Tennessee Valley Authority

Nuclear Energy

Why TVA Needs Nuclear Today and Tomorrow

April 2012

Sequoyah Nuclear Plant in Soddy-Daisy, Tenn.

Introduction

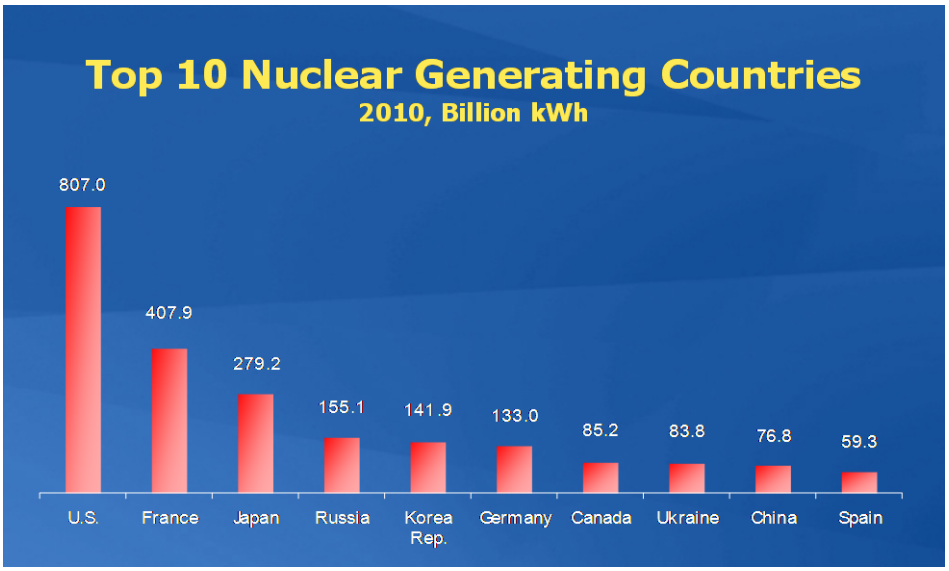
Nuclear power is a proven technology that has been part of TVA's diversified energy supply since the 1970s, along with hydroelectric, coal, natural gas and more recently renewable energy. With production costs among the lowest in TVA's portfolio and reliability among the highest, TVA's three nuclear plants generate about a third of TVA's electricity — safely, economically and carbon free.

Together, Browns Ferry, Sequoyah and Watts Bar contribute more than 6,600 megawatts to the power grid. That's enough electricity to supply more than 3 million homes. TVA's Integrated Resource Plan recommends an even greater role for nuclear power (and energy efficiency) over the next two decades, consistent with TVA's renewed vision to be an industry leader in both areas. With a seventh reactor under construction (Watts Bar Unit 2), an eighth under engineering development (Bellefonte Unit 1) and advanced designs under study, TVA is committed to nuclear energy — today and tomorrow.

Nuclear Overview

Nuclear generation began more than a half century ago and now generates as much global electricity as was produced then (1960) by all sources, according to the World Nuclear Association.

Some two-thirds of the world's population lives in nations where nuclear power plants are an integral part of electricity production and industrial infrastructures. Half the world's people live in countries where new nuclear power reactors are being planned or are under construction.



Source: Nuclear Energy Institute/International Atomic Energy Agency

Today, nearly 440 nuclear reactors produce electricity around the world. More than 15 countries rely on nuclear power for 25 percent or more of their electricity. In Europe and Japan, the nuclear share of electricity is more than 30 percent. In the U.S., nuclear power provides 20 percent of electricity.

Number of U.S. operating reactors: 104 (35 boiling water reactors, 69 pressurized water reactors)*

Boiling Water Reactor Plants	Pressurized Water Reactor Plants
14 have one reactor	15 have one reactor (Watts Bar)
9 have two reactors	24 have two reactors (Sequoyah)
1 has three reactors (Browns Ferry)	2 have three reactors

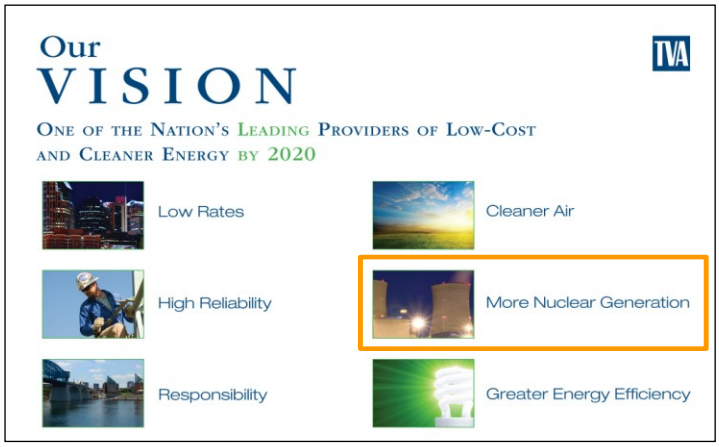
TVA's Watts Bar 2 (under construction) and Bellefonte 1 (under development) are pressurized water reactors.

** In a boiling water reactor, the steam that drives the turbine-generators that make electricity is produced in the reactor. In a pressurized water reactor, the steam that drives the turbine-generators to make electricity comes from a heat exchanger called a steam generator that is fed by coolant heated in the reactor.*

Nuclear capacity worldwide is increasing steadily but not dramatically, according to the Nuclear Energy Institute, with more than 60 reactors under construction in 14 countries, including TVA's Watts Bar Unit 2. Plant licensing extensions, such as that received by TVA's Browns Ferry Plant, are maintaining capacity in the U.S., while Southern Company is beginning to build the U.S.'s first next-generation reactor.

TVA Vision

TVA's renewed vision adopted by the TVA board of directors in 2010 puts the country's largest public utility on a course to a cleaner and more secure energy future — one that relies more on nuclear power and energy efficiency, and less on coal.



Like other utilities, TVA must adapt to challenging economic conditions, tougher environmental standards, the need to modernize its generating fleet and changing customer needs. TVA has identified six focus areas to achieve its vision in these changing times. Adding more nuclear generation is one strategic area that could well help realize some of the others through nuclear's low operating costs, high reliability, 24/7 operations and lack of carbon emissions.

TVA aims to be one of the nation's leading providers of low-cost and cleaner energy by 2020. Specifically, TVA aspires to lead the Southeast in increased energy efficiency and the nation in improving air quality and increased nuclear production.

TVA's Nuclear Fleet

Browns Ferry Nuclear Plant

"It is clear that TVA can best meet its responsibility for a continuing, assured supply of low-cost electric energy for the region it serves by building a nuclear plant."

TVA Chairman Aubrey `Red' Wagner on decision to build Browns Ferry (Decatur Daily - June 18, 1966)

TVA's first nuclear plant, Browns Ferry, is located beside Wheeler Reservoir on the Tennessee River, near Athens, Ala. The plant has three General Electric boiling water reactors. Construction began in 1966 and Unit 1 went into operation in 1973. A fire in 1975, started by a candle used to check for air leaks, forced the safe shutdown of Unit 1 and led to significant additions to Nuclear Regulatory Commission fire protection standards. Unit 2 came online in 1974 and Unit 3 followed in 1976. Browns Ferry was the largest nuclear power plant in the world at the time.

After TVA voluntarily took all of its nuclear units out of service in 1985 for safety upgrades and other program improvements, Browns Ferry Units 2 and 3 returned to operation in 1991 and 1995, respectively. Unit 1 was restarted in 2007, becoming the nation's first nuclear unit to come online in the 21st century.

The plant's 3,300-megawatt capacity today represents about 10 percent of TVA's total generating capacity, enough to meet the needs of about 2 million homes. More than 1,400 employees work at Browns Ferry.

Sequoyah Nuclear Plant

TVA's second nuclear power plant, Sequoyah Nuclear Plant, is located beside Chickamauga Reservoir on the Tennessee River, in Soddy-Daisy, Tenn. The plant has two Westinghouse pressurized water reactors that each produce more than 1,160 megawatts. Together they can supply the energy needs of about 1.3 million homes. Construction began in 1970.

Unit 1 entered commercial operation in 1981 and Unit 2 came online in 1982. After TVA's fleetwide shutdown in 1985, the units returned to service in 1988. Both units have since set marks for continuous runs of more than 500 days (Unit 1 in 2009-2010 and Unit 2 in 2000-2002). Sequoyah has a work force of about 1,100 employees.

Watts Bar Nuclear Plant

TVA's third nuclear power plant, Watts Bar, is located on the northern end of Chickamauga Reservoir on the Tennessee River near Spring City, Tenn. The plant was designed for two Westinghouse pressurized water reactors. Construction began in 1973, but was suspended in the 1980s because of a reduction in the predicted growth of power demand. Unit 1 was completed in 1996, becoming the last new reactor to begin commercial operation in the United States.

In 2000, Watts Bar 1 set its own mark for running for more than 500 consecutive days. In 2007, the TVA board of directors approved completion of Unit 2 and that work is continuing. About 1,100 employees and 2,200 contractors, most involved in Unit 2 construction, work at Watts Bar.

Bellefonte Nuclear Plant

In August 2011, the TVA board of directors approved completion of the Bellefonte Nuclear Plant Unit 1 in Hollywood, Ala. Original construction began in 1974, but was suspended in 1988 because of slowing growth in energy demand. The plant has two incomplete Babcock & Wilcox pressurized water reactors. When Bellefonte Unit 1 begins commercial operation around the end of the decade, the 1,260-megawatt reactor will be the largest in TVA's nuclear fleet. Bellefonte 1's output will be enough to supply 750,000 homes. About 75 TVA employees work at the site, in addition to contractors onsite and offsite.

Plant License Extensions

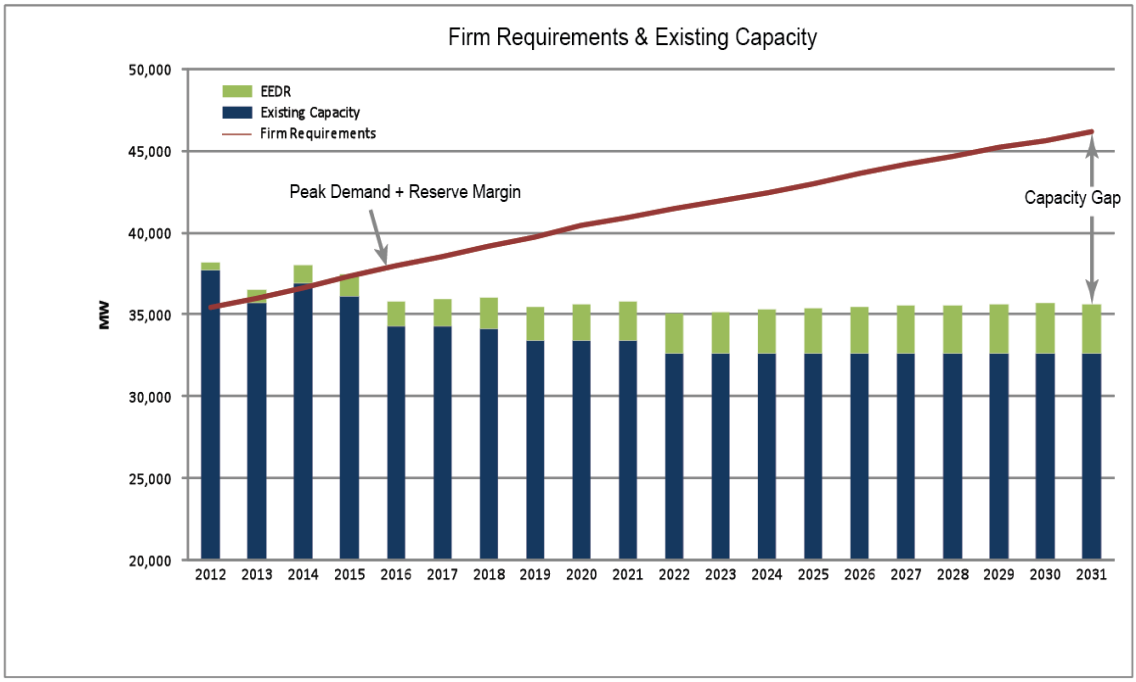
The Nuclear Regulatory Commission (NRC) issues licenses for commercial power reactors to operate for up to 40 years and allows these licenses to be renewed for up to another 20 years. A 40-year license term was selected on the basis of economic and antitrust considerations, not technical limitations, according to the NRC. The decision whether to seek license renewal rests entirely with nuclear power plant owners, and typically is based on the plant's economic situation and whether it can meet NRC requirements. Of the 104 U.S. reactors originally licensed to operate for 40 years, the NRC has approved license renewal for 70 reactors. Operating licenses for Browns Ferry's three reactors were renewed in 2006, allowing continued operation of the units until 2033, 2034, and 2036. TVA is preparing an application to keep Sequoyah's reactors operating to 2040 and 2041. Watts Bar 1's original operating license won't expire until 2035.

Future Options

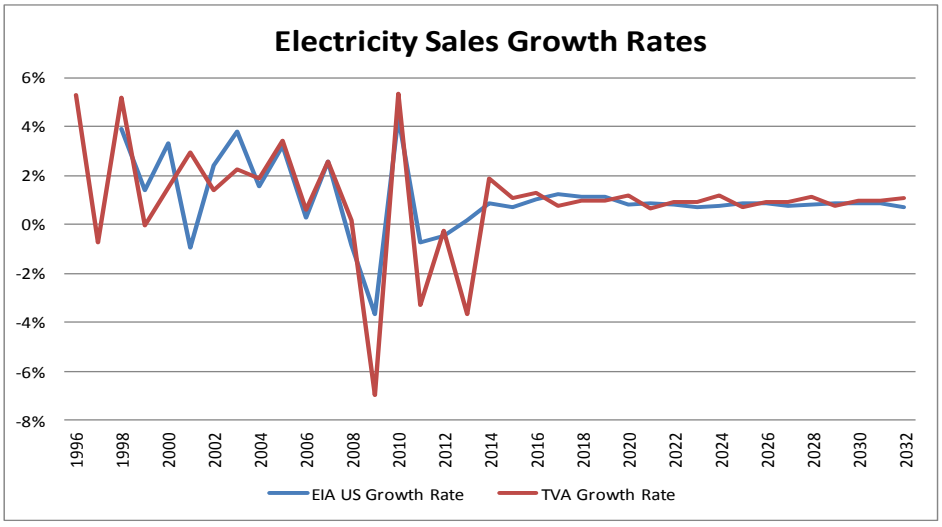
TVA is interested in the development of small modular reactors (SMRs) as part of TVA's continuing effort to advance carbon-free, baseload power generation alternatives. These are small, factory-built, pressurized water reactors of about 150-160 megawatts each that can be installed alone or grouped at a single site. TVA is working with Babcock & Wilcox Nuclear Energy Inc. on the potential use of TVA property along the Clinch River near Oak Ridge, Tenn., for a lead plant site for B&W's mPower modular reactor. The project could involve supplying the U.S. Department of Energy's nearby Oak Ridge National Laboratory. SMR technology is not likely to be in position to meet power supply needs until the mid-2020s, assuming its promise can be realized. This technology is only beginning preliminary engineering and licensing activities. SMRs are still in the demonstration phase.

Need For New Energy Sources

An Integrated Resource Plan (IRP) produced by TVA in 2011 has been compared to an energy roadmap to 2030. The result of two years' analysis and public discussion, the IRP provides options and recommendations that closely track the vision's goals and could result in a more balanced mix of reliable, cleaner and competitively priced power sources to meet expected demand. Even with increases in energy savings — through efficiency and demand response programs — the IRP projects TVA will need more generating capacity due largely to retirement of coal units and some growth. Under most scenarios, the IRP forecast TVA will need 9,600 megawatts of additional capacity and 28,000 gigawatt-hours of additional energy supply by 2019, increasing to 15,500 megawatts and 45,000 gigawatt-hours by 2029. Since the IRP was published, decreases in load due to the economy, along with the acquisition of the Magnolia Combined Cycle Gas Plant, have decreased the need for additional capacity to 6,300 megawatts (before accounting for impacts of energy efficiency and demand response) and 11,000 gigawatt-hours of additional energy by 2019. The need by 2029 is forecasted to be 12,600 megawatts of additional capacity and 35,000 gigawatt-hours of additional energy.



Energy efficiency and demand response (EEDR) programs alone are not expected to be enough to meet TVA's predicted capacity gap by 2030. New generation will be required, especially from nuclear power.



Source: U.S. Energy Information Administration/TVA

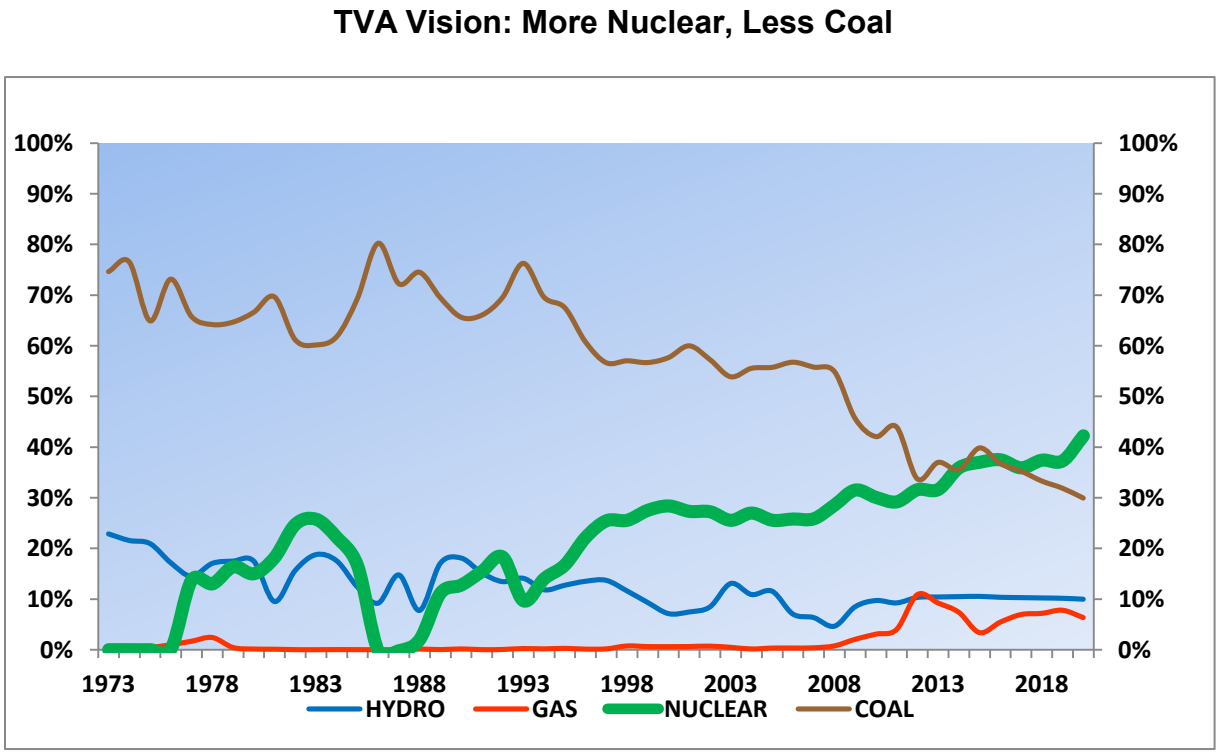
It is important to recognize that lower demand currently, caused by a mix of much milder than normal weather and lingering effects of what was the worst recession since the Great Depression, will not necessarily translate into low growth forever.

In fact, TVA's load forecasters anticipate moderate growth over the next two decades, in line with predictions from the U.S. Energy Information Administration for the nation as a whole. This moderate growth means that while TVA's need for additional resources is not as great over the next 10 years as it has been in the past, it is still significant.

TVA expects that peak demand will grow at a rate of about 1.5 percent over the period from 2013 to 2023, with energy sales growing just slightly below that rate over that same period. After accounting for the planned and anticipated retirement of older, costlier fossil assets (primarily to avoid significant capital investments required by regulation) and the impact of TVA's demand side programs, TVA expects to need well over 5,000 megawatts of resources by 2023 just to maintain its current level of reliability. This means that without any capacity additions, TVA will lack sufficient capacity to serve its load, much less provide reserves needed to maintain system reliability.

TVA has committed to idle or retire 2,700 megawatts of coal-fired generation by 2017. That represents at least 18 of 59 fossil units. Decreased sales and lower gas prices that allowed greater use of combined cycle plants have permitted TVA to accelerate this schedule. As of March 2012, TVA had idled 11 coal units (six units at Widows Creek, one at Shawnee and four units at Johnsonville). One nuclear unit can make as much electricity as five to 10 coal units without the emissions.

TVA has invested more than $5.3 billion to reduce coal-fired emissions of sulfur dioxide and nitrogen oxide by about 90 percent from their peak levels. In 2009, approximately 45 percent of TVA's generation came from non- or low-emitting generating sources (hydro, nuclear and renewable power), up from 37 percent in 2007. TVA projects that by 2029, about 53 percent of its delivered power could come from clean energy sources, including nuclear.



TVA generation from nuclear energy is expected to surpass coal by the end of the decade.

The IRP considered a variety of strategies and dozens of economic scenarios. Over its full 20-year horizon, the IRP identified the need for 1,150 megawatts to 5,900 megawatts of new nuclear generation. Completing the 1,150-megawatt Watts Bar Unit 2 reactor, a project begun in 2007 and still under way, was considered a minimum addition.

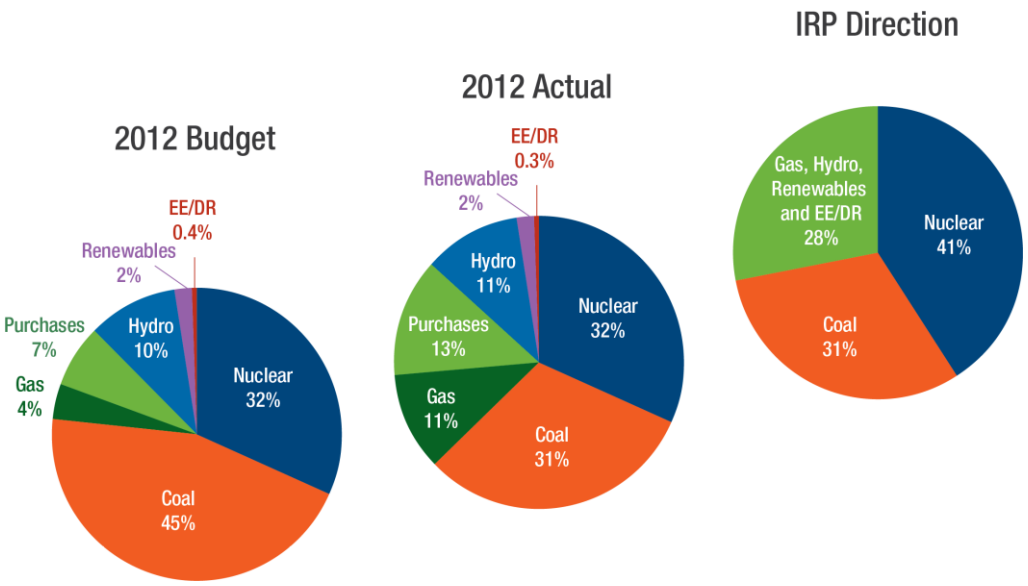
The 1,260-megawatt Bellefonte Unit 1 reactor, approved by the TVA board in 2011 for completion around the end of the decade, was selected in most IRP case studies as the most cost-effective option after finishing Watts Bar 2. New capacity will be needed to serve load reliably beginning in 2016, even with the trend toward lower growth rates in sales and demand.

TVA accounts for uncertainty in demand forecasting by making extensive use of scenario planning and staging capacity additions to allow flexibility of response to changing conditions. These measures, including regular re-evaluation of asset needs, will help to dramatically reduce chances of adding more capacity than is needed to serve customers.

TVA actions to date that follow IRP recommendations and the vision include a continuing focus on the safe operation of TVA's nuclear units while working to add new nuclear generation (completing Watts Bar Unit 2 and developing plans to complete Bellefonte Unit 1.)

A Balanced Portfolio

TVA's power generating system uses a range of technologies to meet the electricity needs of businesses, industry and the 9 million residents of the Tennessee Valley. Coal, nuclear, hydroelectric, natural gas, renewable energy and energy efficiency each have certain advantages and disadvantages. TVA must balance those against the demands of the power system and TVA's customers.



In fiscal 2011, TVA-operated generating facilities produced 143,677 gigawatt-hours of electricity, according to TVA's Form 10-K annual report. Of that, 52 percent came from coal-fired capacity, 34 percent came from nuclear, 9 percent came from hydroelectric, 5 percent came from natural gas and/or oil-fired facilities, and less than 1 percent came from non-hydro renewable resources, including wind, solar and methane.

Midway through 2012, TVA adjusted its generating mix more dramatically than anticipated in a direction outlined by the IRP to take advantage of lower gas prices and more rainfall and runoff. TVA increased both combined cycle gas generation and hydroelectric production. Additionally, lower energy demand due to an unusually warm winter and the post-recession economy allowed TVA to accelerate its planned idling of older fossil units. This reduced coal's contribution to TVA's shifting generating mix. Increasing nuclear's contribution will require additional capacity.

Complex Construction

Adding nuclear generation is not simple. These are multibillion-dollar mega-projects that take years to plan and build. They involve thousands of people from a variety of disciplines, professions and sectors who must work together in a coordinated, extended effort using materials produced from around the globe. The skills and processes required to deliver these projects are frequently held by very few companies, creating resource challenges beyond the obvious issue of maintaining resources across a multi-year schedule. Nuclear mega-projects have the added complexity of stringent quality requirements that must be integrated into every process and task by every person performing on the project.

TVA has demonstrated it can get these jobs done. One example is Browns Ferry Unit 1. Idle since the 1980s, the Browns Ferry reactor returned to service in 2007 after a five-year, $1.8 billion recovery effort. It was this country's first added nuclear generation in the 21st century. TVA is now working on a more complex undertaking — completing Watts Bar 2, which was idled in mid-construction in the 1980s and is today connected to an operating nuclear plant.

TVA has made a commitment to have only one nuclear project at a time under construction. This is a lesson from TVA's experience in the 1960s and 1970s, when TVA attempted to build 17 reactors at seven sites simultaneously in anticipation of dramatic growth in electricity demand. Ultimately, eight reactors were canceled and four were deferred when the predicted growth in demand faded. Today, engineering work will continue on the unfinished Bellefonte Unit 1, but construction won't begin until Watts Bar 2 is finished and fuel is loaded.

Operating Advantages

Nuclear plants are expensive and complicated to build, but comparatively inexpensive to operate. Nuclear is second only to hydroelectric in low production costs — fuel expenses and operations and maintenance (O&M). TVA's nuclear fuel expenses were about a half cent per kilowatt-hour in fiscal 2011, compared with 3 cents for coal, and 4 cents for natural gas and fuel oil. In 2010, TVA's combined production costs (fuel and O&M) for nuclear generation were less than 2 cents per kilowatt-hour (kWh). By comparison, hydroelectric production costs were about a penny per kWh, coal was more than 3 cents and all other sources, including natural gas and diesel, were nearly 5 cents.

The Nuclear Energy Institute found a similar pattern nationally. Citing Federal Energy Regulatory Commission data, NEI said total U.S. electricity production costs in 2010 were 2.14 cents per kWh for nuclear, 3.06 cents for coal, 4.86 cents for gas and 15.18 cents for petroleum. In benchmarking against 10 peer utilities, TVA's nuclear expenses ranked third-lowest and top quartile from 2008-2010.

TVA Fuel Expense Per Kilowatt-Hour
For fiscal years ended Sept. 30
(cents/kWh)

	2011	2010	2009
Coal	3.17	2.90	2.81
Natural gas and fuel oil	3.96	4.37	3.77
Nuclear	0.53	0.52	0.50
Average fuel cost per kWh net thermal generation from all sources	2.21	2.01	1.92

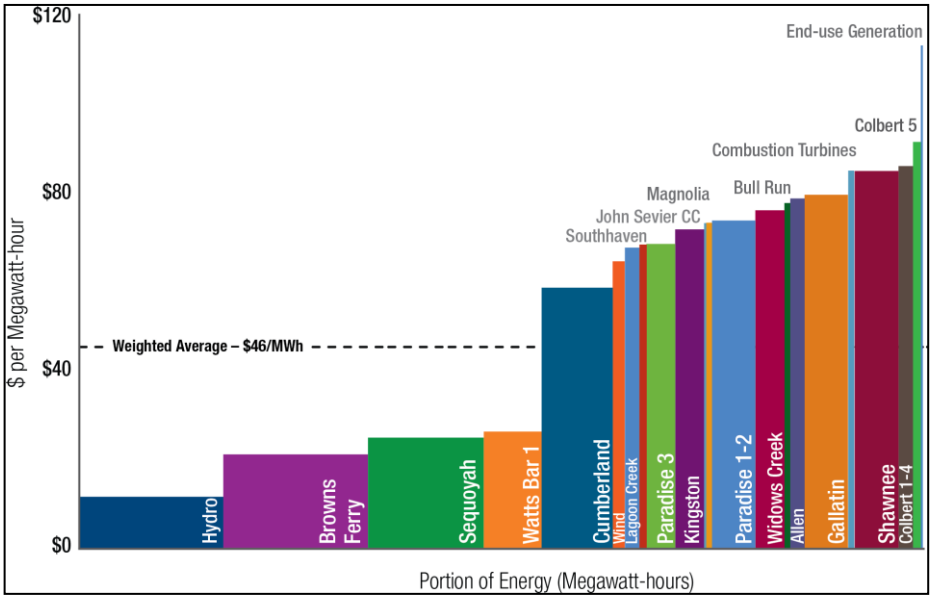
Source: FY2011 TVA 10-K annual report

Nuclear Contribution

There are various ways to calculate how efficiently and reliably a generating plant is performing. Using one set of criteria, Electric Light & Power Magazine reported that Watts Bar 1 ranked No. 6 among the nation's 104 reactors in capacity in 2010 (with a factor of 99 percent) and Browns Ferry was No. 2 in most energy generated by a U.S. plant.

This chart (at right) shows the generation contributed by various energy sources to TVA's diversified power portfolio and their total costs of production, including fuel, operations and maintenance, and capital improvements. Hydro produces energy less expensively, but nuclear (Browns Ferry, Sequoyah and Watts Bar) produces energy in greater quantity. Both have

TVA Energy Cost vs. Generation



total production costs below TVA's weighted average. TVA's 29 hydroelectric dams provide as much energy (about 10 percent) as the Browns Ferry Nuclear Plant alone. Sequoyah produces about 8 percent and Watts Bar 1 produces 3.5 percent of TVA generation. The only other generating facility that produces that much electricity for TVA is Cumberland Fossil Plant, which contributes about 6 percent of TVA's power mix, but also at a greater expense.

TVA reports that net capacity for its nuclear plants ranged from 78 percent at Browns Ferry Unit 2 to 87 percent at Sequoyah Unit 2 in fiscal 2011. Over the 2006-2010 period, TVA's nuclear fleet averaged capacity of 89 percent, which was better than TVA's coal plants and equal to combined cycle natural gas plants.

National Defense

TVA's mission under the TVA Act includes support for national defense. TVA's nuclear program has assumed certain activities that respond to that mission, including the use of surplus enriched uranium from the Department of Energy's defense stockpile as fuel in Browns Ferry and Sequoyah reactors. TVA also is evaluating the potential use of mixed oxide (MOX) fuel at Browns Ferry and Sequoyah. MOX is a mixture of uranium and plutonium that comes from surplus nuclear weapons material. In addition, TVA produces tritium, a short-lived isotope required for defense purposes, for the Department of Energy in conjunction with its power-generating operations at Watts Bar 1.

NRC Oversight

TVA is working to address performance deficiencies cited by the NRC at Browns Ferry 1 after TVA discovered, repaired and reported in 2010 a low-pressure coolant injection value failed due to manufacturing defects. The NRC issued a "red finding" denoting an issue of "high safety significance." While TVA makes material improvements to address this issues at Browns Ferry, additional corrective actions will be made over the next several years at all three nuclear plants. TVA is also responding to lesser NRC issues involving physical security at Watts Bar and unplanned reactor shutdowns at Sequoyah.

Natural Disasters/Fukushima

TVA took swift action after an earthquake and tsunami crippled a Japanese nuclear plant in 2011 to ensure the safety of TVA's nuclear plants and to look for ways to make them even safer. TVA is moving ahead with lessons learned from the Fukushima event especially to protect TVA's nuclear stations from "stacked event" disasters (an earthquake followed by a fire, for example). To ensure that TVA's plants can cool their reactors and used fuel pools if offsite power is lost, TVA is adding portable electric generators and pumps, large diesel-powered electric generators to back up existing generators and battery systems, and an array of other emergency equipment. This work is continuing, and TVA is prepared to adopt further recommendations from the industry and the NRC when those are made. TVA will incorporate these safety enhancements in all three operating plants and in the designs for completing Bellefonte.

Conclusion

Nuclear energy is and will remain an essential part of TVA's vision and power portfolio. The vision places TVA on a course to be one of the nation's leading providers of low-cost and cleaner energy by 2020, and the Integrated Resource Plan considers TVA's continued and growing reliance on nuclear power as a foundation to reaching that goal. TVA's long experience with nuclear generation has shown it to be the best source of competitively priced, baseload electricity available. One that is clean, reliable and safe.

TVA Nuclear Power
At September 30, 2011

Nuclear Unit	Status	Nameplate Capacity (MW)	Net Capacity Factor for 2011	Date of Expiration of Operating License	Date of Expiration of Construction Permits
Sequoyah Unit 1	Operating	1,221	81.1	2020	—
Sequoyah Unit 2	Operating	1,221	86.8	2021	—
Browns Ferry Unit 1	Operating	1,150	80.5	2033	—
Browns Ferry Unit 2	Operating	1,190	77.7	2034	—
Browns Ferry Unit 3	Operating	1,190	83.7	2036	—
Watts Bar Unit 1	Operating	1,230	80.9	2035	—
Watts Bar Unit 2	Under Construction	1,220	—	—	2013

Source: FY2011 TVA 10-K