Energy Vision 2020

VOLUME ONE

Integrated Resource Plan
Environmental Impact Statement

TVA

Energy Vision

2020

VOLUME ONE

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.

For additional information, contact:

Lynn Maxwell
Manager, System Integration
Tennessee Valley Authority
MR 3K, 1101 Market Street
Chattanooga, Tennessee 37402
(615) 751-2539

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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
- Technical Document 7, Customer Service 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"	Q	Flexibility w/External Options
J	Bellefonte Coproduct/Renewables/IPPs	R	Flexibility w/Internal Options
M	DSM/Off-System Sales	S	Low Cost & Rates, Improved Environment
O	Bellefonte Coproduct/More DSM/Off-System Sales	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 l990 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.