment.

Without the Bellefonte conversion options, there would be more of a trade-off between costs and short-term electric rates.

Several strategies, such as Strategy F and Strategy U, have relatively low total resource costs but higher short-term rates. For example, Strategy F has electric rates that are 2 to 2.5 mills greater, or 5 to 7 percent greater, than the

low-cost and low-rate strategies in *Figure 9-5*. In addition, Strategies B, L, and F could be lower cost if they included the Bellefonte conversion option.

Strategies B, L, U, and F all contain more demand-side management (2,500-5,000 megawatts in 2010) than the seven low-cost and low-rate strategies (1,500 megawatts in 2010) shown in the shaded area of *Figure 9-5*. Strategies with more demand-side management tend to reduce total resource costs.

Although the strategies that have more demand-side management can have lower costs, they also have higher short-term and long-term electric rates.

As indicated in Chapter 5, Evaluation Criteria, the total resource costs measure the net benefits, benefits minus costs, to participants in the demand-side management programs. The participants in demand-side management receive benefits from reduced electric bills. Generally, the benefits exceed the cost of installing demand-side management measures. The non-participants' benefits in demand-side management programs are negative (costs exceed benefits) since the electric rates increase—raising their electric bills without a corresponding savings. Electric rates are increased since the revenue loss from reduced sales plus direct demand-side management costs exceeds the benefits of reduced generation costs. The total resource costs are generally reduced by demand-side management activities because the benefits to participants exceed the costs to non-participants in the demand-side management activity.

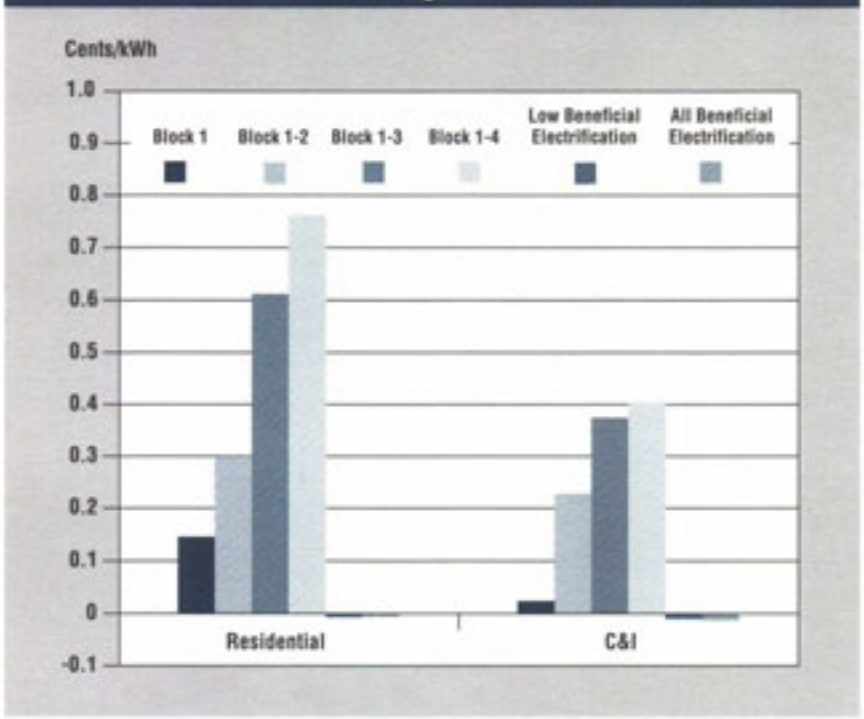
Although there is a reduction in total resource costs with more demand-side management, a portion of the benefits received by the participants is paid by non-participants' increased electric rates and bills. This is commonly referred to as cross-subsidization between participants and non-participants. The higher electric rates and bills for non-participants can be for consumers within the same rate class (e.g., residential) or for consumers in other rate classes, such as industrial customers.

The multi-attribute trade-off analysis examines both total resource costs and electric rates as important criteria for choosing strategies.

An alternative to choosing lower cost or lower rate strategies is to mitigate the effect on electric rates associated with demand-side management activities. There are several possible approaches to mitigating the electric rate effects of demand-side management.

First, demand-side management activities that do not increase electric rates can be implemented. Activities can be implemented such as load management, which reduces peak demands on the power system, and market transformation activities in which the participants or beneficiaries of the demand-side management activity pay the costs. Of the demand-side management activities identified in Chapter 8, the load management of residential and commercial water heating and cooling reduces peak demands without increasing electric rates to non-participants. Two important market transformation activities identified in Chapter 8 are the manufactured homes program and the comprehensive commercial and industrial finance program. With these programs the consumers that receive the benefits of increased energy efficiency and lower electric bills will pay more of the direct costs, resulting in lower impacts on electric rates

FIGURE 9-6. **Rate Changes by Class of Service Due to Demand-Side Management for Fiscal Year 2000**



to the non-participating consumers.

Second, electric rate increases can be more appropriately allocated to the residential or commercial and industrial rate classes. If costs and the loss of revenues are allocated to those classes of service receiving the benefits of demand-side management, then the rate increases will differ from the average rate increase.

The increase in electric rates for residential, commercial, and industrial customer classes for the four blocks of demand-side management and the two blocks of beneficial electrification are shown in *Figure 9-6*. The rate increases are shown for the year 2000. Residential electric rates will increase by a larger amount than commercial and industrial rates for all blocks of demand-side management. Commercial and industrial electric rates show almost no change for the first block of demand-side management. Beneficial electrification results in almost no change in electric rates.

Thus, the electric rate increases are associated with the classes of customers that generally receive the benefits from the demand-side management activity. Note that within a rate class the non-participants will experience an increase in electric rates.

Third, the revenue loss that results from increased demand-side management activities can be reduced by more closely matching cost savings with the revenue changes by changing the overall rate structure or pricing policy. By more closely matching the revenue loss with the costs savings or benefits, the effect on electric rates can be reduced or eliminated. Two such approaches are real-time pricing mechanisms and the unbundling of electric services. With real-time pricing, prices of electricity on an hour-by-hour basis are based on the incremental costs of electric supply. Thus, for any changes in electricity demand, revenue changes match cost changes, which eliminates any cross-subsidization among consumers. TVA's Economy Surplus Power program is a form of real-time pricing for non-firm or interruptible electric power.

The changing competitive structure of the electric industry is resulting in services associated with the delivery of electric power being unbundled. For example, recent proposed actions by the Federal Energy Regulatory Commission (FERC) are likely to result in transmission services being separately priced from generating services associated with the delivery of electric power. Likewise, other ancillary services to transmission, such as voltage control, could be separately priced in the delivery of electricity. Generating

services could also be unbundled by time period (e.g., time-of-day rates) or by type of generation such as peaking, base-load generation, and back-up power for emergencies. This unbundling of services results in prices more closely matching the cost of delivering such services and again reducing the cross-subsidization associated with changes in electricity demands. TVA is currently reviewing and investigating its real-time pricing options and the unbundling of electric services.

All of these approaches to reducing the impact of electric rates of demand-side management activities are being, or will be investigated by TVA now or in the near future. As these investigations are concluded and rate or pricing policies change, TVA will re-evaluate the changes in costs and electric rates associated with demand-side management activities.

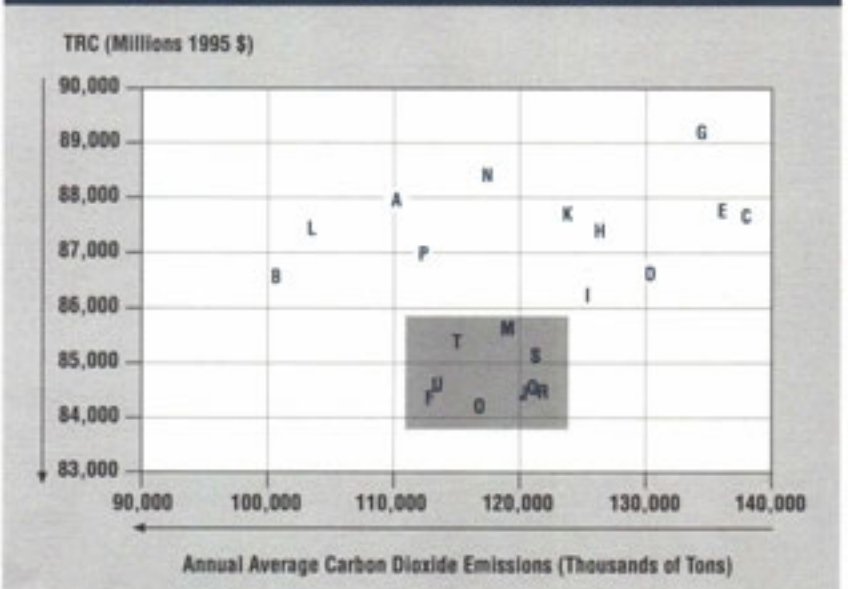
Carbon Dioxide Emissions Versus Total Resource Costs

Nine strategies have low carbon dioxide emissions and low long-term costs. These 9 are Strategies F, J, M, O, Q, R, S, T, and U. Strategies B and L have lower emissions but higher costs. Most environmental measures are correlated (they track with one another); therefore, carbon dioxide emissions are a good surrogate for all environmental measures.

Lower environmental emissions could have been achieved with more demand-side management (Strategies B and L), but only at higher costs as shown in *Figure 9-7*, and higher short-term electric rates shown in *Figure 9-5*.

As indicated in the previous discussion of strategy development, the trade-off between lower electric rates and lower environmental emissions was mitigated. This mitigation occurred through strategies that included clean coal technologies such as integrated gasification combined cycle; renewables such as wind power, the burning of landfill methane in fuel cells, and hydro modernization; and the use of lower carbon dioxide emitting technologies such as natural gas combined cycle, coalbed methane burned in fuel cells, and the repowering of existing coal units with natural gas.

FIGURE 9-7. **Strategy Trade-Off for Average Annual Carbon Dioxide Emissions vs. Total Resource Costs**

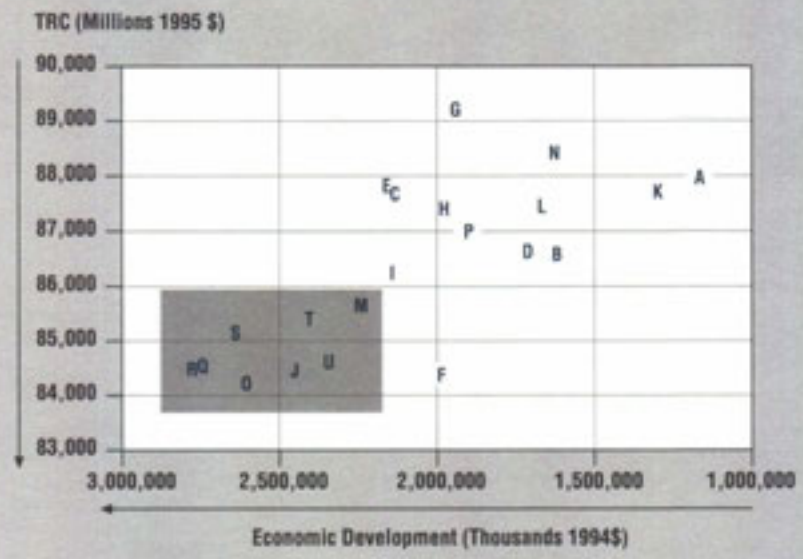


The nine strategies within the box have low to moderate levels of carbon dioxide emissions and relatively low costs.

Economic Development (Personal Income in the TVA Region) Versus Total Resource Costs

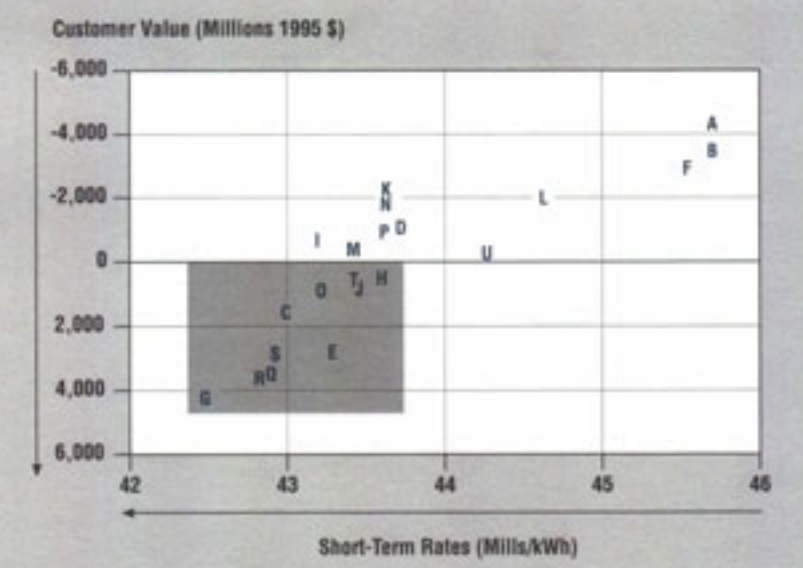
Eight strategies have a positive impact on regional income and low long-term costs. These are Strategies J, M, O, Q, R, S, T, and U. (See *Figure 9-8*.)

FIGURE 9-8. **Strategy Trade-Off for Economic Development vs. Total Resource Costs**



The eight strategies within the box have low costs and high levels of economic development benefits. Economic development is measured by personal income in the TVA region.

FIGURE 9-9. **Strategy Trade-Off for Short-Term Rates vs. Customer Value**



The ten strategies within the box have low short-term rates and high customer value.

Short-Term Rates Versus Customer Value

Ten strategies have low short-term rates and high customer value. These are Strategies C, E, G, H, J, O, Q, R, S, and T. (See *Figure 9-9.*) Four strategies—C, E, G, and H—had not been previously identified as best performers. They emphasize additional off-system sales and beneficial electrification. Since off-system sales and beneficial electrification increase value, these activities also are included in strategies M, O, Q, R, and S.

A summary of trade-off graphs for the 21 strategies as compared to the reference case is shown in a strategy index, illustrated as *Figure 9-10.* The numbers in bold type represent im-provements over the reference case.

From the trade-off graphs and the summary (*Figure 9-10*), there are 13 strategies that could possibly produce two or more of the following: low cost, low debt, low electric rates, low environmental emissions, high economic development, and high customer value. From these strategies several were eliminated.

- Strategies F and U produce low cost and improved environment, but were eliminated due to the higher short-term electric rates.
- Strategies G and E produced high customer value, but increased environmental emissions and debt. In these strategies value was created by beneficial electrification and off-system sales. These customer service options were included in other strategies such as Q, R, and S.
- Strategy C also had higher value, but was eliminated due to high environmental emissions.
- Strategy H also had high value,

FIGURE 9-10. **Summary of Strategy Evaluations**

		Customer Value Test Contribution Split ($mil.)	TRC ($mil.)	Short-Term Rates (mills/kWh)	Total Debt 2001 ($mil.)	CO_2 (kTons/yr.)	SO_2 (kTons/yr.)	Solids (kTons/yr.)	Annual Average Income ($mil.)
D	Reference (Combined Cycle, Purchased Power, Coal)	(1,076)	86,634	44	27,514	130,352	563,048	6,166,437	1,711
		Relative to Reference Case			Percent of Reference Case				
A	Min CO_2—Nat Gas Repowering of Existing Coal	(4,331)	1.02	1.05	**0.97**	**0.85**	**0.86**	**0.79**	0.68
B	Min CO_2—Nat Gas Repowering of Existing Coal and Renewables	(3,470)	1.00	1.05	**0.97**	**0.77**	**0.86**	**0.82**	0.95
C	Low-Cost Producer (Coal-Based)	**1,633**	1.01	**0.98**	**0.98**	1.06	**0.98**	1.22	**1.25**
D	Reference (Combined Cycle, Purchased Power, Coal)	(1,076)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
E	Max Customer Value Index—Off-System Sales, High BE, Declining Block Pricing	**2,779**	1.01	**0.99**	1.02	1.04	**0.92**	1.29	**1.26**
F	Low TRC/High DSM	(2,925)	**0.97**	1.04	**0.97**	**0.87**	**0.87**	**0.96**	**1.16**
G	Maximum Sales	**4,210**	1.03	**0.97**	1.02	1.03	1.02	1.02	**1.13**
H	Maximum Capacity Diversity	**486**	1.01	1.00	**0.99**	**0.97**	1.01	1.00	**1.16**
I	Bellefonte Nuclear Partnership	(681)	1.00	**0.99**	1.02	**0.96**	**0.97**	**0.99**	**1.25**
J	Bellefonte Coproduct, Renewables, IPPs	**820**	**0.97**	**0.99**	**.99**	**0.92**	**0.96**	**0.94**	**1.43**
K	Defer and Build BFN 1 and WBN 2 with Reference Expansion	(2,197)	1.01	1.00	1.05	**0.95**	**0.96**	**0.98**	0.76
L	Minimum CO_2 with Less DSM	(2,005)	1.01	1.02	**0.97**	**0.79**	**0.88**	**0.83**	0.97
M	Combined DSM and Off-System Sales	(397)	**0.99**	**0.99**	**0.98**	**0.91**	**0.91**	1.08	**1.31**
N	Decentralized Generation with More Renewables	(1,891)	1.02	1.00	**0.99**	**0.90**	1.01	**0.97**	.95
O	Bellefonte Coproduct, More DSM, More Off-System Sales	**872**	**0.97**	**0.99**	**0.99**	**0.90**	**0.92**	**0.94**	**1.52**
P	Low-Cost Renewables, Low-Price DSM, Repowering	(938)	1.00	1.00	**0.98**	**0.86**	**0.92**	**0.87**	**1.11**
Q	Flexible Strategy with External Options	**3,450**	**0.98**	**0.98**	**0.97**	**0.93**	**0.90**	**0.97**	**1.61**
R	Flexible Strategy with Internal Options	**3,511**	**0.98**	**0.98**	**0.99**	**0.93**	**0.93**	**0.96**	**1.62**
S	Low Cost, Low Rates, Improved Environment	**2,829**	**0.98**	**0.98**	**0.99**	**0.93**	**0.93**	**0.96**	**1.54**
T	Low-Cost Renewables, Low-Price DSM, Repowering, BLN Coproduct Partnership	**542**	**0.99**	**0.99**	**0.99**	**0.88**	**0.92**	**0.85**	**1.40**
U	Low-Cost Renewables, More DSM, Repowering, BLN Coproduct Partnership	(284)	**0.98**	1.01	**0.98**	**0.87**	**0.91**	**0.85**	**1.37**

All 21 strategies are evaluated for selected criteria and compared to the reference or no action alternative strategy (Strategy D). The customer value is measured in millions of dollars and the other criteria are compared to the reference strategy. The reference strategy is indexed as1.0. Strategies whose criteria are in bold type are better than the reference strategy.

but was eliminated due to the high resource costs. In addition, this strategy contained many options contained in Strategies J, M, Q, R, S, and T.

This analysis identified seven strategies as having low cost, low debt, low electric rates, low environmental emissions, high customer value, and high impact on economic development. These strategies are as follows:

- Strategy J – Bellefonte Coproduct, Renewables, Independent Power Producers

- Strategy M – Combined Demand-Side Management and Off-System Sales
- Strategy O – Bellefonte Coproduct, More Demand-Side Management, More Off-System Sales
- Strategy Q – Flexible Strategy with External Options
- Strategy R – Flexible Strategy with Internal Options
- Strategy S – Low Cost, Low Rates, Improved Environment
- Strategy T – Low-Cost Renewables, Low-Price Demand-Side Management, Repowering, Bellefonte Coproduct Partnership

Environmental Consequences

This section summarizes potential environmental impacts associated with alternative energy strategies. It compares the impacts of alternative strategies and provides the important findings of TVA's environmental analysis for Energy Vision 2020.

TVA'S ANALYTICAL APPROACH REDUCES THE RISK OF ADVERSE ENVIRONMENTAL IMPACTS ASSOCIATED WITH STRATEGIES

The analytical approach used for Energy Vision 2020 is the multi-attribute trade-off method. This approach allows TVA to integrate—quantitatively—the identified environmental impacts and formulate strategies that mitigate them.

TVA developed more than 2,000 different strategies for Energy Vision 2020. These strategies consist of different combinations of energy resource options that were first screened for acceptable performance using multiple criteria, including environmental criteria. In this process, the environmental performance of the strategies was fully integrated into the evaluation in the same manner as financial, rate, economics, and other criteria. Environmental impacts of each strategy are compared to all other evaluation criteria and to all other strategies on an objective basis. This process identified real trade-offs among criteria. One of the most important trade-offs occurred between better environmental performance and electric rates. Achieving better environmental performance (less impacts) typically produces higher costs or rates. In the past, utilities usually have had to choose between lower costs or rates or better environmental performance.

The integrated multi-attribute trade-off method allowed TVA to mitigate potential environmental trade-offs by reformulating strategies to lessen the degree of trade-off. Energy resource options that were primarily responsible for producing undesirable results in either rates or environmental areas were replaced by options that produced more desirable results. These modified strategies were then reintegrated and their performance with respect to the evaluation criteria and trade-offs was reexamined. This was done several times until seven modified strategies were created that respond reasonably well to all Energy Vision 2020 criteria, including environmental criteria. Potential trade-offs were sharply reduced.

With the seven strategies, it is possible to meet the future needs of TVA's customers with much better environmental performance compared to the reference strategy and other unmitigated strategies.

AIR IMPACT SUMMARY

This section summarizes the differences among TVA's final energy strategies with respect to potential impacts on air resources. Chapter 3 provides an overview of air quality issues, existing air quality impacts, sources of air emissions, air pollution trends, and emerging regulations. The air impacts considered in Energy Vision 2020 are human health impacted by inhalation, visibility, crop and forest productivity, materials damage, and greenhouse gases.

FIGURE 9-11. **Air Quality Impact Environmental Indices for Each Strategy and Impact Area**

Strategy	Health-Inhalation	Visibility Impairment	Forest & Crops Productivity	Materials Damage	Greenhouse Gases
D- Reference	1.00	1.00	1.00	1.00	1.00
J	0.98	0.97	0.98	0.97	0.93
M	0.94	0.93	0.95	0.93	0.91
O	0.95	0.94	0.96	0.94	0.90
Q	0.94	0.92	0.95	0.93	0.93
R	0.95	0.94	0.96	0.95	0.93
S	0.95	0.94	0.96	0.95	0.93
T	0.91	0.91	0.91	0.91	0.87

Air indices have been developed for health-inhalation impacts, visibility impairment, forest and crop productivity, materials damage, and greenhouse gases.

Indices were developed to help characterize how the emissions associated with alternative strategies might contribute to these four air impact categories. *Figure 9-11* shows these indices for the final strategies. How these indices were derived is explained in Volume 2, Technical Document 1, Comprehensive Affected Environment. TVA's final strategies were compared to the "No Action" strategy, which is the reference strategy (Strategy D). As indicated, Strategy D was assigned a value of 1.0. The values for the other final strategies then indicate whether they are better or worse than Strategy D with respect to the impact in question (a value greater than 1.0 indicates a worse effect, less than 1.0 a better effect).

TVA's Existing Energy Resources Are the Primary Contributors to Impacts

One of the most important conclusions to be drawn from TVA's Energy Vision 2020 evaluation is that TVA's existing coal-fired units are responsible for most of TVA's contribution to the identified environmental impacts. TVA's coal-fired plants produce air pollution, water pollution, and solid waste. These environmental outputs are associated with a number of environmental problems.

TVA's contribution to many environmental problems has been substantially reduced over the years and is being reduced still further. For example, TVA's sulfur dioxide emissions from its coal-fired units have been reduced by over 60 percent since the mid-1970s and will be reduced still further in response to the Clean Air Act Amendments of 1990. These reductions lessen TVA's contribution to such impacts as acid rain and visibility impairment. However, compared to most new energy resource options, TVA's existing coal-fired units are significantly worse environmental performers.

Energy Vision 2020 focuses primarily on what additional energy resource options, if any, should be added to TVA's system in the future. Consequently,

repowering of selected less-efficient coal-fired units is one of the better options for reducing emissions.

Greenhouse Gas Emissions

There remains considerable uncertainty regarding the possible effect of carbon dioxide and other emissions on global climate. However, at the Earth Summit in Rio de Janeiro, Brazil in June 1992, the United States and over 150 other nations signed the United Nations Framework Convention on Climate Change, establishing the objective of stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous manmade interference with the climate system. In October 1993, the President announced the Climate Change Action Plan which has the goal of returning United States greenhouse gas emissions to 1990 levels by the year 2000. As part of this action plan the United States Department of Energy initiated the Climate Challenge which is a voluntary program to manage United States electric utility greenhouse gases through reduction, avoidance, or sequestering of greenhouse gases.

On April 20, 1994, the Climate Challenge Memorandum of Understanding was signed by the Department of Energy, four utility organizations, and TVA. Subsequently, 104 individual Climate Challenge Participation Accords have been signed with the Department of Energy that represent 487 utilities including TVA. The efforts taken by TVA and the other 450 plus Climate Challenge participants will help mitigate possible negative effects utility emissions may have on global climate in a more cost-effective manner than other control measures such as emissions regulations or carbon taxes. A 22.7 million ton reduction in carbon dioxide by the year 2000 is committed to in TVA's Climate Challenge Participation Accord. These reductions are projected from TVA's 1987 to 1990 baseline emissions and the emissions projected by a year 2000 modified reference case. Primarily, TVA greenhouse gas reductions by the year 2000 come from increased use of nuclear power, biomass cofiring, demand-side management programs, fossil-fueled power plant efficiency improvements, transmission system improvements, and hydroelectric power plant modernization.

Other Air Quality Impacts

A number of other conclusions can be derived from Energy Vision 2020's assessment of potential air resource impacts:

- Although coal usage is projected to increase under all strategies, sulfur dioxide and nitrogen dioxide emissions are expected to decrease compared to 1996 levels.
- Sulfur dioxide emissions are projected to decrease from 1996 levels by 47-51 percent in 2020, depending on the strategy.
- Nitrogen oxides emissions are projected to decrease by 10-20 percent by 2000, then increase, but still remain some 3-13 percent below 1996 levels.
- For all strategies, decreases in TVA's contribution to human health impacts, visibility impairment, decreased forest and crop productivity, and materials degradation are expected.

- TVA's contribution to ozone-related impacts is expected to be reduced under all strategies, but TVA's reductions are likely to be offset by emission increases elsewhere in the region. (Mobile source emissions are projected to increase substantially.)
- Among the final strategies, only Strategy D (the reference strategy) and Strategy T (including low-cost renewables) show a noticeable difference in air resource impacts. The reference or "No Action" strategy uses the most coal and has the greatest impacts. Strategy T repowers several existing coal-fired units and uses the most natural gas and renewable resources. This results in a reduction in TVA's contribution to impacts ranging from 9 to 13 percent.

WATER RESOURCE IMPACT SUMMARY

This section summarizes the differences among TVA's final strategies with respect to potential impacts on water resources. Three water-quality impacts were considered: human health impacts by ingestion, impacts on water supply and waste assimilation, and impacts on fish, aquatic life, and aquatic biodiversity. Chapter 3 provides an overview of water quality issues, existing water quality impacts, sources of pollution, water pollution trends, and regulation.

FIGURE 9-12. **Water Quality Impact Environmental Indices for Each Strategy and Impact Area**

Strategy	Health-Ingestion	Water Supply & Waste Assimilation	Fish and Aquatic Life and Biodiversity
D - Reference	1.00	1.00	1.00
J	1.00	1.00	0.99
M	1.01	1.00	1.00
O	1.00	0.99	0.99
Q	1.01	0.99	0.99
R	1.01	1.00	1.00
S	1.01	1.00	1.00
T	0.92	0.99	0.96

Water indices have been developed for health-ingestion, water supply and waste assimilation, and fish and aquatic life and biodiversity.

As with air resource impacts, indices were developed to help characterize how alternative energy resources strategies may contribute to these impact categories. *Figure 9-12* shows these indices. TVA's final strategies are compared to the "No Action" strategy, which is the reference strategy for Energy Vision 2020 (Strategy D). As indicated, there are only slight differences among TVA's final seven strategies and Strategy D for most water resource impacts. Because less coal is burned under Strategy T (low-cost renewables) and coal use produces some water resource-related impacts, only this strategy shows a noticeable improvement with respect to potential impacts.

The water health by ingestion index uses three weighted measures: power production from nuclear, coal-fired, and peaking hydro. Hydro peaking and nuclear power production are constant for all seven final strategies, as well as the reference strategy. As a result, differences in coal-fired (existing plants) power production governs the index. Strategies M, Q, R, and S all have increased coal-fired power production from existing plants compared to the reference strategy. This results in index values slightly greater than 1.0.

A number of conclusions can be derived from Energy Vision 2020's assessment of potential water resource impacts. These include:

- The effects of damming rivers, including operation of existing hydroelectric units, is responsible for the more important water resource impacts. However,

since no new dams are proposed in the final strategies or the reference strategy, this impact is the same across all strategies.

- Increasing the capacity of TVA's existing hydroelectric plants is environmentally beneficial. This produces new capacity without constructing new plants. New plant construction, particularly a new hydroelectric dam, is more environmentally damaging. Also, new turbine designs used in increasing the capacity of existing hydroelectric plants incorporate technology that introduces oxygen into the water released through the turbine. This increases dissolved oxygen and helps combat the low dissolved oxygen problem that exists today below a number of TVA dams.
- TVA's existing coal-fired plants are responsible for most of TVA's contribution to water pollution. As described in the section on Air Resource Impacts, cost-effective repowering of selected less-efficient coal-fired units provides some of the best options for water quality.
- Repowering or adding capacity at any existing facility is preferable from a water resource perspective because it lessens the risk of impacts to these resources.

LAND RESOURCE IMPACT SUMMARY

The primary land resource issues for Energy Vision 2020 are potential changes in land use and impacts to land resources. Chapter 3 provides an overview of land resource issues and uses. Because land resource impacts tend to be so site-specific in nature, developing indices for such impacts was not helpful. Land resource impacts can be more fully and meaningfully evaluated when proposals to put specific energy resource options in place are made in the future. These impacts will be addressed in subsequent environmental reviews.

However, certain conclusions or observations can be made at this programmatic level of review based on the generic attributes of various energy resource options. *Figure 9-13* shows the estimated total acreage (land use) that would likely be affected by TVA's final strategies and Strategy D, the reference, "No Action," strategy. From the standpoint of land consumption, Strategy T uses the most land. This is due primarily to the extensive acreage that is needed to support wind turbines.

FIGURE 9-13. **Estimates of Direct Land Use for Plant Siting, Power Transmission, and Plant Access for Each Strategy**

Strategy	Megawatts (Year 2020)	Total Land Use (Acres)
D-Reference	16,037	10,883
J	16,456	17,711
M	14,765	16,299
O	15,406	16,080
Q	16,100	15,335
R	16,720	15,685
S	15,976	16,541
T	17,715	61,957

Other conclusions include:

- Resource options that involve expansions at existing plants or the repowering of existing units have little or no land resource impacts.
- The 2,000 megawatts of wind energy capacity in Strategy T is estimated to require 50,000 acres of land at high elevations where the wind resource tends to be found in or close to the TVA region. Wind turbines are also visually prominent and would have some of the most important aesthetic impacts among the various resource options.
- All of TVA's final strategies, including the reference strategy, expand TVA's use of coal. Coal mining and coal combustion waste disposal are two indirect land uses that have

undesirable land resource impacts. Total coal use rises about 35 percent for most strategies compared to current coal use. Only Strategy T is noticeably different, using about 12 percent less coal than the reference or, "No Action," strategy.

- There is sufficient land in the TVA region to allow energy resource options to be put in place without impacting sensitive land resources such as wetlands or endangered species. Land resources should not be a constraint on putting any of the energy resource options identified in TVA's final strategies in place, with the possible exception of wind turbines.

FIGURE 9-14. **Value of Flexibility**

Resource Type	Net Benefits $/MW-Year
PEAKING	
Inflexible combustion turbine (CT)	4,900
Call option (1-year contract)	5,000
Flexible combustion turbine (CT)	6,400
BASE LOAD	
Inflexible combined cycle (CC)	-21,500
Inflexible independent power producers (IPP)	-20,000
Inflexible integrated gasification combined cycle (IGCC)	-6,300
Flexible combined cycle (CC)	800
Flexible integrated gasification combined cycle (IGCC)	1,701
Call option (multi-year contract)	5,000
Call option (1-year contract)	7,000
BLN/coproduct	71,000

The net benefit of flexible options—both TVA-built and external—are greater than the net benefit of inflexible options.

Managing Risk—Hedging Uncertainties

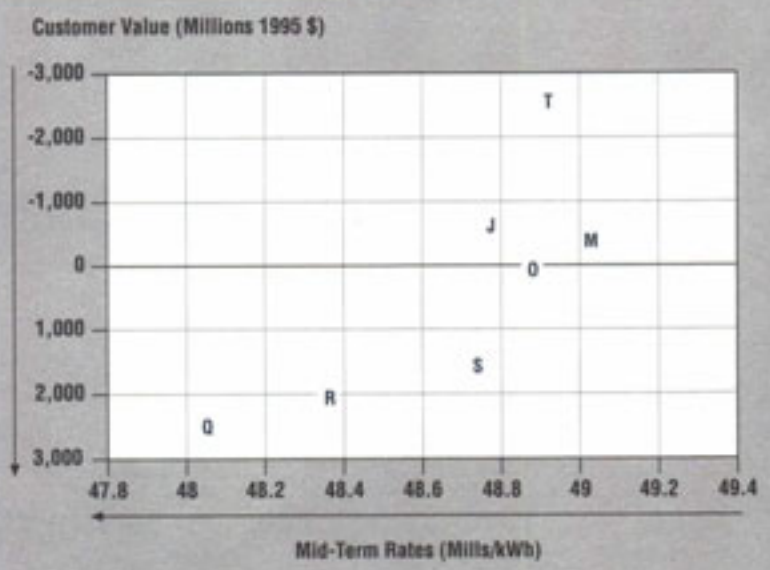
Energy Vision 2020 seeks to provide a robust and flexible set of resource strategies. Robust strategies successfully meet key evaluation criteria for a large range of uncertainties. Flexible options can provide TVA with the ability to respond or adapt to a changing environment as it moves into the 21st century.

Trade-off analysis was used to identify strategies that hedge uncertainties. A strategy hedges an uncertainty if it limits the risk of cost increases compared to other strategies. *Figures 9-14* through *9-21* illustrate the analysis done for the uncertainties of load growth, natural gas pricing, environmental regulations, and nuclear power performance.

UNCERTAINTY IN LOAD GROWTH

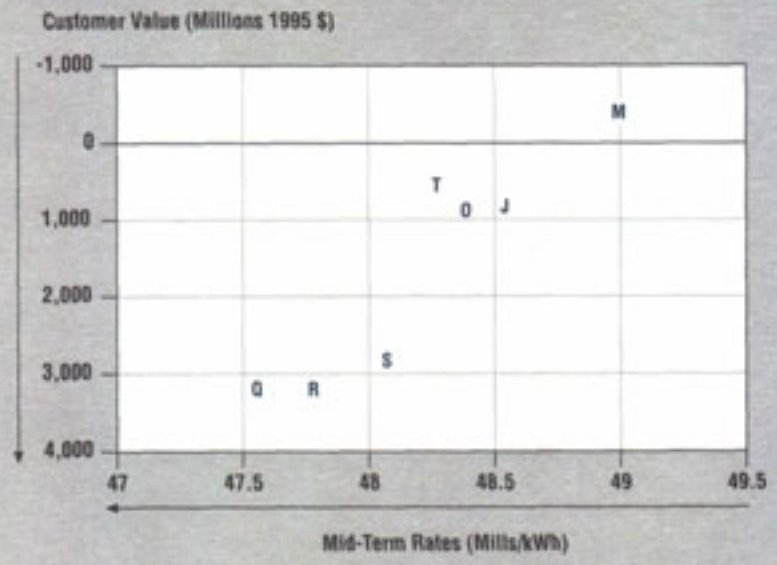
The range of forecasts of future load growth is quite large, indicating, for one, the uncertainty in future competitive conditions. Two strategies were developed that provide resource alternatives and are flexible in the face of uncertain load growth. Strategy Q contains call options on future power. Call options provide TVA the right to buy future power without obligation to buy from suppliers. TVA can buy the right to the power and decide at a later date whether to purchase it. Likewise, Strategy R contains flexible supply-side

FIGURE 9-15. **Value of Flexibility for Load Growth Uncertainty—High Load Growth**



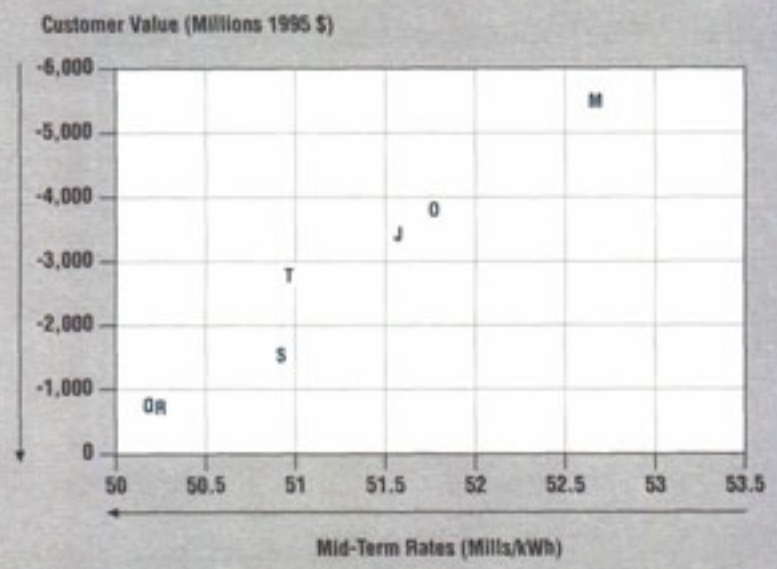
The flexible strategies (Q and R) have lower short-term rates and high value compared to the other key strategies.

FIGURE 9-16. **Value of Flexibility for Load Growth Uncertainty – Medium Load Growth**



The flexible strategies (Q and R) have lower short-term rates and high value with medium load growth as well as high load growth.

FIGURE 9-17. **Value of Flexibility for Load Growth Uncertainty – Low Load Growth**



The flexible strategies (Q and R) have lower short-term rates and high value with low load growth as well as medium and high load growth.

options that TVA would build. These TVA-built options have shorter lead times compared to the inflexible options. (An inflexible option results in significant cost penalties if construction is stopped.)

The net benefits of buying flexible options compared to resource alternatives that do not have flexibility are shown in *Figure 9-14*. The inflexible options, such as a combustion turbine, independent power producer, integrated gasification combined cycle plant, or clean coal plant tend to have negative net benefits. The flexible options for the peaking call option, base-load call option, and flexible integrated gasification combined cycle plant tend to have positive net benefits. Thus, the flexible options tend to have a higher value than the inflexible options.

Trade-off graphs for customer value and electric rates for high, medium, and low load forecasts are shown in *Figures 9-15, 9-16,* and *9-17*. In these graphs, the flexible strategies—Q and R—tend to have higher value and lower electric rates regardless of the load forecasts. Since these strategies include beneficial electrification, customer value is used as the measure of benefits and costs, rather than total resource cost. As a measurement, total value better captures the benefits and costs associated with increases in electricity consumption from beneficial electrification and variation in load growth.

UNCERTAINTY IN NATURAL GAS PRICES

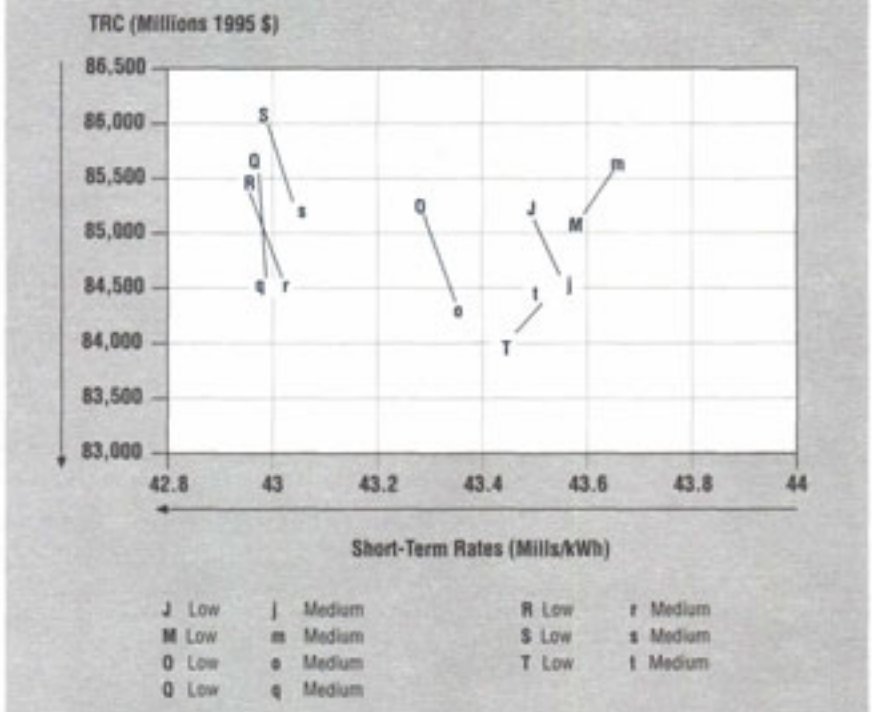
In trade-off analysis, the difference was examined between medium and low natural gas prices. *Figure 9-18* shows the analysis of strategies for the medi-

um and low natural gas prices. (In terms of uncertainty in natural gas prices, most of the public comments indicated TVA's natural gas price forecasts were too high. Recognizing those comments, TVA concentrated on the medium and low natural gas prices.) In *Figure 9-18*, the uncertainties other than natural gas were held at their mid-range values.

In the figure, low natural gas prices are shown in uppercase letters and medium natural gas prices are shown in lowercase letters. The line between the medium and low gas prices indicates the change in total resource cost for each strategy.

Strategies M and T contain clean coal technologies. With Strategy T, costs will increase less than for Strategy M with rising natural gas prices, since Strategy T also contains renewables. Flexibility to adapt to changing gas prices can be provided by including clean coal technologies and renewables in strategies. For example, TVA could build a combined cycle plant with natural gas as the fuel and, at a later time, add coal gasification if natural gas prices increase.

FIGURE 9-18. **Cost Risk Due to Uncertainty in Natural Gas Prices**



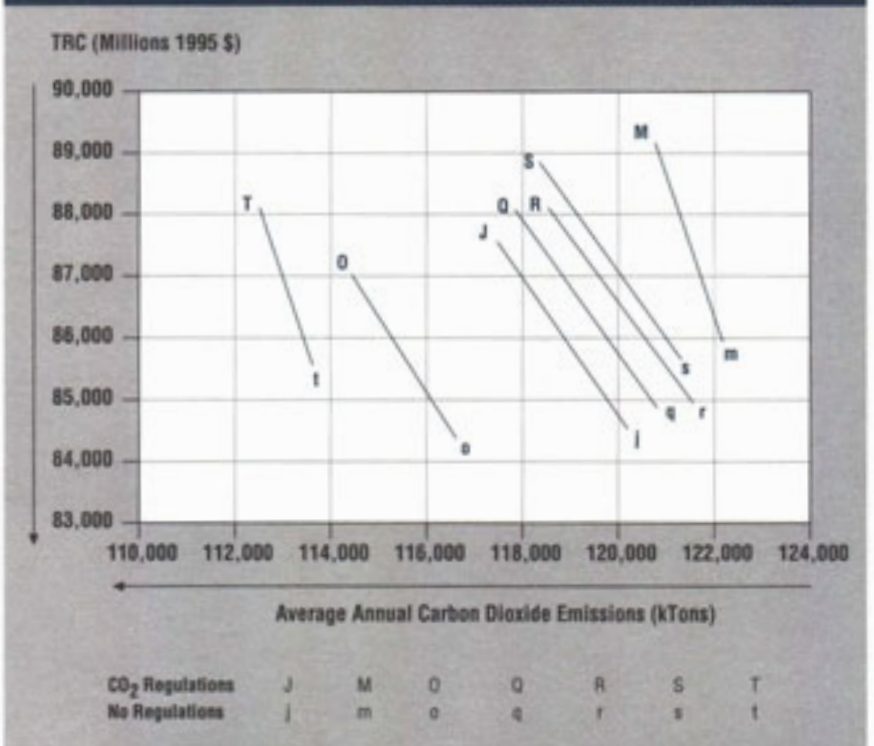
Low natural gas prices are indicated with uppercase letters and medium or higher natural gas prices are indicated with lowercase letters. The length of the line indicates the change in costs due to natural gas price variations.

Several strategies—particularly Strategies J, O, Q, R, and S—contain coal gasification with the production of a chemical coproduct. Chemical coproducts traditionally have been produced with natural gas; therefore, prices of coproducts are based on natural gas prices. High natural gas prices will result in higher prices of the chemical coproduct and lower costs for strategies that contain this option. In other words, for these strategies, higher natural gas prices result in lower costs. The chemical coproduct provides a hedge or offset to rising natural gas prices.

UNCERTAINTY IN CARBON DIOXIDE REGULATIONS

The mid-range future assumes there will be no additional carbon dioxide regulations. *Figure 9-19* illustrates the analysis of the change in costs and carbon dioxide emissions if there are regulations on carbon dioxide emissions. The analysis assumes, as a worst case, a cap on carbon dioxide emissions, with purchases and sales of carbon dioxide allowances at $10 per ton of carbon dioxide. (Carbon dioxide regulations have been modeled similar to current acid rain regulations, which permit buying and selling of sulfur dioxide allowances.)

FIGURE 9-19. **Low-Cost Risk Due to Carbon Dioxide Regulations**



Lowercase letters indicate costs and carbon dioxide emissions with no carbon dioxide regulations; uppercase letters indicate costs and emissions with carbon dioxide regulations. The length of the line indicates the increase in costs for carbon dioxide regulations.

The analysis indicates that the lower cost strategies are robust; they remain lower cost, even with carbon dioxide regulations. For example, Strategies J, O, Q, and R have relatively low costs without carbon dioxide regulations (lowercase letters) and low costs with carbon dioxide regulations (uppercase letters), compared to other strategies. These strategies are relatively robust because they contain options that have low carbon dioxide emissions or offset carbon dioxide emissions, such as natural gas-based combined cycle plant, fuel cells using landfill methane, renewables, and demand-side management options.

UNCERTAINTY IN AIR AND WATER QUALITY REGULATIONS

The mid-range future was based on current air and water regulations including compliance with the acid rain provisions of current Clean Air Act regulations. Additional air and water quality regulations could occur, which would increase the cost of compliance. The effect on selected strategies for additional air and water regulations is shown in *Figure 9-20.* Sulfur dioxide emissions are used to measure the impacts of both air and water regulations. Current regulations are shown in lowercase letters, and more stringent regulations are shown in uppercase letters. Strategies J, O, R, and Q have lower costs regardless of the uncertainty in air and water regulations.

For some strategies the lines connecting the no regulations case with the regulations case cross. For example, if one begins with a flexible approach such as with Strategy Q, both costs and sulfur dioxide emissions can be minimized with no regulations. With regulations, one might want to switch strategies to Strategy O, which contains more renewables to minimize emissions and costs.

UNCERTAINTY IN NUCLEAR PERFORMANCE

The uncertainty in nuclear performance is represented by variations in capacity factor, operation and maintenance costs, and the cost to complete the nuclear units. All of the strategies except for Strategy K assume that Watts Bar Unit 2 and Browns Ferry Unit 1 are kept in deferral status and canceled in the year 2000. Strategy K assumes that these two units will be kept in deferral status until 2000, at which time construction will resume. Strategy K also assumes that work

on Watts Bar Unit 2 and Browns Ferry Unit 1 would be completed in 2005 and 2006, respectively.

Three levels of nuclear performance were considered: poor, moderate and good. As indicated in the trade-off graph in *Figure 9-21*, with moderate or poor performance, the lowest cost strategy—Strategy D, the reference case—defers and cancels both nuclear units. With good nuclear performance, the lowest cost strategy—Strategy K—defers and then completes the nuclear units.

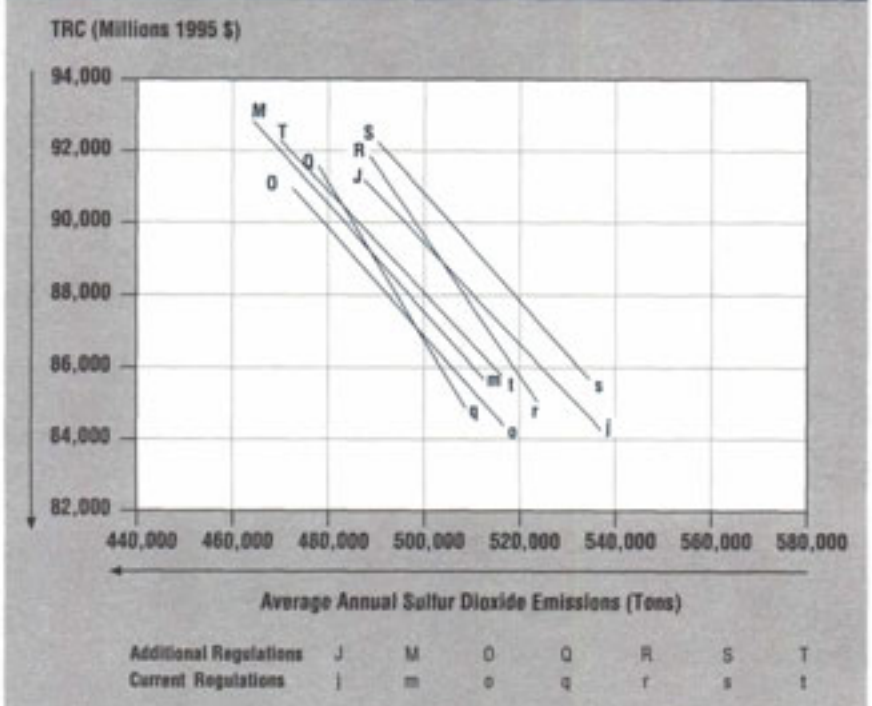
Final Evaluation

A summary of strategy evaluations according to customer value, total resource cost, short-term rates, environment, debt, and economic development, and five uncertainties—load growth, natural gas prices, environmental regulations, nuclear performance, and customer services effectiveness—is illustrated in *Figure 9-22*. Note that the environmental uncertainty combines the uncertainty in carbon dioxide regulations and additional air and water regulations.

After evaluation, seven strategies have emerged that offer lower cost, lower debt, better value, and improved environmental performance and economic development impact, compared to the other strategies. These strategies are as follows:

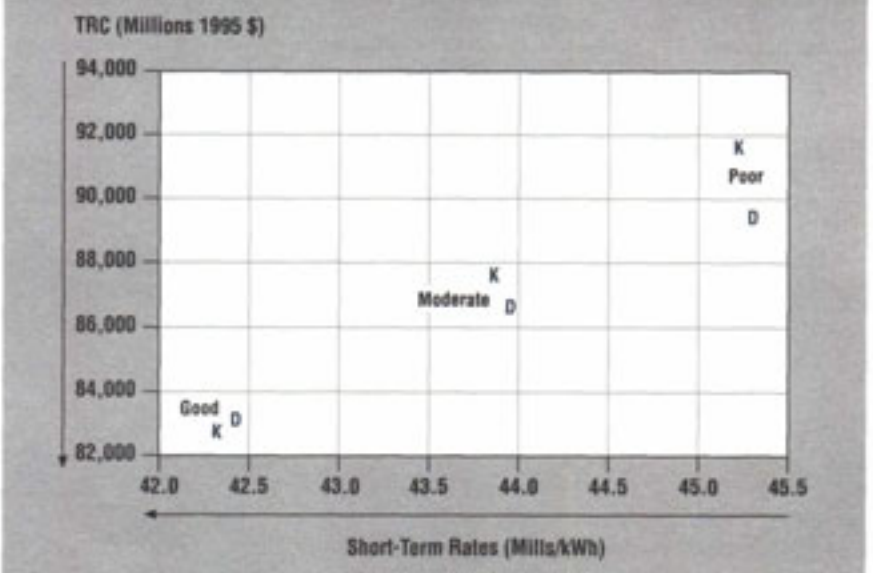
- Strategy J - Bellefonte Coproduct, Renewables, Independent Power Producers
- Strategy M - Combined Demand-Side Management and Off-System Sales
- Strategy O - Bellefonte Coproduct,

FIGURE 9-20. **Cost Risk Due to Additional Air and Water Regulations**



Current air and water regulations are indicated with lowercase letters, and additional air and water regulations are indicated with uppercase letters. The length of the line indicates the cost risk to additional air and water quality regulations.

FIGURE 9-21. **Cost Risk Due to Nuclear Performance Uncertainty**



Nuclear performance uncertainty represents three uncertainties: operation and maintenance cost, capacity factor, and cost to complete construction. Cost and rates are shown for poor, moderate, and good nuclear performance. Except for good nuclear performance, completing Watts Bar Unit 2 and Browns Ferry Unit 1 leads to higher costs.

FIGURE 9-22 Strategy Performance Matrix

Strategy	CRITERIA						UNCERTAINTY				
	Value	Cost	Rates	Environ.	Debt	Econ. Dev.	Load Growth	Natural Gas Prices	Environ. Reg.[1]	Nuclear Perf.	Customer Service Effective-ness
A Minimum CO_2—Natural Gas Repowering of Existing Coal	Poor	Poor	Poor	Good	Good	Poor					
B Min CO_2—Natural Gas Repowering of Existing Coal and Renewables	Poor	Mod.	Poor	Good	Good	Poor			Hedge		
C Low-Cost Producer (Coal-Based)	Good	Mod.	Good	Poor	Good	Mod.		Hedge			
D Reference	Good	Mod.	Poor	Poor	Good	Poor					
E Maximum Customer Value Index—Off-System Sales, High BE, Declining Block Pricing	Good	Poor	Mod.	Poor	Mod.	Mod.	Hedge	Hedge			
F Low TRC, High DSM	Poor	Good	Poor	Good	Good	Mod.		Hedge			
G Maximum Sales	Good	Poor	Good	Poor	Mod.	Mod.	Hedge				
H Maximum Capacity Diversity	Mod.	Mod.	Mod.	Poor	Good	Mod.			Hedge		
I Bellefonte Nuclear Partnership	Mod.	Mod.	Good	Mod.	Mod.	Mod.			Hedge	Hedge	
J Bellefonte Coproduct, Renewables, IPPs	Mod.	Good	Mod.	Mod.	Good	Good		Hedge	Hedge		
K Defer and Build WBN Unit 2 and BFN Unit 1	Poor	Mod.	Mod.	Mod.	Mod.	Poor				Hedge	
L Minimum CO_2 with Less DSM	Poor	Poor	Poor	Good	Good	Poor			Hedge		
M Combined DSM and Off-System Sales	Mod.	Good	Mod.	Mod.	Good	Mod.		Hedge			
N Decentralized Generation with More Renewables	Mod.	Poor	Mod.	Mod.	Good	Poor			Hedge		
O Bellefonte Coproduct, More DSM, More Off-System Sales	Good	Good	Good	Mod.	Good	Good		Hedge	Hedge		Hedge
P Low-Cost Renewables, Low-Price DSM, Repowering	Mod.	Mod.	Mod.	Good	Good	Mod.					
Q Flexible with External Options	Good	Good	Good	Mod.	Good	Good	Hedge	Hedge	Hedge		
R Flexible with Internal Options	Good	Good	Good	Mod.	Good	Good	Hedge	Hedge	Hedge		
S Low Cost, Low Rates, Improved Environment	Good	Good	Good	Mod.	Good	Good		Hedge	Hedge		
T Low-Cost Renewables, Low-Price DSM, Repowering, BLN Coproduct Partnership	Good	Good	Good	Good	Good	Good		Hedge	Hedge		
U Low-Cost Renewables, More DSM, Repowering, BLN Coproduct Partnership	Good	Good	Mod.	Good	Good	Good		Hedge	Hedge		

[1] Includes uncertainty in air, water, and CO_2 regulations

The evaluation of strategies is summarized qualitatively for key evaluation criteria and for the key uncertainties. The qualitative assessment was based on a ranking of the strategies with "good" representing the upper third; "moderate," the middle third; and "poor," the lower third.

More Demand-Side Management, More Off-System Sales
- Strategy Q - Flexible Strategy with External Options
- Strategy R - Flexible Strategy with Internal Options
- Strategy S - Low Cost, Low Rates, Improved Environment
- Strategy T - Low-Cost Renewables, Low-Price Demand-Side Manage- ment, Repowering, Bellefonte Coproduct Partnership

These strategies also provide hedges against the key uncertainties that allow TVA to manage risks.

The Long-Term Plan – Preferred Alternative

Energy Vision 2020 integration results are captured in the long-term plan. The plan sets forth a range of actions TVA can take to meet future needs of its customers.

In developing the long-term plan, TVA has selected a portfolio (also referred to as a bundle) of resource options from the seven key strategies. All of the resource options contained in the seven strategies are included in the portfolio. Much like a portfolio of stocks is chosen to manage risk and accomplish specific objectives, the portfolio of resource options enables TVA to meet customer needs at an acceptable level of risk and meet the objectives of balancing costs, rates, environmental impact, debt, and economic development.

When TVA refers to "balancing" the "environment" or "environmental impacts" in the context of these objectives it is referring to costs of meeting environmental requirements, the consequences of environmental uncertainties, and environmental impacts, expressed both quantitatively and qualitatively, of proposed actions or strategies.

To manage risk, the portfolio provides a robust and flexible set of resource options. Options that are robust can withstand a large range of uncertainties. Flexible options can be altered or modified as TVA moves into the 21st century. Robust and flexible options were identified in the analysis of managing risk.

The long-term plan is presented in *Figure 9-23*. As illustrated, a portfolio of resource options (taken from seven strategies) provides for TVA's supply-side (peaking and base load), customer service, and environmental requirements.

For example, combustion turbines, purchases of peak power, and call options on peaking power will supply peaking power for 1996-2005. For 2005-2020, compressed air energy storage is added as a supply-side peaking option.

Nine options supply base-load power for 1996-2005. These include call options on base-load power, improvements to existing hydro system, combined cycle plant with pre-siting and engineering, purchases from independent power producers with and without cogeneration, combined cycle repowering of coal-fired plants, renewables—landfill methane and refuse-derived fuel, coalbed methane, Bellefonte or greenfield coal gasification and coproducts with partners, and an additional coal-fired unit at Shawnee Fossil Plant.

FIGURE 9-23. Long-Term Plan

This long-term plan is defined to meet key objectives. The plan is organized by supply-side options for the short term (1996 – 2005) and the long term (2006 – 2020), customer service options and actions which hedge key uncertainties.

Develop a preferred portfolio of resource options for the long term from key strategies. Objectives of the portfolio are:

1. Balance costs, rates, environment, debt, and economic development.
2. Provide a robust set of resource options or flexibility to adapt to uncertain load growth, future market prices, changes in environmental regulations, and changes in market regulations to manage risk.

Strategies

- J – Bellefonte Coproduct, Renewables, IPPs
- M – Combined DSM and Off-System Sales
- O – Bellefonte Coproduct, More DSM, More Off-System Sales
- Q – Flexible Strategy with External Options
- R – Flexible Strategy with Internal Options
- S – Low Cost, Low Rates, Improved Environment
- T – Low-Cost Renewables, Low-Price DSM, Repowering, Bellefonte Coproduct Partnership

Options		1996 –2005	2006 –2020
Supply	Peaking	• Combustion turbines, purchases of peak power, and call options on peaking power	• Compressed air energy storage (CAES)
	Base Load	• Call options on base-load power • Improvements to existing hydro system • Combined cycle with pre-siting and engineering • Purchases from independent power producers with and without cogeneration • Combined cycle repowering of coal-fired plants • Renewables—landfill methane and refuse-derived fuel • Coalbed methane • Bellefonte coal gasification and coproducts with partners • Additional coal unit at Shawnee • Improvements in existing system • Nuclear partnership	• Wind turbines • Coal refinery • Cascaded humidified advanced turbine (CHAT) • Integrated gasification combined cycle (IGCC) • Integrated gasification with CHAT (IGCHAT)
Customer Service		• DSM—low price and cost (examples of programs)	• Residential new construction • Commercial and industrial comprehensive finance • Industrial motors
		• Beneficial Electrification (examples of programs)	• Residential heating, air conditioning, and water heating • Commercial cooking • Industrial electrotechnologies
		• Flexible DSM and Beneficial Electrification	
Environmental		• Pursue a flexible strategy of fuel switches, scrubbers • Global climate challenge—improvements to existing system, biomass cofiring	

RESOURCE ALTERNATIVES TO MANAGE RISK

Uncertainty	Options
• Load Growth	• Call options on purchases from external suppliers • Flexible internal supply options • Small modular options—landfill methane, coalbed methane, and distributed resource alternatives • Flexible DSM options
• Natural Gas Prices/Coproduct Prices	• Integrated gasification combined cycle (IGCC) • Integrated gasification cascaded humidified advanced turbine (IGCHAT) • Bellefonte coal gasification with a chemical coproduct
• Environmental Regulation—Air, Water, CO_2 Regulation	• Renewables—wind, landfill methane, biomass • Coalbed methane • Aggressive DSM and beneficial electrification • Natural gas-based resource alternatives

Base-load power for 2005-2020 will be supplied by wind turbines, a coal refinery, the cascaded humidified advanced turbine (CHAT), an integrated gasification combined cycle plant, and integrated gasification with CHAT.

In the short- and long-term, TVA will rely on demand-side management and beneficial electrification. Examples of demand-side management include energy efficiency improvements, residential new construction and commercial and industrial finance plans to improve demand-side management. Examples of beneficial electrification include residential heating, air conditioning and water heater programs; commercial cooking programs; and industrial electrotechnology programs.

A flexible strategy of fuel switches and scrubbers, along with system improvements addressing global climate changes and biomass cofiring, are the long-term environmental control options.

In addition, 10 options address 3 key uncertainties: load growth, price of natural gas and coproducts, and environmental regulations.

Call options from external suppliers, flexible internal supply options, and small modular options like landfill methane, coalbed methane, distributed resource alternatives, and flexible demand-side management address load growth uncertainty.

Three options address uncertainty in natural gas and coproduct prices, including an integrated gasification combined cycle plant, integrated gasification cascaded humidified advanced turbine, and Bellefonte coal gasification with a chemical coproduct.

Renewables—wind, landfill methane, and biomass; natural gas-based resource alternatives; coalbed methane; repowering of existing coal-fired plants; and aggressive demand-side management and beneficial electrification address environmental regulations.

The long-term plan or portfolio provides resource options that are largely derived from the seven best strategies previously identified. These resource options will be implemented as necessary to meet customer needs. Thus, this long-term plan also provides for low cost, low debt, low electric rates, improved environment, and high economic development compared to all strategies.

The long-term portfolio is compared to all strategies for the key criteria in *Figure 9-24*. For example, the range of total resource costs for all strategies is from $84.2 to $89.2 billion. The long-term portfolio has a range at the lower end of this range of $84.2 to $85.6 billion. Thus, the long-term portfolio results in the best values for the key criteria.

FIGURE 9-24. **Long-Term Plan – Range of Values for Criteria**

	All Strategies	Long-Term Portfolio
Total Resource Costs (Billions of $)	$84.2 – $89.2	$84.2 – $85.6
Total Debt in 2001 (Billions of $)	$26.7 – $28.8	$26.7 – $27.2
Short-Term Rates (Mills/kWh)	42.5 – 45.7	42.8 – 43.4
Annual Average CO_2 Emissions (Millions of Tons)	101.0 – 138.0	115.0 – 121.6
Personal Income (Millions of $)	$1,100 – $2,770	$2,240 – $2,770
Customer Value (Millions of $)	$-4,100 – $4,100	$-400 – $3,510

ENVIRONMENTAL IMPACTS OF PORTFOLIO ALTERNATIVE

As explained earlier in this chapter, TVA has identified a portfolio of options—taken from the seven final strategies—as its preferred strategy for the long-term plan. Thus, potential impacts depend on those options eventually implemented. Although the impacts cannot be definitively assessed, the impacts of the seven final strategies are likely to provide the boundaries—best and worst case—for the portfolio.

Concerning the environment, it is unlikely that implementation of portfolio options would achieve better or worse environmental performance than the range of impacts for the seven strategies. In any event, impacts of the portfolio are likely to be much less than those associated with the "No Action" alternative, Strategy D.

All the options included in this portfolio are available to TVA management. The specific choices recommended to TVA for implementation are included in the short-term action plan presented in the next chapter.

Chapter Ten

Short-Term Action Plan

Chapter Ten: Short-Term Action Plan

The short-term action plan identifies specific actions to meet TVA's customer needs from 1996-2002. The short-term action plan is derived from the portfolio of options presented in the long-term plan, which was discussed in the preceding chapter.

The short-term action plan relies heavily on flexible supply-side and demand- side resources. These resources meet Energy Vision 2020 criteria and manage risk by providing flexibility in the face of uncertain load growth and other factors.

Because the future usually does not turn out as expected, the short-term action plan will need revisions as TVA learns more about the future. The long-term plan provides the guidance and flexibility to do this.

This Chapter Includes:

- Development of the Plan
- Description of the Plan
- Implementation of Resource Options
- Investigation/Research and Development (R & D)
- TVA's Compliance with Environmental Regulations

  Will Provide a Safety Net

Short-Term Action Plan

Development of the Plan

TVA has developed a short-term action plan from the long-term plan described in the last chapter. The short-term action plan incorporates actions TVA will take over the next three years to meet customer needs from 1996-2002. For customer needs after 2002, TVA has the time and the opportunity to choose among many of the resource options in the long-term plan. Thus, no short-term actions are necessary at this time to meet the needs after 2002.

The short-term action plan incorporates resource options from several strategies and identifies specific TVA actions to meet customer needs from 1996-2002.

The actions recommended for implementation in the short-term action plan *(Figure 10-1)* are derived from the portfolio (see Chapter 9). The short-term action plan relies heavily on the flexible strategies.

A number of different criteria were used in the evaluation of energy resource strategies in Energy Vision 2020. These included long-run cost/value, rates, reliability, environment, economic development, financial requirements, risk management, and equity among rate classes. As can be seen in the trade-off graphs in Chapter 9, Figures 9-4 through 9-10, many strategies were considered in trying to create a balance among all the evaluation criteria. The long-term and short-term resource plans achieve this balance.

The short-term strategy is based on the implementation of flexible resource options due to the large uncertainty in future load growth. There were concerns expressed in the planning process about whether the load forecast is too high and about the large uncertainty in future load growth. By implementing flexible resource options, if load growth is low (no growth) then these options will not be purchased, but if load growth is higher, these resource options can be implemented.

The customer service options in the short-term action plan are based on new and expanded demand-side management programs including energy efficiency, load management, and beneficial electrification.

TVA has identified customer service options in the short-term action plan for immediate full scale implementation or for implementation as flexible demand-side management options. The flexible demand-side management options will be implemented at a reduced scale at first, but can ramp up quickly in response to resource needs. Through actions taken in the short-term action plan, TVA will be developing a marketing infrastructure along with knowledge of program concepts, technologies, and delivery strategies to enable TVA to meet changing market conditions. TVA will build capabilities and develop partnerships with distributors and trade allies to deliver large scale demand-side management programs as needed. Full-scale and flexible programs implemented in the short-

FIGURE 10-1. **Short-Term Action Plan**

Short-Term Actions—Supply-Side	Milestones
Purchase Call Options	
• Base-Load Coverage - 2001–2002	Implement up to 3,000 MW
• Winter and Summer Peaking Coverage - 1998–2002	
Hydro Modernization Projects	
• Invest in hydro modernization projects between 1996–2007	Achieve 150 MW
Bellefonte Nuclear Plant Conversion to Combined Cycle Plant	
• Converting the Bellefonte Nuclear Plant to a combined cycle plant utilizing natural gas or gasified coal as the primary fuel has been identified as one of the most viable alternatives. Such an alternative provides the opportunity to utilize a substantial portion of the Bellefonte non-nuclear plant equipment. However, there is a degree of uncertainty and market risk associated with this alternative which requires further in-depth engineering and financial examination. Accordingly, TVA will use an outside, independent team of technical and financial experts to assess and develop the Bellefonte conversion strategy more fully over the next 18 to 24 months. During the course of the study, TVA will also pursue the evaluation and development of a demonstration gasification plant with the Department of Energy. In the meantime, the Bellefonte plant and Watts Bar Nuclear Plant Unit 2 will continue in a deferred status. TVA will continue to be receptive should outside entities propose an acceptable financial arrangement to complete these units as nuclear facilities in partnership with TVA.	18–24 month study
• Browns Ferry Nuclear Plant Unit 1 will continue in its inoperative status.	
Renewables	
• Implement cost-effective biomass cofiring	
- Cofiring precommercial demonstration runs at existing TVA coal-fired plants	1996
- Initiate first commercial wood waste cofiring project operation	1997
• Investigate biomass energy facilities	1996–97
• Implement a flexible wind project	1996–97
• Determine coalbed methane resources feasibility	1996–97
• Inventory sites suitable for landfill methane	1996
• Initiate 25-kW landfill methane fuel cells pilot	1997–98
Additional Capacity Development	
• Acquire three sites and develop preliminary engineering modules suitable for coproduction, combined cycle, combustion turbines, cascaded humidified advanced turbines, and compressed air energy storage	1996–1998
• Investigate cogeneration and other unique energy supply arrangements	1996
Implement a Flexible Phase II Acid Rain Strategy	
• Strategy/Plan Definition	1996
• Initiate early implementation options	1996–97

term action plan will provide the foundation of programs that can be relatively quickly scaled up or down as conditions warrant.

TVA has included all of the demand-side activities in the low price block (Block 1) in the short-term action plan. In addition, TVA included options from Blocks 2 and 3 in the short-term action plan to address lost opportunities (energy-efficient new homes) and to promote market transformation (heat pump water heater, manufactured housing, home self-audit, and student self-audit). Equity among customers is addressed through a flexible program to improve the energy efficiency of low income housing.

FIGURE 10-1. **Short-Term Action Plan** *CONTINUED*

Short-Term Actions—Customer Services	Milestones
DEMAND-SIDE SAVINGS	Up to 650 MW - 2002, Up to 2,200 MW - 2010
Residential	
Full Scale Programs	Revisions in Place
• Heat Pump Leasing / Financing	1996–97
• Ground Source Heat Pump Leasing	1996–97
• New Homes Program	1996–97
• Manufactured Housing - New Construction	1996–97
• Residential Self-Audit	Launch 1996–97
• Load Management	Revisions in Place
- Air Conditioners	1996–97
- Water Heaters	1996–97
Flexible Residential Demand-Side Programs for Selected Market Segments	Launch Phase 1
• Efficiency Products Catalog - Mail Order	1997
• Lighting Products Retail Component	1997
• Low Income Program - Site Visit	1997
• Student Self-Audit - Schools Environmental	1997
• Heat Pump Water Heater Initiative	1997
Commercial and Industrial	
Full Scale Programs	Launch 1996–97
• Commercial and Industrial Energy Services	1996–97
- Comprehensive Measures Financing	1996–97
- Commercial New Construction	1996–97
- Commercial Lighting	1996–97
- Commercial Appliances	1996–97
- Industrial Process Energy Efficiency	1996–97
- Industrial High Efficiency Motors	1996–97
• Commercial Cool Storage	1996–97
Flexible Commercial and Industrial Programs	Launch Phase 1
• Commercial Group Load Curtailment	1997
• Commercial Rooftop Cool Storage Program	1997
BENEFICIAL ELECTRIFICATION	
Residential	
• HVAC and Water Heating applications to improve consumer value	1996–97
• Initiate Flexible Security Lighting and Lawn Mower Programs	Launch 1997
Commercial and Industrial	
• Commercial Space Conditioning and Water Heating	Launch 1996–97
• Commercial Cooking and Security Lighting	Launch 1996–97
• Industrial Electrification Programs for Processing Heating, Food Processing, and Environmental Technologies	Launch 1996–97
• Flexible Industrial Electrification Options for Curing & Drying applications and Textile processes	Launch Phase 1 - 1997
General Research and Development	
• Develop telecommunication supported demand-side management programs	Launch 1996
• End-use renewables, market transformation, load management new technologies, targeted distributed generation, photovoltaics, electric vehicles	Launch 1996–97

The beneficial electrification options are designed to increase customer value, enhance economic development, and improve the environment. Such activities include industrial electrotechnologies and electric transportation.

In the longer term, the short-term action plan emphasizes research and development of renewable resource options in addition to clean coal technologies. Renewables research will include evaluation of biomass cofiring, wind resource investigations, investigation of landfill and coalbed methane potential, end-use photovoltaics, and distributed generation technologies including fuels cells and targeted demand-side management. Of course, in the long term, after 2002, there is sufficient time and flexibility to make any decisions, and no commitments are being made for resources after 2002 in the short-term action plan.

Description of the Plan

The short-term action plan is organized into two areas:

- Implementation of Resource Options
- Investigation/Research and Development (R&D).

Supply-side and customer service options are identified for each area. The short-term action plan is illustrated in *Figure 10-1.*

Implementation of Resource Options

To supply power, the short-term action plan identifies the following actions:

- Buying call options, including base load in 2001–2002 and peaking for winter and summer in 1998–2002.
- Converting the Bellefonte Nuclear Plant to a combined cycle plant utilizing natural gas or gasified coal as the primary fuel has been identified as one of the most viable alternatives. Such an alternative provides the opportunity to utilize a substantial portion of the Bellefonte non-nuclear plant equipment. However, there is a degree of uncertainty and market risk associated with such an alternative which requires further in-depth engineering and financial examination. Accordingly, TVA will use an outside, independent team of technical and financial experts to assess and develop the Bellefonte conversion strategy more fully over the next 18 to 24 months. During the course of the study, TVA will also pursue the evaluation and development of a demonstration gasification plant developed with the Department of Energy. In the meantime, the Bellefonte plant and Watts Bar Nuclear Plant Unit 2 will continue in a deferred status. TVA will continue to be receptive should outside entities propose an acceptable financial arrangement to complete these units as nuclear facilities in partnership with TVA.
- Browns Ferry Nuclear Plant Unit 1 will continue in its inoperative status.
- Investing in siting and pre-engineering for a coproduction facility, a com-

bined cycle facility, combustion turbines, cascaded humidified advanced turbines and compressed air energy storage systems. Three sites, in the western part of the TVA system, will be developed for this generation.

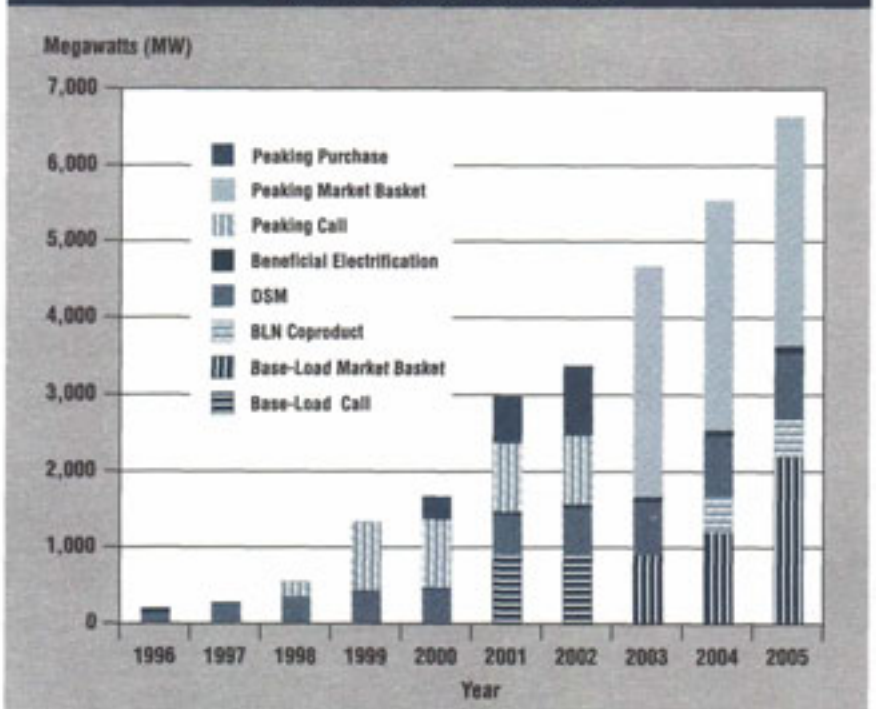
- Modernizing TVA's hydro plants.
- Perform cost-effective biomass cofiring.
- Implement a flexible plan for Phase II acid rain compliance.

A summary of the annual resource additions that meet customer needs from 1996-2005 are shown in *Figure 10-2*.

In the short-term action plan, TVA will implement three types of customer service options—demand-side management, beneficial electrification, and off-system sales. The demand-side management options to be implemented immediately are:

- A Heat Pump/Ground Source Heat Pump program that promotes quality installations of higher efficiency heat pumps by offering customers financing or leasing options and maintenance contracts.
- A Residential New Construction program that promotes higher efficiency standards and quality construction in new homes through incentives for homebuilders.
- A Manufactured Housing program that transforms the market by promoting installation of efficient heating, ventilation, air conditioning, and water heating equipment, proper duct design, and improved duct insulation by manufacturers during construction.
- A Residential Self-Audit program that provides homeowners a method to conduct their own home survey and receive a detailed computerized analysis identifying energy efficiency opportunities.
- A Residential Air Conditioner and Water Heater Load Management program that uses a radio control system to cycle water heaters and air conditioning load to reduce power system demand during times of peak electrical usage.
- A Commercial Cool Storage program that promotes thermal energy storage technologies to shift energy use from on-peak periods to off-peak periods.
- The Comprehensive Measures Financing option was expanded to over twice its original level to form the Commercial and Industrial Energy Services option. This option

FIGURE 10-2 **Short-Term Actions**



Short-term actions for both supply and customer services are indicated annually from 1996 to 2005.

provides project management services, technical assistance, and financing. The original option was targeted to building retrofits. The expanded option combines parts of the technology replacement options (Lighting, Appliances, High-Efficiency Motors), the Commercial New Construction option, and the Industrial Process Energy Efficiency options in a financing program. This allows TVA to capture much of the commercial and industrial energy efficiency potential in Block 2. This program includes targeted incentives directed to lost opportunity projects such as new construction or chiller replacements. The program will promote market transformation by providing trade ally incentives for architects and engineers to design energy-efficient buildings and to equipment dealers (e.g., motor dealers) to stock and sell high-efficiency equipment.

The plan calls for eight flexible customer service programs: six demand-side management programs and two beneficial electrification programs. The demand-side management programs include:

- A Residential Heat Pump Water Heating program that offsets the up-front cost of high-efficiency water heating technologies by offering residential customers financing or leasing options.
- A Residential Student Audit program that presents the self-audit package to students to conduct a home audit and to create greater understanding of the benefits of energy efficiency.
- A Low Income program that works with government agencies and community action agencies to directly install low-cost efficiency measures for participants in their homes.
- A Catalog and Retail Sales program that is designed to transform the market for high-efficiency lighting products, security lighting, and other efficient electric appliances through a catalog and in cooperation with participating retail outlets.
- A Commercial Rooftop Cool Storage program that promotes an emerging thermal storage technology that reduces customer equipment costs and shifts energy use from on-peak periods to off-peak periods. Initially, the program will focus on the development and commercialization of the rooftop cool storage technology. TVA is currently demonstrating this technology within the Valley.
- A Commercial Group Load Curtailment program that provides bill credits to commercial customers, or groups of customers, who are able to reduce demand for electricity by 100 kilowatts or more during peak demand hours.

In the short term, the demand-side management activities were grouped into four areas:

- Expansion of existing programs (Heat Pump/Ground Source Heat Pump program)
- Peak clipping or reduction (Residential Air Conditioner and Water Heater Load Management and Commercial Cool Storage programs)
- Energy efficiency improvements for lost opportunities (Residential New

Construction, and Commercial and Industrial Comprehensive Financing programs)

- Market transformation opportunities (Manufactured Housing program, Residential Self-Audit program, and the Commercial and Industrial Comprehensive Financing program)

A primary objective common to all programs is to increase public awareness of the benefits of energy efficiency and to provide consumers and trade allies with information on energy-efficient building equipment and practices. All programs will include promotional activities and educational components which support this important objective.

The long-term plan contains demand-side management options largely from demand-side management Blocks 1 and 2. The short-term plan contains almost all of the demand-side management programs identified in Blocks 1 and 2 with two options identified in Block 3. The specific programs included in the short-term plan compared to the demand-side management blocks are shown in *Figure 10-3*.

FIGURE 10-3. **Demand-Side Management in Short-Term Action Plan**

	OPTIONS CONSIDERED MW in 2010	SHORT-TERM ACTION PLAN MW in 2010	Recommended Action
Block 1			
Commercial Cool Storage	120	120	Flexible DSM
Rooftop Cool Storage	93	93	Flexible DSM
Commercial Group Load Curtailment	242	242	Flexible DSM
Residential Load Management - Air Conditioning	53	53	Immediate Implementation
Residential Existing Load Management - Air Conditioning	0	0	Immediate Implementation
Residential Existing Load Management - Water Heating	0	0	Immediate Implementation
Residential Heat Pump Leasing Program	518	518	Immediate Implementation
Residential Efficiency Products Catalog	107	107	Flexible DSM
Industrial Technology - High Efficiency Motors	14	14	Implemented w/C&I Energy Services
Residential Lighting Products - Retail Component	103	103	Flexible DSM
Comprehensive Measure Financing	170	170	Implemented w/C&I Energy Services
Residential Ground Source Heat Pump Leasing	62	62	Immediate Implementation
Total MW - Block 1	**1,482**		
Block 2			
Residential Self-Audit	19	19	Immediate Implementation
Residential New Homes	184	184	Immediate Implementation
Commercial Technology Rebates - Lighting	511	75	Implemented w/C&I Energy Services
Residential Low Income Program	75	75	Flexible DSM
Residential Load Management - Water Heaters	84	84	Immediate Implementation
Commercial New Construction	188	40	Implemented w/C&I Energy Services
Commercial Technology Rebates - Appliances	69	22	Implemented w/C&I Energy Services
Refrigerator Turn-In	13		
Residential Student Self-Audit	23	23	Flexible DSM
Small Commercial Retrofit	98		
Total MW - Block 2	**1,264**		

FIGURE 10-3. **Demand-Side Management in Short-Term Action Plan** *CONTINUED*

	OPTIONS CONSIDERED MW in 2010	SHORT-TERM ACTION PLAN MW in 2010	Recommended Action
Block 3			
Residential Load Management - SCADA	0		
Comprehensive Measure Rebates	311		
Industrial Energy Efficiency - Distributor Served	190	20	Implemented w/C&I Energy Services
Industrial Energy Efficiency - Direct Served	169	20	Implemented w/C&I Energy Services
Industrial Technology Rebates - Adj. Speed Drives	6		
Energy Efficient Pricing (opt-out)	56		
Residential Heat Pump Water Heating Leasing	103	103	Flexible DSM
Residential Direct Install	386		
Commercial Technology Rebates - HVAC	223		
Residential Manufactured Housing Program	53	53	Immediate Implementation
Total MW - Block 3	**1,497**		
Block 4			
Residential Load Management - New Technology	0		
Commercial HVAC Maintenance Program	26		
Residential Heat Pump Loans	469		
Residential Efficient Air Conditioning	133		
Residential Heat Pump Rebates	527		
Residential Load Management - Storage Water Heaters	39		
Industrial Technology Rebates - Comp. Air Eff.	4		
Residential Appliance Rebates Program	41		
Residential Low Income Weatherization Program	6		
Residential Solar Water Heater Program	4		
Commercial New Construction - Renewables	40		
Total MW - Block 4	**1,289**		
Total DSM Impact - 2010	**5,532**	**2,200**	

The demand-side management programs included in the short-term plan are of two types: First, those that are to be immediately implemented or are expansions of existing programs. These programs will result in a demand savings of 600 megawatts by 2002 and 1,450 megawatts by 2010. Second, flexible demand-side management programs have been identified. The programs are similar to the flexible supply-side options. These flexible demand-side programs have two phases of development. In the first phase, the programs are tested in the marketplace as experiments or pilot programs. The second phase would be full implementation and would occur if the first phase proves cost-effective and there is a need for the demand savings on the power system. The flexible demand-side management programs would add 50 megawatts by 2002 and potentially 750 megawatts by 2010. In the short-term action plan the total demand savings is expected to be 650 megawatts by 2002 and 2,200 megawatts by 2010 if all flexible demand-side management programs are implemented.

Beneficial electrification options are included in the short-term action plan to encourage energy efficiency and reduce peak demands on the power system, but at the same time minimize the impact on electric rates.

The four beneficial electrification options to be implemented immediately are:

- A Residential Heating and Air Conditioning program that promotes high-efficiency heat pumps as an alternative to equipment using other fuels.
- An Industrial Electrotechnologies program that promotes selected electrotechnologies to industrial customers to enhance competitiveness and address environmental concerns. This program will target the food process industry and will also promote electrotechnologies to improve process heating and to provide environmental solutions.
- A Commercial Heating and Air Conditioning program that promotes high-efficiency electric heating, ventilation, and air conditioning equipment as an alternative to equipment using other fuels.
- A Commercial Cooking program that promotes high-efficiency electric cooking equipment to commercial customers in cooperation with trade allies and equipment dealers.

The flexible beneficial electrification programs include:

- An Industrial Electrotechnologies program that promotes selected electrotechnologies to industrial customers to enhance competitiveness and address environmental concerns. This option will assess the applicability of electrotechnologies for the textile and chemical/metal industries and for industrial curing and drying.
- A Residential Security Lighting program that promotes security lighting products through a catalog and in participating retail outlets.

The beneficial electrification options are designed to increase consumer value, as are the demand-side management programs.

Off-system sales will better utilize existing assets from 1996-2002.

Investigation/Research and Development (R&D)

The short-term action plan calls for research and development programs covering supply-side and customer service options. TVA will pursue research or demonstration projects in the following supply-side areas:

1. Investigate cogeneration and other unique energy supply arrangements.
2. Developing new capacity using such technologies as cascaded humidified advanced turbines, distributed generation, and fuel cells. An explanation of these technologies is given below.
   - A cascaded humidified advanced turbine is a gas turbine with a unique configuration that allows the unit to have efficiencies similar to a conventional combined cycle plant (a type of plant that generates electricity first from

the heat produced by burning gas and then again from heat extracted from exhaust steam), but without the addition of a steam turbine and associated equipment. The cascaded humidified advanced turbine should have a capital cost somewhat less than for a combined cycle installation of similar generating capacity.

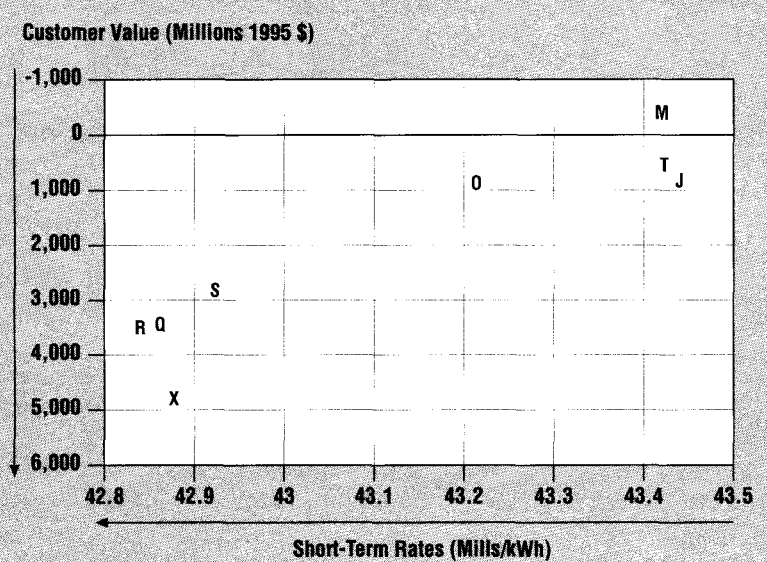
- Distributed generation refers to the location of smaller-scale power generating units near the power consumer. Examples would be gas turbines or diesel generators located in power transmission substations or installed adjacent to large industrial or commercial power consumers. The close proximity of the power generator to the power user significantly reduces the losses associated with the transmission of power.
- Fuel cells are devices similar to batteries, except they are capable of generating power rather than simply storing power. A fuel and a form of air or oxygen are consumed in the cell by a chemical reaction that creates electricity.

3. Developing renewable energy options to include investigations and research into the possibility of using wind resources, landfill methane, coalbed methane, end-use photovoltaics to produce power, and biomass energy projects.
   - Large wind turbines (windmills) have the potential to be a viable generation source, subject to the availability of wind at volumes and speeds capable of supporting this type of generating equipment. Short-term actions by TVA will include a flexible wind project at a selected site in the TVA service area. The first phase will determine the potential for this technology.
   - Methane (gas) from sanitary landfills offers another possible option as an innovative fuel source. Landfills are filled with organic waste material and sealed (covered) in such a way that air cannot gain admittance to the material. As the material decomposes, methane is produced. The methane can be collected by a series of wells drilled into the waste layers. Once collected, the methane can be used as a fuel by conventional power generation equipment such as internal combustion engines, gas turbines, or fuel cells.
   - Coalbed methane is produced in the same way as methane from a landfill. As the organic material in the coalbed decomposes to form coal, methane is produced as a byproduct. The methane can be collected from the coalbed prior to opening the coal seam for mining by a series of wells drilled into the seam. Like landfill methane, this gas can be used as a fuel in conventional power generation equipment.
   - Photovoltaics is a technology that converts solar energy into electricity. TVA will investigate the use of photovoltaics for end-use applications at remote sites where electricity is not readily available.
   - Investigate a biorefinery that uses refuse-derived fuel (garbage), wood waste, and energy crops to produce chemicals and boiler fuel.
   - Investigate a refuse-derived fuel/biomass energy facility that uses compost and biomass waste as a fuel.

Customer service research and development efforts during the short term for new demand-side management communications technologies and end-use renewables include:

- A market transformation research and development project that will explore alternative strategies for increasing the supply and demand for energy-efficient buildings and equipment. The project will be conducted in conjunction with distributors, trade allies, and state and local code officials.
- A communication technology research and development project that is proposed to demonstrate two-way communication technologies with a distributor of TVA power to enable TVA, distributors, and end-use customers to better manage electric load.
- An energy management/remote data acquisition project that is proposed to use two-way communication technologies for remote control of building energy management systems, and to allow TVA and distributors to collect customer energy use data remotely.
- Research on targeted applications of demand-side management, distributed renewable and non-renewable generation, and storage technologies to achieve transmission and distribution system benefits.
- An end-use photovoltaics research and development project that will examine how photovoltaics technologies can be used to reduce customers' energy costs and how these can be used in specific locations to reduce system generation, transmission, and distribution costs. The project will include TVA's membership in the Utility Photovoltaic Group (UPVG).
- Research and development activities for electric transportation that will focus on the development and demonstration of solutions to electric transportation limitations. TVA activities will concentrate on five areas of focus: vehicle evaluations, business impacts, stakeholder partnerships, awareness and education, and infrastructure development.

FIGURE 10-4. **Trade-Off for Customer Value vs. Short-Term Electric Rates**



The short-term plan, (X), has the highest customer value and approximately the same short-term rates as Strategies Q, R, and S.

TVA compared the short-term action plan with seven previously identified long-term strategies across key evaluation criteria. Long-term actions identified in Strategy Q (see Chapter 9) were combined with the recommended short-term supply-side and customer service options to make an eighth strategy. The trade-off graphs illustrated in *Figures 10-4, 10-5, 10-6,* and *10-7* show how the short-term action plan, identified as (X), compares with the other long-term strategies. The

FIGURE 10-5. **Trade-Off for Short-Term Rates vs. Total Resource Costs (TRC)**

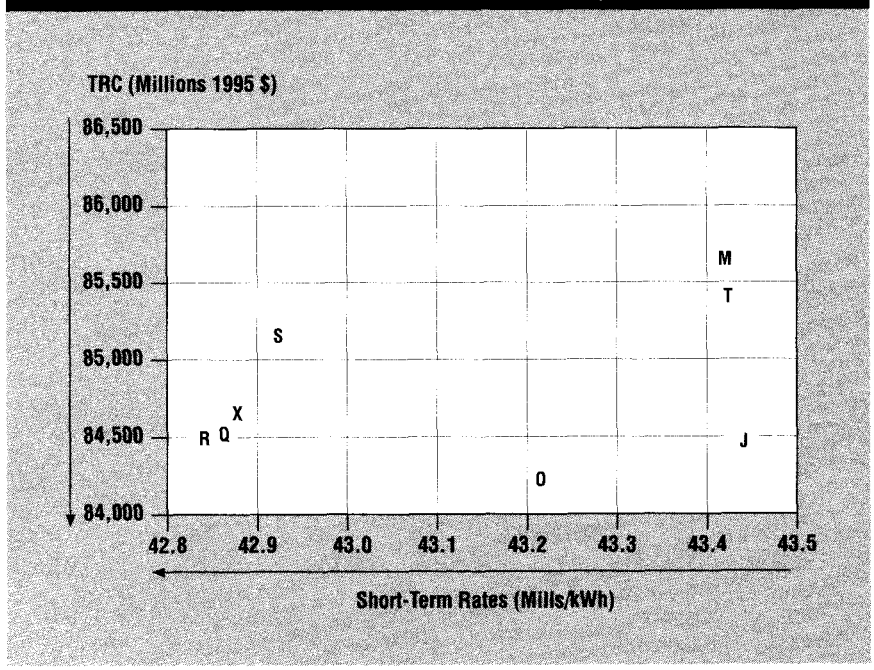
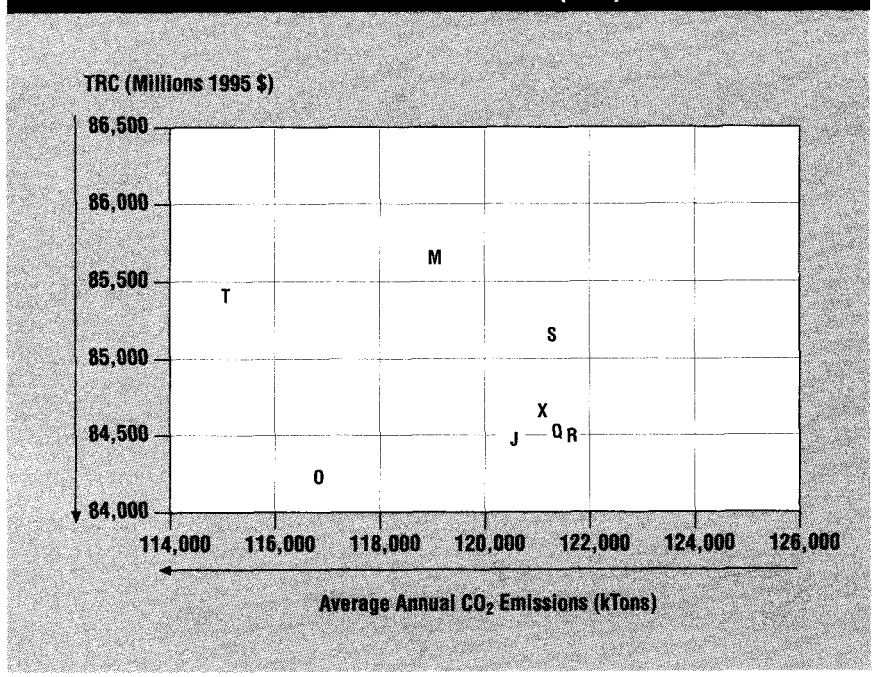


FIGURE 10-6. **Trade-Off for Carbon Dioxide Emissions vs. Total Resource Costs (TRC)**



trade-off graphs that show the short-term action plan are not designed to identify additional trade-offs between the short-term action plan (X) and the other strategies. The trade-off graphs are included to show that the short-term action plan is consistent with the seven best strategies, particularly Strategy Q.

The short-term strategy increases customer value and increases short-term rates slightly, compared to Strategy Q. Debt remains at the same level, total resource cost is slightly higher, and carbon dioxide emissions are reduced.

The short-term action plan, just as the long-term plan, provides for low cost, low debt, low electric rates, improved environmental emissions, high customer value, a high impact on economic development, and risk management.

Throughout Energy Vision 2020, three key concerns have been competitively priced electricity for customers, TVA's debt, and concern for the environment.

The projected electric rates, debt, and carbon dioxide emissions resulting from the short-term action plan for the period 1996-2005 are shown in *Figures 10-8, 10-9,* and *10-10,* respectively.

As indicated in *Figure 10-8,* electric rates adjusted for inflation decline from 1996 to 2005. As indicated in *Figure 10-7,* total debt in 2001 remains below the $30 billion statutory limit. In *Figure 10-9* the ratio of total debt to total assets declines from 0.85 to 0.73. This decline reflects less reliance on debt to finance capital expenditures. As shown in *Figure 10-10,* carbon dioxide emissions remain below 110 million tons per year from 1996-2000

FIGURE 10-9. **Ratio of Total Debt to Total Assets Short-Term Strategy** *(1996-2005)*

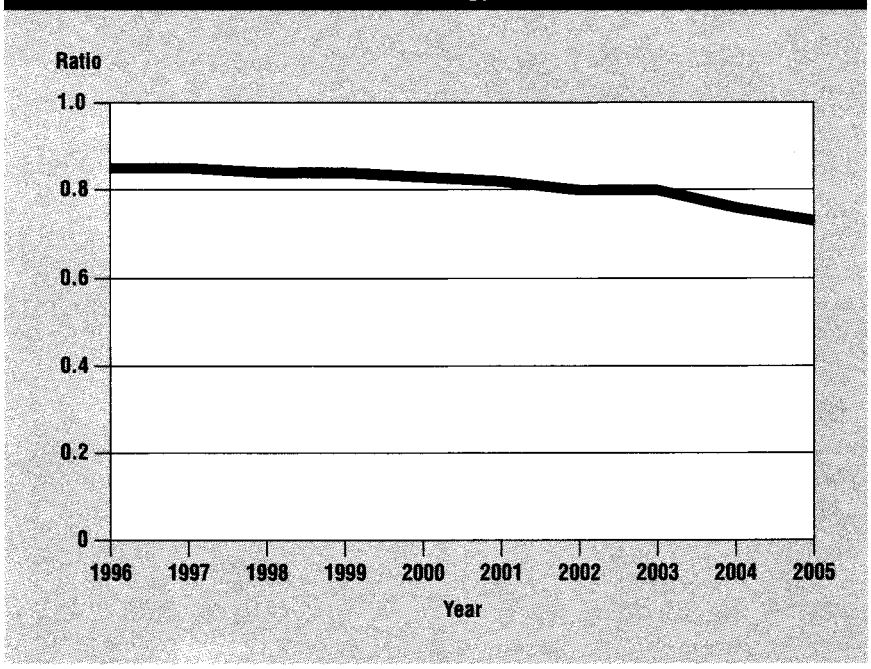
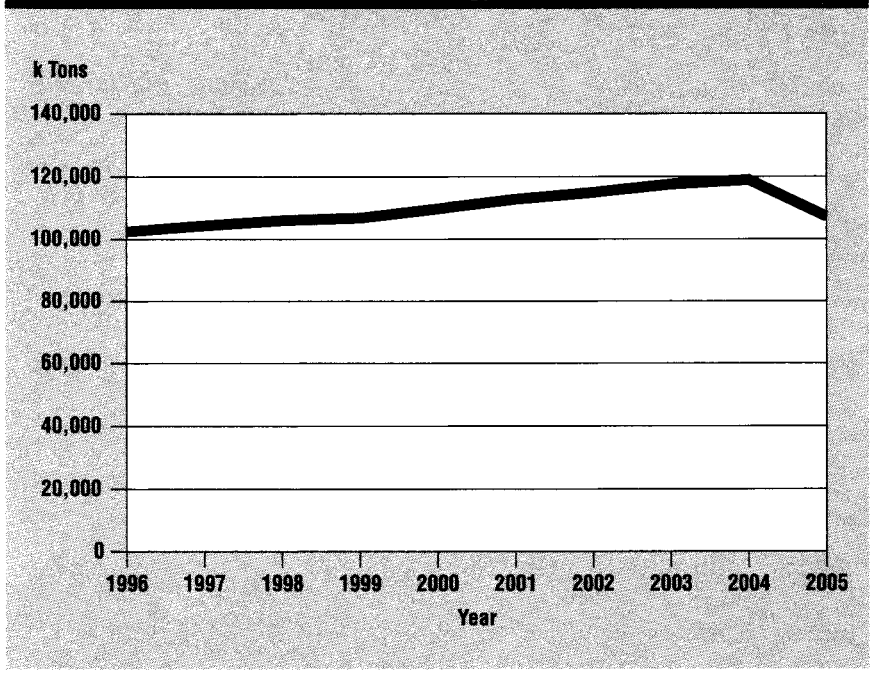


FIGURE 10-10. **Annual Carbon Dioxide Emissions Short-Term Strategy** *(1996-2005)*



Clean Air Act, the Clean Water Act, the Endangered Species Act, the Surface Mining Reclamation and Control Act, and the Resource Conservation and Recovery Act are just a few of the major laws in this country that are formulated to prevent or lessen various kinds of environmental impacts.

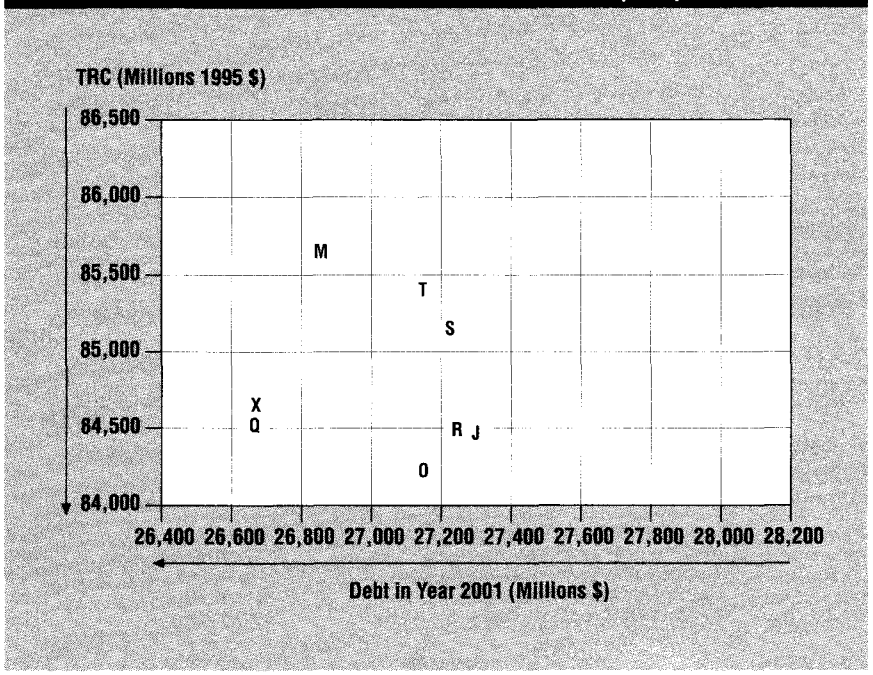
No major energy resource can be put in place without complying with a substantial number of federal, state, and local environmental requirements. These regulatory processes typically have multiple opportunities for public comment and participation. Most federal environmental laws allow citizens to bring suit to enforce compliance with requirements. Also, various federal, state, and local environmental regulatory agencies exist to police compliance.

Although these environmental laws and their implementing regulations do not eliminate all risk of environmental impacts, they substantially reduce those risks, especially the risk of significant impacts. Consequently, the risk of significant impacts associated with the implementation of any of the final strategies identified in Energy Vision 2020 is substantially lessened because of TVA's mindfulness of environmental regulations as each alternative was studied. Moreover, such impacts will be identified in the subsequent environmental reviews that TVA will conduct before it decides to put specific options in place.

and below 120 million tons per year from 2001-2005.

As previously explained, the recommended short-term action plan is derived from the portfolio of options presented in the long-term plan. Although the short-term action plan provides flexibility, even the near-term future usually does not turn out as expected. The plan, therefore, will be reviewed on an ongoing basis and revised as necessary. The long-term plan provides TVA with guidance on making changes to the short-term action plan.

FIGURE 10-7. **Trade-Off for Debt in the Year 2001 vs. Total Resource Costs (TRC)**



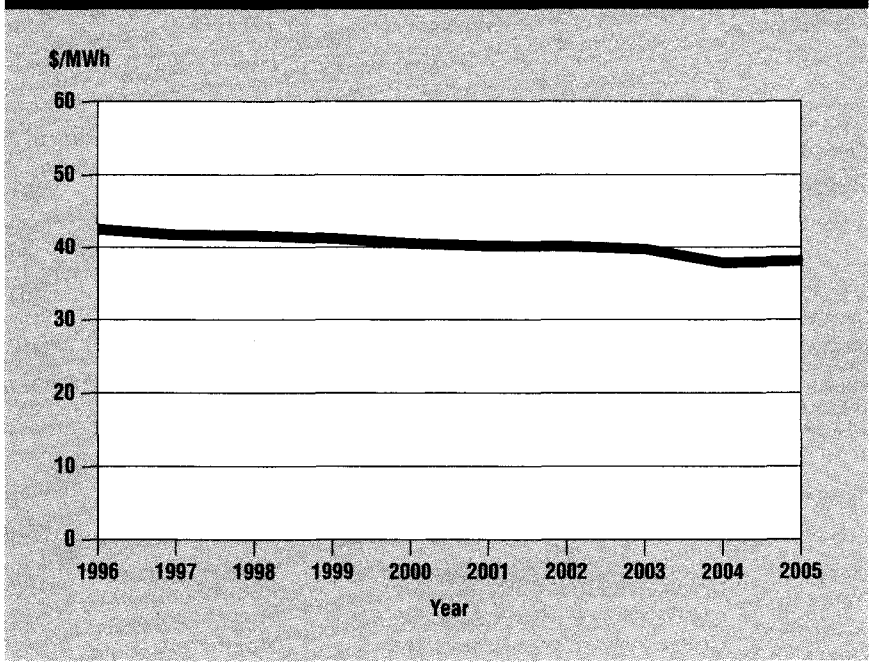
TVA's Compliance with Environmental Regulations Will Provide a Safety Net

A number of environmental consultation, review, and permit requirements would apply to energy resource options that are put in place. The nature of these requirements varies depending on the kind of option. More extensive requirements would apply to those actions having more substantial environmental impacts.

These reviews or requirements include:

- National Environmental Policy Act (NEPA): Actual implementation of options identified in the plan would be "tiered" off the Energy Vision 2020 Integrated Resource Plan/ Environmental Impact Statement, and as appropriate, will be preceded by more specific NEPA reviews.
- Reviews, laws, or permits governing air pollution, wastewater discharge, solid and hazardous waste management, protection of wetlands and floodplains, endangered species, cultural resources, and farmland protection. The

FIGURE 10-8. **Average System Rates Adjusted for Inflation Short-Term Strategy** *(1996-2005)*



Glossary

Glossary

The development and understanding of Energy Vision 2020 requires the careful, consistent use of certain key terms and phrases. Here are definitions of terms that are used often in the process. (Terms in definitions which are themselves defined in the Glossary are printed in *italics.*)

A

A&I Costs—Those expenses anticipated over the life of a facility for additions and improvements. These costs are typically capitalized.

Abatement—Reducing the degree of intensity of, or eliminating, pollution.

A/C—Air Conditioning.

Acid Gas—The gas product from a coal gasification unit that has not had the sulfur compounds removed.

Acid Deposition—The wet or dry deposition of acidic chemical compounds from the atmosphere.

Acid Rain—A complex chemical and atmospheric phenomenon that occurs when emissions of sulfur dioxide and nitrogen oxides and other substances are transformed by chemical processes in the atmosphere, often far from the original sources, and then deposited on Earth in either a wet or dry form. The wet forms, popularly called "acid rain," can fall as rain, snow, or fog. The dry forms are acidic gases or *particulates.*

Add-Ons—Purchases of new or additional equipment of a type previously not present in an existing facility, such as the purchase of a food freezer for a home that previously had none or the purchase of a second room air-conditioner.

Administrative Costs—Expenses incurred by the utility for program planning, design, management, and administration. They include labor, office supplies, data processing, and other such costs. They exclude the costs of marketing, purchase of equipment for programs, incentives, and monitoring and evaluation.

Advanced Batteries—An advanced technology battery that has more storage capacity than a lead acid battery.

Aesthetics—The visual perception of appearance of features in relation to one's sense of beauty.

AFUE—Annual fuel utilization efficiency (AFUE) is an efficiency rating used for natural gas appliances based on average usage including on and off cycling described in a standardized Department of Energy test procedure. These ratings are listed in publications from the Gas Appliance Manufacturers Association (GAMA).

Agricultural Sector—The group of nonresidential customers engaged in the production of crops or livestock, forestry, fishing, hunting, or trapping.

Air Separation Plant—A facility that produces nitrogen and oxygen from air.

Air Toxins—Various man-made and naturally occurring materials that are known or suspected of causing serious public health impacts, but for which no *National Ambient Air Quality Standards* exist.

Allowance—*Emissions Trading Options.*

Alluvial—Sediment deposited by flowing water.

Ambient—Surrounding.

Ambient Air Quality Standards—See National Air Quality Standards.

Anaerobic—Life in the absence of air or free oxygen.

Annual Participation—The number of customers enrolled in a particular utility sponsored customer service program for a given year.

Annual Participation Rate—The ratio of the number of participating units in a particular year to the number of eligible units.

Aquatic—Characteristic of or pertaining to water.

Aquifer—A water-bearing rock, rock formation, or group of rock formations.

Archaeological Resources—Material remains of past human activity.

ASD—An adjustable speed drive (ASD) may be used to control the speed of an electric motor.

ASHRAE—American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc.

Attainment Areas—Those areas that meet all *National Ambient Air Quality Standards* as determined by monitoring air pollutant levels.

Attributes—A measure of a resource option's characteristics or a measure of evaluation results.

Availability—The percentage of time in a given year that a TVA power plant (or generating unit in a power plant) can be called on to produce power.

Avoided Cost—The incremental cost to TVA for *capacity* or *energy* or both which, TVA would have to pay for the next best alternative option.

B

Base Load—The minimum *load* over a given period of time.

Base Load Capacity—Large power plants, often coal- or nuclear-fueled, which are designed to operate around the clock at high *capacity factors.*

Base Load Unit—Units or plants which are designed for nearly continuous operation at or near full capacity to provide all or part of the base load. A generating unit which is normally operated to meet all, or part, of the minimum load demand of a utilities system over a given amount of time.

Baseline—A mid-range set of assumptions on all variables, reflecting a "business as usual" decision strategy.

Beneficial Electrification—Promoting the use of electricity and electrical technologies in processes that will improve a customers productivity, quality of life, or economy over existing energy sources or technologies.

Benefit/Cost Ratio—The ratio of benefits produced by a course of action to the costs incurred in undertaking the course of action.

Benthic Invertebrates—An animal living on sea or lake bottoms that lacks a backbone or spinal column.

Benthos—Aquatic invertebrates that live on or in the first few inches of mud, sand, gravel, or other materials that make up the bottom of streams and lakes, e.g., worms, snails, crayfish, mussels, clams.

Best Management Practice (BMP)—A practice, or combination of practices, that is determined to be the most effective, practical means of preventing or reducing non-point source pollution to a level compatible with maintaining water quality.

Biocide—A substance that is destructive to many different organisms.

Biodiversity—The diversity of life in all its forms and all its levels of organization. Also termed "biological diversity".

Biomagnification—The accumulation of chemicals in organisms beyond the concentration that would occur if the chemical were in equilibrium between the organism and its surroundings. Biomagnification can occur in both terrestrial and aquatic environments.

Biomass—A source of energy embodied in organic matter (mainly plants). Biomass-based energy systems use wood, agricultural and wood waste, municipal waste, and landfill gas as fuels.

Biomass Cofiring—The use of *biomass* as a secondary fuel supplement in a coal-fired plant.

Biota—The animal and plant life of a particular region considered as a total ecological entity.

BLN—Bellefonte Nuclear Plant

Boiler—A component that consumes a fuel for a heat source to produce steam from water.

Boiling Water Reactor—A nuclear power reactor cooled and moderated by ordinary water, which is allowed to boil in the core to generate steam that passes directly to the turbine.

Bottom Ash—A solid residue from combustion of a fuel, such as coal.

British Thermal Unit (Btu)—A commonly used unit of energy, especially for fuels or heat. A kilowatthour is equal to 3412 Btu.

Buffering Capacity—Ability of a stream to absorb acids and bases without altering the stream pH.

C

CAES—*Compressed Air Energy Storage.*

Call Option—A financial tool that provides TVA the right to buy future power from another utility, an independent power producer, or a cogenerator. TVA can buy the right to actually purchase power and decide at a later date whether to purchase it.

Canopy—Refers to a layer of foliage in a forest formed by the crowns of trees.

Capability—(1) With respect to *supply-side resources*, the amount of electric power that a generating unit or electric system can reliably deliver under specified conditions over a specified period of time; (2) with respect to *demand-side resources*, the ability and skills to perform *demand-side*

management activities such as market research, program design, evaluation, etc.

Capacity—The amount of electric power that can be delivered by a generating unit or electric system, as determined by manufacturer's nameplate ratings or by testing. (For example, the capacity of a combustion turbine power plant, based on its nameplate rating, would be stated as 225 *MW*.)

Capacity Factor—A universal standard for measuring power plant performance. The ratio a plant's actual output to its maximum potential output, expressed as a percentage.

Capacity Margin—The total installed capacity of TVA's system in excess of peak load, divided by total installed capacity. Stated another way, Capacity Margin = (*Reserve Margin*) / (1 + *Reserve Margin*).

Carbon Dioxide (CO_2)—A colorless, odorless, nonpoisonous gas that results from fossil fuel combustion and is normally a part of the *ambient* air.

Carbon Monoxide (CO)—A colorless, odorless, poisonous gas produced by incomplete fossil fuel combustion.

Cascaded Humidified Advanced Turbine (CHAT)—An advanced Ericson cycle that employs intercooling, recuperation, reheat, and humidification of a *combustion turbine* with a cascaded topping turbine.

Cedar Glades—Distinctive plant communities occurring where certain types of limestone weather to produce bare rock outcrops or thin layers of soil.

CHAT—*Cascaded Humidified Advanced Turbine.*

Chemical Coproduction—The production of a chemical product while simultaneously producing electricity.

Chlorofluoro-Carbons (CFCs)—A family of inert, nontoxic, and easily liquefied chemicals used in refrigeration, air conditioning, packaging, and insulation or as solvents and aerosol propellants. Because CFCs are not destroyed in the lower atmosphere, they drift into the upper atmosphere, where their chlorine components destroy ozone.

Class I Areas—National parks and wilderness areas given protective air quality standards, as designated by the *Clean Air Act Amendment of 1977.*

Clean Air Act Amendment of 1970—Enabling legislation, which instructs the Environmental Protection Agency (EPA), to set air quality standards for pollutants of concern.

Clean Air Act Amendment of 1977—Legislation which provides greater regulatory authority to the EPA to set specific provisions to protect national parks and wilderness areas designated as *Class I areas.*

Clean Air Act Amendment of 1990—Legislation which added additional regulatory authority to enforce compliance with air quality standards in *non-attainment areas.* It also set new requirements for *acid rain*, hazardous air pollutants, and for the monitoring and reporting on air emissions.

Climate Challenge—The principle utility industry component of President Clinton's Climate Change Action Plan, which provides for voluntary limiting *greenhouse gases* emissions (primarily CO_2).

CO—*Carbon Monoxide.*

CO_2—*Carbon Dioxide.*

Coal Gasification—The process of converting coal into gas.

Coal Plant—An electric generation plant that uses coal as its main source of fuel.

Coalbed Methane—A gas that is present in coal seams.

Cogeneration—The sequential production of electricity and useful thermal energy (generally steam or hot water) from a single fuel source.

Coincident Peak—The *demand* of a TVA customer or group of customers at the time TVA's entire system is at its *peak load.*

Coincident Peak Demand—The load (in *kW*) of an end use, customer, or group of customers at the time the utility experiences its greatest demand for electricity.

Combined-Cycle Generating Unit—A generating unit that combines a simple cycle *combustion turbine* and a heat recovery steam generator, which uses the exhaust heat from the *combustion turbine* to generate steam which in turn drives a steam turbine. (Electricity is generated by both *turbines.*)

Combustion Technology—*Combustion turbines—combined cycles* and simple cycles.

Combustion Turbine (CT)—A gas *turbine* that burns natural gas, fuel oil, or other similar fuels and drives a turbine and generator to produce electricity. Typically used as the primary generator of electricity in a combined cycle installation.

Commercial Sector—The group of non-residential and non-industrial customers that provides services, including retail, wholesale, finance, insurance, and public administration.

Commodity—Products that, in the eyes of the buyers, are identical regardless of who produced it. An example is coal that meets a particular standard.

Commodity Industry—An industry that produces a *commodity*. For example, most agriculture and mining industries are commodity industries.

Community—An assemblage of plants, animals, bacteria, and fungi that live in an environment and interact with one another, forming a distinctive living system with its own composition, structure, environmental relations, development, and functions.

Compressed Air Energy Storage (CAES)—Compressed Air Energy Storage (CAES) combines features from conventional *combustion turbines* and *pumped hydro storage*. During periods of relatively low electric loads, and therefore low power generation costs, air is compressed and stored in an underground reservoir. During periods of high electric loads, the compressed air is released to drive turbine generators to produced electricity. The equipment is analogous to the compressor used in a combustion turbine, and the process is similar to the pumping and storing of water at a higher elevation in pumped hydro generation.

Configuration Control—The process of maintaining consistency between the physical condition of a nuclear plant and its associated design and engineering records.

Conservation—A reduction in either *energy* usage or *peak demand* so as to provide the prior end-use service levels at a lower cost.

Constraint—A qualification of the minimum and / or maximum amount of an output or cost that could or should be produced or incurred in a given time period.

Contingency—A plan or reserve capacity to handle an unplanned outage of a generator, transmission line, transformer, or other piece of electrical equipment on a transmission system.

Conversion—The modification of a power plant (either fully or partially constructed) to enable the plant to use a fuel that is different than the fuel originally intended. For example, a partially constructed nuclear plant might be modified so that it would use pulverized coal as a fuel source.

COP—The Coefficient of Performance (COP) is the ratio of useful energy output (e.g., but of space or water heating value) to the energy input (btu value of natural gas or electricity).

Coproduct—A secondary product that is produced usually in an industrial process in addition to the primary product.

Cost-Effectiveness—A measure of the degree to which a course of action provides benefits in excess of its cost.

Cradle-To-Grave—A term used to describe the generation (e.g., mining), transportation, storage, treatment, and disposal of a fuel or waste product.

Criteria—Units of measure used in integrated resource planning. They are derived from issues or concerns. For example, an evaluation criteria for concern over future rates can be short-term rate impact.

Cultural Resources—The physical remains (artifacts, ruins, burial grounds, petroglyphs, etc.) and conceptual contents or contexts (such as a setting for legendary, historic, or prehistoric events for native people) of an area which are useful in gaining knowledge about man's past.

Cumulative Effects—The net/total changes in electricity use or demand caused by all of the program's participants from the time of a program's inception through the current year.

Cumulative Participation—The net/total number of participating units from the start of a program through the current year.

Cumulative Participation Rate—The ratio of the total number of participating units from the start of a program through the current year to the total number of eligible units.

Cumulative Probability Distribution—A table or graph that shows the chance that an unknown value will turn out to be less than each of a series of given values. For example, if a random July day in the year 2000 is picked, one might estimate that there is a 10 percent probability that the high temperature will be below 70 degrees, 25 percent probability of it being below 80 degrees, 50 percent chance of below 90 degrees, 90 percent chance of below 100 degrees, and 99.9 percent chance of below 110 degrees.

Customer Class—A group of customers with similar characteristics, such as economic activity or level of electricity use. Standard electric utility customer classes include residential, commercial, and industrial.

Customer Service Options—Actions taken to influence the nature of loads on the customer side of the meter.

D

DBH—*Diameter at Breast Height.*

Decision Analysis—A decision-making process that provides a mathematical framework by which a large set of resource *strategies* can be evaluated for a number of uncertain parameters. For example, an ultimate decision might include five sub-decisions, each with five key uncertain parameters, for which there are three values representing the range of likely outcomes. Under this example, 1,115 scenarios would be evaluated in making the decision.

Decommissioning—The process of closing down and putting a facility into a safe state after its useful life has come to an end.

DECON—A nuclear decommissioning option, where all radioactive and contaminated materials are removed from the plant. The reactor site may then be released for unrestricted use with no further licensing requirements. Under this option, it is assumed that the entire reactor facility will be dismantled and disposed.

Declining Block Rates—An electric rate structure that assesses a lower average unit charge as usage increases.

Delivery Point—A physical location on TVA's transmission system that is the contractual point at which a customer takes delivery of electricity from TVA.

Delta—In load forecasting, the increase or decrease in the forecast sales caused by the high or low levels of any of the assumptions in the forecast.

Demand—The amount of electric energy used at a specific point in time, measured in watts (or multiples thereof, such as *kilowatt*, *megawatt*, or *gigawatt*). Demand is measured for individual customers, for groups or classes of customers, and for TVA's system as a whole.

Demand-Side Management (DSM)—Activities which influence electricity use on the customer's side of the meter. Examples include home weatherization, use of compact fluorescent lighting, etc.

Demand-Side Management Measure—A single technology, such as a compact fluorescent light bulb, which can be used to alter customer *load.*

Demand-Side Management Programs—Organized utility activities that are intended to affect the amount and timing of customer electricity use.

Demand-Side Resource—Bundles or packages of DSM activities which can be used to reduce customer energy demands, and thus be viewed in many respects like a generating source.

Derating—Lowering the capacity rating of a generating unit due to factors such as age, loss of efficiency in equipment, loss of availability, or loss of reliability of the unit.

Derivatives—Financial instruments for a commodity whose value is tied to something else, such as fuel costs or interest rates. Derivatives do not call for immediate delivery of the commodity from seller to buyer. *Call options* and futures are examples of these instruments.

Design Capacity—The generating capability of a plant that sets the sizing of all plant components. This is usually close to the full load capability of a plant.

Diameter at Breast Height (DBH)—Tree diameter (outside bark) at breast height (4.5 feet above the ground).

Diesel Generators—An electrical generator powered by a traditional diesel engine.

Direct-Installation Programs—Activities in which the utility (or its contractor) installs *DSM measures* in the facilities of participating customers; such programs generally cover low-cost measures, such as water heater wraps and compact fluorescent lamps.

Direct Served Customers—A group of approximately 60 ultimate consumers with large or unusual power requirements that are served directly by TVA.

Dispatchable—Capable of being connected or disconnected from a utility's system as necessary for cost-effective and efficient operation of the system. Generally applies to generating facilities, but could also apply to a load which is interruptible when necessary.

Dispersed Load Center—Distribution of electricity from a point at which the load of a given area is assumed to be concentrated.

Distributed Generation—Power generation facilities located close to energy users. These are normally small size units (i.e., less than 50 MW) and may include both generation and energy storage technologies.

Distributor—A company that usually buys wholesale electricity from a provider and delivers it to individual commercial, industrial, and household customers.

Diversified Coincident Peak Demand Effect—The change caused by a utility's DSM program in the demand for electricity at the time the utility experiences its system peak.

Diversified Demand—The average load (in kW) across a group of customers or end uses during a given time period.

DOE 2—A public domain building energy analysis software program developed with funding from the Department of Energy.

DSM—*Demand-Side Management.*

DX—Direct expansion (DX) refers to cooling equipment with a refrigerant to air coil and no chilled water system.

E

Early Replacement—The removal of equipment before it reaches its normal retirement age and the substitution of new, typically more efficient equipment for the old.

Econometric Models—Models that use statistical relationships between past electricity sales and actual major historical factors, such as economic activity and prices, to forecast future electricity sales.

Economic Dispatch—The hour-by-hour operation of TVA's system of generating units to meet hourly and daily load swings in a way that minimizes the cost of producing electricity.

Economic Potential—An estimate of the possible energy savings assuming that all energy-efficient options will be adopted and all existing equipment will be replaced with the most efficient whenever it is cost-effective to do so, without regard to market acceptance.

Economy Surplus Power (ESP)—A form of interruptible power sold by TVA. The price for ESP changes hourly and is based on a markup over the incremental cost of the power. There are several variations of ESP with different markups and interruption provisions.

Ecosystem—Any unit that includes all organisms (i.e., the community) in a given area interacting with the physical environment.

EER—Energy efficiency ratio (EER) is a ratio calculated by dividing the cooling capacity of a cooling unit in *Btus* per hour (Btuh) by the power input in watts at any given set of rating conditions, expressed in Btuh per watt (Btuh/watt). These ratings are listed in publications by the Air-Conditioning & Refrigeration Institute (ARI).

EF—Energy Factor (EF) is a measure of the overall efficiency rating of a water heater certified by the Gas Appliance Manufacturers Association (GAMA).

Effects—These include: (a) direct effects caused by an action and occur at the same time and place; (b) indirect effects caused by an action and occur later in time or farther removed in distance, but still reasonably foreseeable. Effects and impacts as used in this document are synonymous.

Effluent—Wastewater—treated or untreated—that flows out of a treatment plant, sewer, or industrial out fall. Generally refers to wastes discharged into surface waters.

EIS—Environmental Impact Statement.

Electric and Magnetic Fields (EMF)—Two types of energy fields which are emitted from any device that generates, transmits, or uses electricity.

Eligible Market—The subset of the total market that is qualified to participate in a customer service program based on the program's participation criteria.

Embayment—A body of water forming a bay.

Embedded Costs—Costs already incurred or committed to. Usually applies to an investment such as a generating plant or transmission line.

EMF—*Electric and Magnetic Fields.*

Emission—Pollution discharged into the atmosphere from smokestacks, other vents, and surface areas of commercial or industrial facilities; from residential chimneys; and from motor vehicle, locomotive, or aircraft exhausts.

Emissions Offsets—Reductions in emissions from existing facilities used to offset the emission produced from a new facility.

Emissions Trading Options—An Environmental Protection Agency policy that allows an electric plant complex with several facilities to decrease air pollution from some facilities while increasing it from others, so long as total results are equal to or better than those required by previous limits. Facilities where this is done are treated as if they exist in a bubble in which total air pollutant emissions are averaged out. Complexes that reduce emissions substantially may be able to "bank" their "credits/*allowances*" or sell them to other industries.

EMS—Energy management system is a term used for automated control of *HVAC* and lighting systems in buildings.

Endangered Species—Any biotic species formally listed as in danger of extinction throughout all or a significant portion of its range of habitat.

Endemic—Native to and limited to only a particular region.

End Use—The ultimate benefits provided by electricity. For example, commercial electric energy uses can be segmented into several end uses, such as lighting, air conditioning, ventilation, heating, cooking, refrigerating, etc.

End Use Model—An energy demand forecasting approach which is based on the end uses of electricity and the factors that influence such end uses, such as electricity consumption, end-use efficiencies, turn-over of appliance stock, etc.

Energy—The amount of power consumed over a period of time, measured in watt hours, *kWh*, *MWh*, or *GWh*.

Energy Efficiency—(1) With regard to *supply-side resources*, reducing the amount of fuel required to produce a given amount of electric energy; (2) with regard to *demand-side management resources*, reducing the amount of electric energy used without reducing the functionality of that use—for example, by replacing a 74-watt incandescent light bulb with an 18-watt compact fluorescent light bulb delivering the same amount of lumens.

Energy Efficiency Programs—Programs (sometimes called energy conservation programs) that are aimed at reducing the amount of energy used by specific end-use devices and systems without degrading the services provided, thereby reducing overall electricity consumption (*kWh*), often without regard for the (e.g., peak or of-peak) timing of program-induced savings. Such savings are generally achieved by substituting technically more advanced equipment to produce the same level of end-use services (e.g., lighting or warmth) with less electricity.

Energy Storage—A mechanism for retaining energy during light load periods, when energy production costs are relatively low, and releasing the energy during high peak periods. The duration of an energy storage cycle rarely exceeds one week.

ENTOMB (Entombment)—A nuclear decommissioning option that consists of sealing residual radioactive or contaminated materials and components within a structure that prevents access by unauthorized personnel. The entombment boundary would normally consist of those portions of the reactor building above certain levels of radioactivity. If necessary, additional reinforced concrete is poured to close up these areas, integral access hatches, and manways. Non-radioactive systems and structures are drained and de-energized, then secured throughout the dormancy period until final disposition.

Environmental Externalities—Externalities are activities which result from the production and consumption of goods and services that impose costs or benefits on society that are not reflected in the prices of those goods or services. For example, negative externalities such as pollution and sonic booms can impose costs on a society that are not reflected in the prices of those goods associated with the pollution or sonic boom. Discussions of externalities in the utility industry have generally dealt with environmental externalities arising from various forms of pollution.

Environmental Mitigation—Reducing the potential degree of environmental impact.

Environmental Protection Agency (EPA)—A federal agency charged with implementing a number of environmental statutes.

EPACT of 1992—The Energy Policy Act of 1992 introduced many topics such as *energy efficiency*, *DSM*, *IRP*, *renewable* energy sources, transmission access, research on EMF, and energy independence.

Equipment Cost—The price of components that the utility purchases directly for a DSM program, including the cost of DSM measures distributed free to participants.

Erosion—The process by which soil particles are detached and transported by water and gravity to some downslope or downstream point.

ESP—*Economy Surplus Power.*

Evaluation Criteria—Measures to evaluate the contribution of resource options to stated objectives and values.

Evaluation and Measurement—The phase of a DSM program which focuses on determining the effectiveness and actual field results of the program.

Existing Buildings—Structures that are in use as of the beginning of the current year.

Externalities—Consequences or impacts of resource development and consumption that are not directly accounted for in the price paid for the resource developed and consumed.

Federally Listed—Animals or plants that have been officially added to the Federal lists of endangered or threatened wildlife or plants by the U.S. Fish and Wildlife Service and/or the National Marine Fisheries Service.

F

Feedstock—The raw materials utilized by a chemical production facility to make the final product.

FERC—Federal Energy Regulatory Commission

Firm Capacity—(1) With regard to *supply-side resources*, a binding commitment to purchase or sell *capacity*. Purchases increase the capability of TVA's system; sales decrease TVA's *capability*; (2) with regard to *demand-side management resources*, the amount of capability that must be provided to a customer under normal conditions.

Firm Power—Power sales which do not have arrangements in the contract for interruptions. *(See Interruptible Power)*

Firm Power Supply Contracts—Contracted power supply that is available 100 percent of the time except under conditions such as Force Majure (circumstances that are normally beyond the control of the contracting parties, e.g., "Acts of God").

Fixed Costs—Costs associated with constructing and maintaining resources in an operable condition, including capitalized construction costs, fixed operating and maintenance costs and fuel inventory costs. These costs are recovered whether or not the resource is actually operated.

Flexible Option—A resource option that can be altered or modified in accordance with TVA needs.

Flexible Strategy—A combination of options that can be easily altered over time to meet TVA's power needs.

Flexibility—The degree to which resource decisions can be changed over time as events unfold and near-term futures become more clearly known.

Fluidized Bed—A Fluidized Bed Combustion Boiler burns solid fuel with a mixture of limestone to reduce sodium dioxide (SO_2)emissions without the addition of a flue gas desulfurization system.

Fly Ash—The small ash particles that are carried out of a combustor with the existing flue gas. These particles are collected by appropriate equipment prior to discharging the flue gas into the atmosphere.

Forced Outage—The occurrence of a component failure or other condition that requires removal of a generating unit from service immediately or up to and including the next weekend.

Forest Cover Type—A descriptive classification of forest land based on present occupancy of an area by tree species (also known as "forest type"), such as:

- Oak-hickory. Forests in which upland oaks or hickory, singly or in combination, constitute a plurality of stocking.
- Oak-pine or mixed. Forests in which hardwoods (usually upland oaks) constitute a plurality of stocking but in which pines account for 25 to 50 percent of the stocking. (Common associates include gum, hickory, and yellow-poplar.)

Forward Contract—A transaction in which two parties agree to the purchase or the sale of a commodity at some future time under such conditions as the two agree upon.

Fossil Fuel Plant—A plant using coal, oil, natural gas or other fossil fuel as its source of energy.

Free Drivers—Customers who take *DSM* program recommended actions because of the program, but who do not participate directly in the program (e.g., they do not claim rebates).

Free Riders—Customers who would have adopted program recommended actions even without the program, but who participate directly in the program (e.g., they claim rebates).

Fuel Cells—A device capable of converting a fuel and an oxidizer directly to electricity.

Fuel Switching Programs—Programs that encourage customers to change from one fuel to another for a particular end-use.

Full-Scale Programs—Mature, system wide programs that are available to all of the eligible customers in the utility's service area.

Future—A combination of discrete values for key uncertainties that TVA is treated explicitly in Energy Vision 2020. For example, a *future* might assume a high rate of load growth, low oil prices, low coal prices, high interest rates, and no new carbon dioxide (CO_2) emission regulations.

Futures (Financial Market)—The sale of a product for delivery at some time in the future for a specified price. Most major commodity markets have well-organized active futures markets. For example, farmers will sometimes sell part of their crops for fall delivery before the crop is even planted.

G

Gas-Fired Combined Cycle—A generating unit consisting of a combustion turbine generator and a steam turbine generator. The primary fuel is natural gas.

Gasifier—A collection of equipment that produces a fuel gas from a typically solid fuel. This fuel gas is suitable for use as a fuel in a combustion turbine or as a feedstock for a chemical processing plant.

General Information Programs—Customer Service programs that inform customers about DSM options through such mechanisms as brochures, bill stuffers, TV and radio ads, and workshops.

Geographic—Belonging to or characteristic of a particular region.

Gigawatt—GW, an amount of electric power equal to 1,000 *MW* or 1 billion watts.

Gigawatt hour—GWh, an amount of energy equal to 1,000 *MWh* or 1 billion watt -hours.

Global Warming—The theory that certain gases such as carbon dioxide (CO_2), methane (CH_4), and chlorofluorocarbon (CFC) in the earth's atmosphere effectively restrict radiation cooling, thus elevating the earth's ambient temperatures.

Greenfield Site—A new site which has not previously been developed.

Greenhouse Effect—The build-up of carbon dioxide and other trace gases that allows light from the sun's rays to heat the Earth but prevents a counterbalancing loss of heat.

Greenhouse Gas Emissions—A gas whose presence in the upper atmosphere contributes to the greenhouse effect by allowing visible light to pass through the atmosphere while preventing heat radiating back from the Earth from escaping. Greenhouse gases from *anthropogenic sources* include *carbon dioxide, nitrous oxide, methane,* and *chlorofluoro-carbons (CFCs).* There also are even larger quantities of naturally occurring greenhouse gases, notably ozone and water vapor, whose concentrations may be affected by interactions with atmospheric pollutants.

Groundwater—Water within the earth or geologic stratum that supplies wells and springs.

GW—Gigawatt, an amount of electric power equal to 1,000 MW, or 1 billion watts.

GWh—Gigawatt hour, an amount of energy equal to 1,000 MWh, or 1 billion watt-hours.

H

Habitat—The total environmental conditions on a unit of land including food, cover, and water within the home range.

Habitat Diversity—The variety and variability of habitat types, as well as their interrelationships on a given area and scale.

HAP—*Hazardous Air Pollutants.*

Hardwoods—Angiosperms, usually broadleaf and deciduous. Soft hardwoods are soft-textured hardwoods such as boxelder, red and silver maples, hackberry, sweetgum, yellow poplar, blackgum, sycamore, black cherry, and elm. Hard hardwoods are hard-textured hardwoods such as sugar maple, hickory, dogwood, persimmon, black locust, beech, ash, black walnut, and all commercial oaks.

Hazardous Air Pollutants (HAP)—Air pollutants that are not covered by ambient air quality standards but that present, or may present, a threat of adverse health or environmental effects. These include an initial list of 189 chemicals designated by Congress that is subject to revision by the Environmental Protection Agency.

Hazardous Waste—A byproduct of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity) or appears on special *Environmental Protection Agency* lists.

Haze—Atmospheric moisture, dust, smoke, and vapor suspended to form a partly opaque condition.

Heat Rate—A measure of efficiency for electric generating units, based on the amount of thermal energy (measured in BTUs) needed to produce a *kWh* of elec tricity. The lower the heat rate, the more efficiently the generating plant turns fuel into electricity.

Heat Recovery Steam Generator—Heat Recovery Steam Generator recovers heat from combustion turbine exhaust gases to raise steam to power a steam turbine, which can be used to generate additional electricity.

Heavy Metals—Natural elements such as lead, mercury, cadmium, and nickel. They are mined from the earth and used in numerous manufacturing processes and countless products.

Herbicide—Any substance or mixture of substances intended to prevent the growth of, or destroy, unwanted plants or vegetation.

High-Level Waste—Material that is highly radioactive. In a nuclear power plant, high-level waste is spent fuel.

Historic Site—See Archeological Resources.

HSPF—Heating Season Performance Factor (HSPF) is the total heating output of a heat pump during its normal annual usage period for heating divided by the total electric power input in watt-hours during the same period. This rating is listed in publications by the American Refrigeration Institute (ARI).

Hydro Electric Power Generation—A dam creates an upper and a lower water reservoir. The height difference between the two reservoirs establishes potential energy that is used to generate electricity by allowing water from the upper reservoir to flow through a hydro *turbine* to the lower reservoir.

I

IGCC—*Integrated Gasification Combined Cycle.*

Impacts—*Effects.*

Impoundment—A body of water or sludge confined by a dam, dike, floodgate, or other barrier.

Incentive—An award offered to encourage participation in a *DSM* program or adoption of recommended measures.

Incentive Programs—Programs that offer cash or noncash awards to customers, trade allies, or employees to encourage participation in a *DSM* program and adoption of recommended measures.

Incremental Cost—The additional cost incurred because of an activity. For example, a plant sitting idle has costs associated with it such as interest on funds used to build it and basic maintenance. When started up, the plant has additional costs such as fuel, additional maintenance, and other costs. These latter costs are the incremental costs of producing the product. Similar terms are *avoided cost*, variable cost, and marginal cost.

Incremental Fuel Cost—The cost of replacing a unit of fuel in today's market.

Incremental Participation—The cumulative number of program participants in the current year minus the cumulative number of participants in the previous year.

Independent Power Producer (IPP)—Any person or entity who owns or operates, in whole or in part, one or more new independent power production facilities.

Industrial Customer—In the context of Energy Vision 2020, a business engaged in industrial activities, which buys electrical energy either from TVA directly or a distributor, depending upon its electrical energy requirements.

Industrial Sector—The group of nonresidential or commercial customers that provides products, including agriculture, construction, mining, and manufacturing.

Inflexible Option—A resource option that cannot be changed once construction or implementation begins (e.g., construction of a combustion turbine).

Integrated Gasification Combined Cycle (IGCC)—Integration of a coal gasification plant with a combined cycle plant. A coal gasification plant is a facility that converts coal into a synthetic fuel gas.

Integrated Resource Planning (IRP)—A utility planning process that evaluates *supply-side resources* and *DSM* resources on a level playing field to reliably and cost effectively meet the future energy needs of customers.

Integration—The process of combining resource options to become strategies, and uncertainties to become futures. Strategies are combined with futures to create scenarios.

Interactive Planning—A process whereby the assumptions, supporting data and information, and preliminary results of planning are subject to open and systematic discussion with *stakeholders* to discover the interactive and interdependent effects of planning factors.

Interconnection—An electrical connection on TVA's transmission system between TVA and a neighboring utility which allows the transfer of electrical energy between TVA's transmission system and the neighboring utility's transmission system.

Intermediate Unit—A generating plant that operates between 15 percent and 60 percent of the time. An intermediate plant normally runs more hours than a peaking plant, but less than a base-load plant.

Internalized Costs—Costs which result from the production and consumption of goods and services that are reflected in the price of those goods and services.

Interruptible Power—A type of *demand-side management* activity in which the power contract allows TVA limited rights to turn off the power when overall demand is high in return for a lower electricity price to the customer (*See Firm Power*).

Interruptible Power Contracts—Power supply contracts under which the consumer agrees to temporarily reduce its electric usage when the utility so requests. In return, the consumer is charged a reduced electric rate.

IPP—*Independent Power Producer.*

IRP—*Integrated Resource Planning.*

Issue—An expressed concern regarding TVA's energy resource plan or its implementation. For example, an industrial customer may see low electricity rates as vital to its continued operation.

K

Karst (Topography)—The relief of an area underlaid by limestone that dissolves in differing degrees, thus forming numerous depressions or small basins.

Karst Region—A particular geographic region of irregular limestone in which erosion has produced fissures, sinkholes, underground streams, and caverns.

Kilowatt—kW, which is the amount of power equal to 1,000 watts.

Kilowatt hour—kWh, which is the amount of energy equal to 1,000 watt-hours.

KM—Kilometer, unit of length equal to 1,000 meters.

kW—Kilowatt, which is the amount of power equal to 1,000 watts.

kWh—Kilowatt-hour, which is the amount of energy equal to 1,000 watt-hours.

L

Lacustrine—Living or growing in lakes; of or related to lakes.

LAER—Lowest Achievable Emission Rate

Lead (Pb)—A heavy metal that is hazardous to health if breathed or swallowed. Its use in gasoline, paints, and plumbing compounds has been sharply restricted by federal regulations, but enormous quantities of lead already released into the environment are causing significant problems.

Levelized Cost—A stream of equal periodic costs or revenues that has the same present value as a given unequal stream of costs or revenues.

Licensing Basis—Those engineering, design, and analysis records and other documents that ensure conformance of a nuclear unit with applicable regulations.

Life-Cycle Costs—The total costs associated with the production and consumption of a resource during its use.

Lignite—An imperfectly formed coal, usually dark brown and often having woody texture.

Limited Interruptible Power (LIP)—A form of interruptible power sold by TVA. LIP customers get discounts from firm power rates in exchange for granting TVA limited rights to interrupt the power if necessary when the power supply situation is very tight. TVA's right to interrupt may be limited by serveral contract terms, such as the amount of power TVA may curtail, the period of interruption, or the duration between interruption.

Load—The amount of electric power that is drawn from TVA's electric system at a given point in time.

Load-Building Programs—Programs that aim to increase electricity consumption, generally without regard to the timing of the increased usage (e.g., peak or off-peak).

Load Factor—A measure of the variability in electric usage, defined as the ratio of energy actually consumed to the potential consumption at peak load for the period of time of interest. Load factor is usually calculated over a one year (8,760 hours) time period.

Load Forecast—A projection of future electricity sales measured in *kilowatt hours* and *peak loads* measured in *megawatts*. Depending on its intended use, a load forecast can cover a period as short as one hour or as long as 25 years or more.

Load Management—The control of customer demand during peak periods or during periods when supplies of electricity are short. Control can occur through the rescheduling or the direct curtailment of power demand. Unlike energy conservation, load management may not conserve energy.

Load Not Served—A measure of the reliability of a power system.

Load Profile—A curve or chart showing electrical power supplied or required plotted against time of occurrence; this illustrates the varying magnitude of the electric power load over time.

Load Shape—The time-of-use pattern of customer electricity use, generally a 24-hour pattern or an annual (8,760-hour) pattern.

Load Shifting Programs—Programs that aim to move or reschedule electricity consumption from one time to another (usually from the on-peak to off-peak periods during a single day).

Loop Flow—A flow of electricity from one place to another that follows a path other than the one specified in a contract or otherwise intended. A loop flow may pass through the transmission system of a utility not involved in the original transaction.

Loss of Load Expectation—The expected time that capacity is not sufficient to meet the system demand.

Loss of Load Probability—A measure of the expected number of hours per year that system demand will exceed system capacity.

Low-Level Waste—Radioactive material that is only slightly or moderately radioactively contaminated. Low-level radioactive waste consists largely of ordinary trash and other items that have come into contact with radioactive materials.

M

Mainstream Reservoirs—Reservoirs on large rivers such as the Tennessee River.

Maintenance Outage—The removal of a generating unit from service to perform work on specific components that could have been postponed past the next weekend, but which could not be postponed from season to season . This is work done to prevent a potential *forced outage.*

Market Potential—An estimate of the possible energy savings that would occur because of normal market forces (i.e., likely customer adoption over time of various actions without a *DSM* program).

Mature Trees—Trees that have grown into the sawtimber class but have not yet begun to decline and die from natural processes.

Megawatt—MW, the amount of power equal to 1,000 KW or 1,000,000 watts.

Methane (CH_4)—A greenhouse gas that is colorless, nonpoisonous, and flammable and is created by anaerobic decomposition of organic compounds.

mg/m^3—Micrograms per cubic meter.

micro-ACCESS—A building energy analysis software program available through EPRI.

microns—A unit of length equal to one millionth of a meter.

Milepost 160—Marker on the Tennessee River that is considered to be a central location of the Tennessee Valley service area.

Mitigation—Measures taken to reduce adverse impacts.

Mn—Manganese, a hard and brittle metallic element that resembles iron but is not magnetic.

Mobile Sources—Transportation air pollution sources, primarily automobiles and trucks.

Monitored Retrievable Storage (MRS)—A temporary (40 years) collection and storage facility for spent nuclear fuel rods until a permanent waste repository is available.

Monitoring and Evaluation Costs—Expenditures associated with the collection and analysis of data used to assess DSM program operations and effects.

Multi-Attribute Tradeoff Analysis—An approach designed for interactive participation by a group to make tradeoff comparisons among different attributes for many strategies and futures.

MW—Megawatt, the amount of power equal to 1,000 KW or 1,000,000 watts.

MWh—Megawatt hour, the amount of power equal to 1,000 kWh or 1,000,000 watt hours.

N

NAPAP—*National Acid Precipitation Assessment Program.*

National Acid Precipitation Assessment Program (NAPAP)—A 10-year scientific study of the effects of, and sources contributing to, *acid deposition* that was conducted by the federal government from 1980 to 1990.

National Ambient Air Quality Standards (NAAQS)—Uniform, national air quality standards established by the *Environmental Protection Agency* that restrict ambient levels of certain pollutants to protect public health (primary standards) or public welfare (secondary standards). Standards have been set for *ozone, carbon monoxide, particulates PM (10), sulfur dioxide, nitrogen dioxide,* and *lead.*

Native Species—Species normally indigenous to an area; not introduced by man.

Natural Resources—The elements of the natural environment that are evaluated as resources (i.e. water resources, forests).

NEPA—National Environmental Policy Act.

Net Effect—The change in electricity use or demand for a participating customer that can be attributed to the utility *DSM* program, expressed in *MWh*/year and *MW.*

New Construction—Buildings and facilities that are constructed during the current year; it may also include major renovations of existing facilities.

New Construction Programs—Customer service programs that affect the design and construction of residential and commercial buildings and manufacturing facilities; such programs may also include major renovations of existing facilities.

New Participants—Customers who take part in a customer service program during the current year and did not participate in the program during the previous year.

NIMBY—An acronym for "Not In My Backyard", used to characterize a person or group resisting development of a project within their neighborhood or another geographic area of concern.

Nitrogen Dioxide (NO_2)—The result of nitric oxide combining with oxygen in the atmosphere. A major component of photochemical smog.

Nitrogen or Nitrous Oxides (NO_X)—A product of combustion by mobile and stationary sources and a major contributor to the formation of ozone in the troposphere and acid deposition.

Non-attainment Area—A geographic area that does not meet one or more of the *National Ambient Air Quality Standards*

for the criteria pollutants designated in the Clean Air Act.

Non-coincident Peak—The absolute peak demand imposed on TVA by a customer, group of customers or all the customers as a whole, but not necessarily at the same time.

Non-point Sources—Pollution sources that are diffuse and do not have a single point of origin or are not introduced into a receiving stream from a specific outlet. The pollutants are generally carried off the land by storm water runoff.

Normal Replacement—The removal of worn-out (and perhaps obsolete) equipment and the installation of new equipment.

NO_X—Nitrogen Oxide or Nitrous Oxide.

O

Off-Peak—The periods of time during which energy is being delivered far below the maximum demands that could be placed on a utility system.

Off System Sales—Sales of electricity by TVA to utilities outside the TVA service area.

On-Peak—The periods of time during which energy is being delivered near, or at, the maximum coincident peak load.

OPEC—Organization for Petroleum Exporting Companies.

Operating and Maintenance (O&M) Costs—Noncapital, equipment-related expenses that continue over the life of the equipment; they include fuel costs as well as costs for maintaining and servicing equipment. There are both fixed and variable O&M costs.

Options—Actions TVA can take to resolve an issue. For example, if TVA forecasts an energy deficit, it has the option to meet it with *DSM* programs or with other resources.

Option (Financial Market)—In financial markets, the right to buy or sell something at some time in the future at a specified price. For example, a utility that is unsure about whether it will need an additional 100 *MW* of power next winter may buy an option from a neighboring utility today. The neighboring utility is then obligated to deliver the power at the agreed-upon price if the other utility requests it. However, the utility that bought the option is under no obligation to buy the power.

Option Purchase Agreement—A proposal, in the form of *call options, put options,* or *forward contracts,* by marketers, brokers, and others in the electric industry to sell TVA electricity.

Outage—The operating condition of a generating unit when it is unavailable for service.

Ozone (O_3)—A substance found in the stratosphere and the *troposphere.* In the stratosphere (the atmospheric layer beginning 7 to 10 miles above the Earth's surface) ozone is a form of oxygen found naturally that provides a protective layer shielding the Earth from ultraviolet radiation. In the troposphere (the layer extending up 7 to 10 miles from the Earth's surface), ozone is a chemical oxidant and a major component of photochemical smog. Depending on its concentration, ozone can seriously affect the human respiratory system and is one of the most widespread of all the criteria pollutants. Ozone in the troposphere is produced through complex chemical reactions of *nitrogen oxides* and sunlight.

P

Palustrine—Relating to marshes or wetlands.

Participant Costs—Those expenses associated with taking part in a *DSM* program paid by the customer and not reimbursed by the utility.

Participants—Units used by a utility to measure participation in its DSM programs; such units of measurement include customers or households for residential programs and customers, floor area, or kW-connected for commercial and industrial customers.

Participation Rate—The ratio of the number of *participants* in a program to the number eligible for the program, with both the numerator and denominator defined in the same units.

Particulate—Minute separate particles.

Particulate Collection Devices—Environmental control systems (i.e., *electrostatic precipitators,* baghouses) designed to remove suspended *particulate* matter (i.e., *fly ash*) from coal-fired boiler flue gas.

Pathogens—An agent that causes disease, especially a microorganism such as a bacterium or fungus.

PCBs—*Polychlorinated byphenals.*

Peak Demand—The maximum rate of electricity use, expressed in *kW.*

Peak Load—The maximum load experienced by TVA's electric system over a given period of time.

Peak-Clipping Programs—Load reduction programs that aim to reduce electricity demand (*kW*) at certain critical times, typically when the utility experiences system peak demand.

Peaking Capacity—Capacity that is available for use and used to meet peak load. Such capacity, usually represented by *combustion turbines*, often has low capital costs and high fuel costs, and is designed to operate for relatively short periods of time.

Peaking Units—A generating unit available to assist in meeting that portion of peak load which is above base and intermediate loads.

Penetration—The ratio of the number of new units of a specific type (e.g., DSM measures) installed to the total number of new units installed during a given time (e.g., the fraction of new air-conditioner sales that exceeds an energy-efficiency ratio of 10).

Pesticide—Chemical materials used to control undesirable insects, animals, diseases, vegetation, or other forms of life.

pH—A measure of the acidity or alkalinity of a solution. pH is represented on a scale of 0 to 14, with 7 being a neutral state, 0 most acid, and 14 most alkaline.

Phase I and Phase II Acid Rain Control—The 1990 Clean Air Act Amendments require fossil-fuel fired generation units to reduce their SO_2 and NO_X emissions in two phases in order to control acid rain. The Phase I compliance period commences on January 1, 1995; the Phase 2 compliance period commences on January 1, 2000.

Photovoltaics—Solar-photovoltaic (PV) power plants convert solar energy to electricity using a semiconductor material, usually silicon doped with phosphorus and boron, to generate direct current.

Physiographic Provinces—Systematic description of areas with some point of physical geology in common.

Pilot Program—A program designed and implemented to test a technology, process, or product on a limited basis in order to evaluate its effectiveness and identify potential problem areas.

Planned Outage—The removal of a generating unit from service for inspection and/or general overhaul of one or more major equipment groups. This is work which is usually scheduled well in advance of the planned outage period (e.g., annual boiler overhaul, five-year turbine overhaul).

Plume—A flowing, often somewhat conical, trail of emissions from a continuous point source.

PM 10—Minute separate particles equal to 10 microns or less.

Point Sources—A stationary location or fixed facility from which pollutants are discharged or emitted. Also, any single identifiable source of pollution, for example, a pipe, ditch, ship, ore pit, or factory smokestack.

Parts per million (PPM)—The number of parts of a given substance or pollutant in a million parts of a base material; a measure of concentration.

Present Value—The value of future dollars in terms of what they are worth today. The loan amount one could borrow today and pay back with the future dollars.

Pressurized Water Reactor (PWR)—A light water reactor in which the water used as a moderator is kept under pressure, preventing it from boiling at normal temperatures.

Prevention of Significant Deterioration (PSD)—A program in which state or federal permits for new or modified sources in places where air quality is already better than required to meet primary and *secondary ambient air quality standards.*

Price Taker—In any market, a buyer or seller with no individual control over the price of the product.

Primary Particulates—Particles emitted directly from a source.

Private Costs—Cost borne by those producing a good (e.g., fuel, operation and maintenance, and capital costs). Also referred to as "utility cost.

PSCs or **PUCs**—Public Service Commissions or Public Utility Commissions; state authorities that regulate utilities.

Pulverized Coal—The pulverized coal (PC) fired boiler with *steam turbine* power generation is currently the principal electricity generation technology in the United States.

Pumped Storage Hydro Plant—A hydro plant that continuously recycles water through two reservoirs, one upper and one lower. When demand for electricity is high, water held in the upper reservoir is released through a long underground power tunnel. Electricity is generated by the force of falling water driving hydraulic turbines connected to large generators. When demand is low, the generators reverse and function as electric motors to pump water from the lower reservoir back to the upper, where it is stored for reuse during peak demand periods.

Put Option—An option granting the holder the right to sell the underlying security or commodity at a certain price at a specified period of time.

Q

Qualitative Evaluation—An assessment using qualities or rankings rather than a measurement or estimate of quantity.

Quantitative Evaluation—An assessment based on a measurement or estimate of quantity.

R

Radionuclides—Radioactive nuclides.

Rate Impact Measure Test—A test which measures what happens to customer bills or rates due to changes in utility revenues and operating costs caused by the utility implementing a resource option.

Real Prices—(Or constant dollar prices, prices excluding inflation) As applied to price changes, the rate of change in a price over time adjusted for the overall inflation rate. For example, if the price of a widget goes up 1 percent while the average price of all goods sold in the economy goes up 2 percent, the real price of the widget is said to have declined 1 percent.

Rebate—Money given to customers, contractors, homebuilders, or other trade allies who make equipment choices to help the purchaser defray the incremental cost of DSM measures.

Reburn—A process that reduces emissions of NO_X by staging of the combustion process. A secondary fuel (either pulverized coal or natural gas) is introduced into the furnace after primary combustion and chemically reduces the previously formed NO_X.

Reference Case—One given set of circumstances used to compare all other sets of circumstances. This is TVA's "No Action" alternative.

Regional Haze—A type of visibility impairment which is the result of dispersed and intermixed pollutants from many sources.

Reliability—The ability of TVA's electric system to deliver uninterrupted power to its customers.

Renewable Resources—Power plants or other generating devices whose fuel source is generally considered to be renewable. These include generators fueled by biomass, water, photovoltaics, solar, wave, or wind energy.

Renewables—See *Renewable Resources.*

Repowering—Replacing or adding to the source of power of an existing electric generating station.

Request for Proposal (RFP)—Formal action by TVA to request competitive bids from developers, marketers, brokers, electric utilities, and other entities that can potentially supply low cost power to TVA.

Rerating—Changing the nameplate capacity of a generating unit.

Reserve Margin—The difference between the capability of TVA's electric system and expected *peak load*, expressed as a percentage of expected peak load.

Residential Sector—The group of customers to whom electricity is sold for household purposes, including space heating, water heating, air conditioning, lighting, and appliances in single-family, multifamily, and mobile homes.

Resources—*Supply-side* or *Customer Service Options* which can be used by TVA to meet future customer energy needs.

Resource Option—*Supply-side* or Customer Service actions TVA can take to meet future customer energy needs.

Resource Strategy—A combination of *resource options* used to fulfill a particular *future.*

Retail Competition—Competition for the business of ultimate consumers.

Retrofit—Replacement or upgrading of equipment before it reaches normal retirement age.

Retrofit Programs—Programs that upgrade existing facilities and equipment before they reach their normal retirement age.

Revenue Requirements—The amount or money that must be recovered from customers to cover a utility's fixed and variable costs.

River Substrate—A layer of material or substance in a river.

Robustness—The degree to which an energy resource strategy meets an objective for most or all futures.

S

SAFSTOR—With the Safstor option, fuel assemblies, nuclear source material, and radioactive liquid and solid wastes will be removed from the plant. The external doors and hatches of the buildings will be secured to prevent unauthorized entry. Buildings will be accessible only to fulfill periodic inspections and surveillance requirements. Systems needed for these functions will be maintained throughout the dormancy period in accordance with the requirements of a possession-only license issued by NRC. A full-time security force will also be provided to ensure prevention of unauthorized entry.

Saturation—On the demand side, the percentage of a group of customers that have a particular end use. For example,

the residential saturation of heat pumps is 50 percent if half of residential customers have them. In the commercial sector, saturations (also know as fuel shares) are generally measured on a percentage of square footage basis.

SCADA—*Supervisory Control and Data Acquisition.*

Scenario—In the context of Energy Vision 2020, the combining of one *strategy* with one *future.*

Scoping—The procedure in Energy Vision 2020 by which TVA identified important issues and determined the extent of analysis necessary for an informed decision on a proposed action. Scoping is an integral part of any environmental analysis.

Scrubber—A device that removes sulfur dioxide from flue gas using lime or limestone.

Scrubber Sludge—The *effluent* from a scrubber that is discharged and is stored in a landfill, principally as a calcium sulfate.

Secondary Particulates—Particles formed in the atmosphere from emitted gases.

Sedimentation—The action or process of depositing sediment.

Seedling—Live trees of a species less than 1.0 inch in *diameter at breast height* that are expected to survive and develop.

SEER—Seasonal Energy Efficiency Ratio (SEER) is the total cooling of a central unitary air conditioner or unitary heat pump in Btu's during its normal annual usage period for cooling divided by the total electric energy input in watt-hours during the same period. This rating is listed in publications by the American Refrigeration Institute (ARI).

Sensitive Species—Species that are listed with states as needing special management.

Sensitivity Analysis—The process of changing a characteristic of or assumption about a resource or a streategy in to determine the impact this change has on a set of *evaluation criteria.*

Sheet Erosion—*Erosion* of a uniform layer of surface soil from a large area caused by runoff water.

Short Rotation Woody Crops—A species of trees grown (on a relatively short rotation schedule) for the explicit purpose of harvesting for use in power production.

Soil—A dynamic natural medium composed of mineral and organic materials in which plants grow.

Sorbent—A substance that takes up and holds.

Species—A class of individuals having common attributes and designated by a common name.

Spent Fuel—Nuclear fuel that can no longer economically sustain a chain reaction.

Stakeholder—For the purposes of Energy Vision 2020, an individual, a group of individuals, or an organization that may be affected by or have a vested interest in a TVA decision or action. TVA's stakeholders include its customers, residents of the Tennessee Valley, etc.

State Implementation Plan (SIP)—*Environmental Protection Agency* approved state plans for the establishment, regulation, and enforcement of air pollution standards.

Steam Generator—In pressurized water reactors, a huge "radiator" where heat from the primary (reactor coolant) loop is transferred to the secondary (steam) loop without mixing of the two streams of water.

Storage Units—Facilities that are able to store low cost, off-peak generated energy and discharge this energy during high demand peak periods.

Stranded Costs—Costs that a utility faces because of *stranded investments.* For example, a utility may owe money on a closed plant that is generating no income. If an investment can operate and cover part of its cost, only the portion of the cost not covered would be stranded.

Stranded Investment—An investment in plant or equipment that loses its value because of competition that forces down the price of the product. In the electric utility industry, firms may have been allowed or directed by regulators to build high cost capacity to meet the obligation to serve their customers. If the market is open to competition, lower cost producers may capture these customers, causing the high cost capacity to close and become a stranded investment.

Strategy—In the context of Energy Vision 2020, a combination of options intended to fulfill a particular resource goal. For example, an energy deficiency in 2007 might be met with a combination of *supply-side resources* and *DSM resources.*

Streams—A continually, frequently, or infrequently flowing body of water that follows a defined course. The three classes of streams are:

- Ephemeral: A channel that carries water only during and immediately following rainstorms. Also known as a "dry wash."
- Intermittent: A watercourse that flows in a well-defined channel during the wet seasons of the year, but not the entire year.
- Perennial: A watercourse that flows throughout the year or nearly so (90 per

cent of the time) in a well-defined channel.

Substation—An assemblage of equipment for the purposes of switching and/or changing or regulating the voltage of electricity.

Succession—A process of biotic community development that involves changes in species, structure and community processes over time.

Sulfur Dioxide (SO_2)—A heavy, colorless, gaseous air pollutant formed primarily by the combustion of fossil plants.

Sunk Cost—The sum of previous investments; monies that have already been spent.

Supercritical Pulverized Coal-Fired Plant—A supply-side option that is technically similar to the subcritical pulverized coal (PC) fired plant, except that the supercritical boiler operates at supercritical pressures of greater than 3,200 pounds per square inch.

Supervisory Control and Data Acquisition (SCADA)—A real-time system that gathers information on an electrical system and also can be used to perform real-time control actions to modify the electrical system. These actions can include switching transmission lines in and out of service, switching capacitors in and out of service, starting and stopping generators, etc.. A SCADA system usually has centralized computer controls with communications equipment to gather and transmit real-time information between the central control center and the electric system.

Supply-Side Resource—Resources that meet customer needs by increasing production of electricity (e.g. hydro, fossil, nuclear, combustion turbines, etc.).

Surface Water—Streams, rivers, ponds, lakes, and manmade reservoirs.

Surrogate Measure—A measure that can be used to represent one or more other measures in an analysis. For example, sulfur dioxide can be an effective surrogate for other air pollution emissions elements when analyzing certain air pollution characteristics.

System Energy Requirements—The total energy the generating system needs to produce to meet customer needs over some time period, generally a year. System energy requirements include all sales and *system losses.* Customer needs are measured before *demand-side management* measures are applied.

System Losses—Difference between the energy metered at the generator and the energy recorded at the customers' meters.

System Reliability—The guarantee of system performance at all times and under all reasonable conditions to ensure constancy, quality, adequacy, and economy of electricity. It is also the assurance of a continuous supply of electricity for customers at the proper voltage and frequency.

T

Tailwater—Water downstream from a dam, including those waters released from the dam.

Takeback—Changes in customer behavior resulting in greater energy use stimulated by participation in a *DSM* program.

Target Market—The group of customers (a subset of the eligible market) that is the focus of utility marketing efforts.

Thermal Stratification—Layering of water with different temperatures, where it is warmer near the surface and colder near the bottom.

Threatened Species—Species formally listed as threatened with extinction.

Topography—The physical features of a place or region. Commonly refers to land forms and variation in elevation.

Total Program Costs—All expenses associated with a *DSM* program regardless of whether borne by the utility, participating customer, or trade allies. The costs paid by customers and trade allies are first adjusted for incentives from the utility to avoid double-counting costs.

Total Resource Cost (TRC) Test—A benefit-cost test which measures the net costs of a demand-side program as a resource option based on the total cost of the program, including both the participants' and the utility's costs. The costs in this test are the program costs paid by both the utility and the participants plus the increase in supply costs for any period in which load has been increased. All equipment costs are included in this test.

Total Value Test—Extends the *Total Resource Costs* test to not only include the total cost of an option, but also the effects upon the benefits or "value" that participants and ratepayers receive.

Trade Allies—Organizations (e.g., architect and engineer firms, building contractors, appliance manufacturers and dealers, and banks) that affect the energy-related decisions of customers who might participate in *DSM* programs.

Trade Off—When satisfying more of one need means satisfying less of another.

Transmission System—That portion of a utility that is used for the purpose of transmitting electric energy in bulk to other principal parts of the system or to other utility systems.

Troposphere—Lower atmosphere.

TSP – Total suspended particulate matter.

Turbine—A machine for directly converting the kinetic and/or thermal energy of a flowing fluid (air, hot gas, steam, or water) into useful rotational energy.

U

Unbundling of Services—To give separate prices for transmission services such as delivery of active power, regulation of system frequency, sag and surge control, waveform quality services, etc.) and power generation.

Utility Costs—All the expenses (administrative, equipment, incentives, marketing, monitoring and evaluation, and other) incurred by a utility in a given year for operation of a DSM program regardless of whether the costs are capitalized or expensed.

Uncertainties—In the context of Energy Vision 2020, issues or concerns that are generally beyond TVA's control that may affect the cost or performance of its energy resources in the future.

Utility-Grade Installations—Designs that typically provide greater reliability, particularly under adverse conditions, than *Independent Power Producer* (IPP) installations using similar technologies.

V

Valley-Filling Programs—Programs that typically seek to increase off-peak electricity consumption (without necessarily reducing on-peak demands).

Variable Costs—Costs associated with the generation of electricity that vary with the utilization of the generating station, such as fuel, consumable supplies, etc.

Variable Frequency Drive (VFD)—A variable frequency drive is a type of *ASD* that varies the frequency of the electricity to an electric motor to control it's speed.

Visibility Impairment or Degradation—Visibility Impairment or degradation is usually defined as aesthetic damage where the ability to discern form, color or texture is reduced and therefore the scenic value is also diminished. Or, as stated in 40 CFR 51.30(x), visibility impairment is "...any humanly perceptible change in visibility (visual range, contrast, coloration) from that which would have existed under natural conditions."

Visual Quality Zones (VQZs)—Areas of the landscape denoted by specified distances from the observer. Used as a frame of reference in which to discuss landscape characteristics or activities of man sometimes referred to as "distance zones".

Volatile Organic Compounds—Any organic compound that participates in atmospheric photochemical reactions except for those designated by the *Environmental Protection Agency* administrator as having negligible photochemical reactivity.

Volt—The unit of electromotive force or electric pressure analogous to water pressure in pounds per square inch. It is the electromotive force which, if steadily applied to a circuit having a resistance of one ohm, will produce a current of one ampere.

W

Water Quality—A term used to describe the chemical, physical, and biological characteristics of water, usually with respect to its suitability for a particular purpose.

Watershed—The entire area that contributes to a drainage or stream.

Weather Adjusted (Or Weather Normalized)—Having the effects of the difference between actual and expected normal weather removed. For example, TVA forecasts summer peaks for a normally expected valley-wide average temperature of 96 degrees. If the peak one year occurs at 100 degrees, a weather adjusted peak will be estimated by applying a per degree adjustment factor to the four degree difference.

Wheeling—Transferring electrical energy produced by another utility or an *independent power producer (IPP)* to a customer in one's own service area or through one's own transmission system to a neighboring utility.

Wholesale Electric Competition—Competition for the business of *wholesale power customers.*

Wholesale Customer—An organization that purchases bulk electric power for distribution and resale to ultimate retail consumers. There are 160 municipal and cooperative power distributors that are wholesale customers to TVA.

Wholesale Power—Power sold to other utilities or local power *distributors* for resale to ultimate consumers of electricity.

Wind Farm—Groups of Wind Turbines.

Z

Zebra Mussel—An imported mussel which fouls, among other things, water intake structures.

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