Tennessee Valley Authority

Watts Bar Nuclear Unit 2

The Way Forward to Complete TVA's Seventh Reactor

April 2012

Watts Bar Nuclear Plant near Spring City, Tenn.

Introduction

TVA's Watts Bar Nuclear Plant, home to what is expected to be the first new U.S. commercial reactor of the 21st century, is located near Spring City in southeastern Tennessee. The plant's 1,700-acre site on the northern end of Chickamauga Reservoir has two Westinghouse-designed pressurized water reactors. Watts Bar Unit 1 has performed well since receiving a full-power operating license from the Nuclear Regulatory Commission (NRC) in early 1996, the last operating power reactor to be licensed in the United States.* TVA is working to complete its twin, Watts Bar Unit 2, which promises to be this country's first new reactor since Watts Bar Unit 1.

Bringing Watts Bar Unit 2 online supports TVA's vision to lead the nation in greater nuclear generation. TVA's Integrated Resource Plan (IRP) identified the project as an essential new source of safe, clean, reliable and economical baseload generation. Unit 2 will help meet growing demand for electricity in the Tennessee Valley and replace capacity lost to retiring older, more expensive coal plants in the face of increasingly expensive regulatory requirements. Watts Bar Unit 2's new generation will come without adding to TVA's overall carbon emissions. The unit is expected to generate about 1,150 megawatts (summer net capability), which would equal several coal units and could supply enough power for about 650,000 Tennessee Valley homes.

TVA has been working since 2007 to finish Watts Bar Unit 2. The project is now about 70 percent complete. This paper discusses *the way forward* to bring Watts Bar 2 into commerical operation.

Background

Watts Bar Nuclear Plant has a unique construction and licensing history. The plant was one of seven nuclear stations designed for a total of 17 reactors that TVA began building in the late 1960s and early 1970s to provide low-cost generation to keep pace with rapidly growing demand for electricity.

Watts Bar Timeline

2012....Watts Bar Unit 2 'estimate to complete.' *New cost and schedule to bring Unit 2 online*

2011....Watts Bar Unit 2 construction work force reduced. *800 workers -- to reduce cost, improve efficiency*

2009....TVA applies for Watts Bar Unit 2 operating license. *Request pending with NRC*

2007....Watts Bar Unit 2 completion authorized. *Board agrees to five-year schedule*

1996....Watts Bar Unit 1 begins commercial operation. *Last new reactor in U.S.*

1990....Watts Bar Unit 1 construction resumes. *Watts Bar Unit 2 remains deferred.*

1985....Construction on both Watts Bar units stops. *TVA addresses fleetwide regulatory concerns*

1973....Construction begins on Watts Bar Plant. *TVA is building six plants simultaneously by 1978*

1966....TVA decides to build first nuclear plant. *Browns Ferry is TVA's first nuclear station.*

* In early 2012, the NRC approved new combined construction and operating licenses for Southern Company to build two Westinghouse AP1000 reactors at its Vogtle Plant in Georgia and SCANA Corp. to build two AP1000 reactors at its V.C. Summer plant in South Carolina. The reactors are expected to be in service between 2016 and 2019.

However, by the late 1970s, the decades-long trend of growing electricity demand slowed substantially, both nationally and in the Tennessee Valley. Construction costs were rising due to inflation and new regulatory requirements stemming from the accident at the Three Mile Island nuclear plant in 1979. As a result, TVA re-evaluated its nuclear plans and ultimately canceled construction at three sites (Phipps Bend, Yellow Creek and Hartsville) and deferred construction at two others (Watts Bar and Bellefonte). At the time, TVA had two operating sites, Browns Ferry and Sequoyah.

In 1985, TVA voluntarily took its operating nuclear units (Browns Ferry and Sequoyah) out of service for safety upgrades and other program improvements. The units were subsequently returned to service once necessary improvements were made. TVA resumed construction of Watts Bar Unit 1 in 1990, leading to completion in 1996, while reaffirming the deferral of Watts Bar Unit 2 as a valuable option to be exercised for the benefit of its customers in the future.

When work stopped in 1985, Watts Bar Unit 2 was considered about 80 percent complete, with a total investment of about $1.7 billion. In the years that followed, various pieces of equipment, such as pumps, motors and valves, were salvaged for use in Watts Bar Unit 1 or in Watts Bar's sister plant, Sequoyah. A Detailed Scoping, Estimating and Planning (DSEP) study in 2007 found Watts Bar Unit 2 to be effectively 60 percent complete and estimated that Unit 2 could be finished in about 60 months at a cost of about $2.5 billion. Based on this analysis, the TVA board of directors approved the Unit 2 completion on Aug. 1, 2007. Key factors then that remain important today include:

- Completing Watts Bar Unit 2 puts an existing asset to work, harvesting a significant "installed" value.
- Completing Watts Bar Unit 2 is an achievable, low-cost option to meet the region's near-term energy needs.
- Watts Bar Unit 2 completion and operation will have no significant environmental impact.
- Nuclear power gives TVA a reliable, no-carbon, economical generating source to help keep rates low.

The board approved the project expecting that Watts Bar Unit 2 would begin commercial operation in 2012. In 2011, however, TVA suggested in public statements that Watts Bar Unit 2 was likely to exceed its original timeline and budget. A newly prepared "estimate to complete" (ETC) analysis provides ranges for costs and schedule to finish the work at Watts Bar Unit 2. The unit still is expected to be a good value for TVA's customers when compared with other energy alternatives.

TVA Vision

TVA's renewed vision, adopted by the TVA board in 2010, puts the country's largest public power supplier 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. Adding more nuclear generation is one strategic area that will benefit others through nuclear's low operating costs, high reliability, 24/7 operations and carbon-free emissions.

TVA seeks 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 greater energy efficiency and the nation in improving air quality and increased nuclear production.

The Integrated Resource Plan produced by TVA in 2011 provides options and recommendations that are consistent with the vision's goals and provide a roadmap to a more balanced mix of reliable, cleaner and competitively priced power . Energy savings through efficiency and demand response programs will help curb growth in power demand. But the IRP predicts TVA still will need significant capacity to satisfy customer growth and replace generation lost to the retirement of 2,700 megawatts of aging coal plants. As an example, the IRP baseline scenario forecasts TVA will need 9,600 megawatts of added capacity and 28,000 gigawatt-hours of added energy supply by 2019, increasing to 15,500 megawatts and 45,000 gigawatt-hours by 2029.

Although TVA's power demand growth is currently low, caused by a mix of milder than normal weather and the lingering effects from the worst recession since the Great Depression, TVA's load forecasters anticipate moderate growth over the next two decades. This is in line with U.S. Energy Information Administration estimates for the region, as well as the nation as a whole.

TVA expects that peak demand will grow at a rate of about 1.5 percent per year over the period from 2013 to 2023, with energy sales rising just slightly below that rate over the same period. After accounting for retirement of coal plants and reduced power demand achieved through TVA's demand-side programs, TVA expects to need well over 5,000 megawatts of new electric generation by 2023 just to maintain its current level of reliability. In fact, without new capacity additions TVA will not have sufficient capacity to serve its electrical load, much less provide power reserves needed to maintain system reliability.

The IRP considered a variety of strategies and dozens of economic scenarios. Over its full 20-year horizon, the IRP identified 1,150 megawatts to 5,900 megawatts of new nuclear generation as part of its recommended planning direction. Completing the 1,150-megawatt Watts Bar Unit 2 reactor was considered a minimum addition, and finishing the 1,260-megawatt Bellefonte Unit 1 reactor, approved by the TVA board in August 2011, was seen as the most cost-effective nuclear option after finishing Watts Bar 2.

Estimate To Complete

The "estimate to complete" (ETC) is a comprehensive review of the work, schedule and costs to bring Watts Bar Unit 2 into commercial operation. The study was prepared in collaboration with TVA's construction contractors and outside experts, and includes a "root cause" analysis of the factors that took the project off track.

The ETC includes detailed estimates for remaining quantities of equipment, such as the amount of conduit still to be installed; the projected labor rates for completing remaining work; and needed support activities, such as scaffolding, insulation and painting.

To provide the highest degree of confidence in the cost and schedule forecasts, two independent assessments were made to confirm the report. One assessment reviewed the methodology to prepare the ETC, and the other validated the root cause analysis. Additionally, plant walk-downs or visual inspections were conducted to determine the status of completed work and to validate the quantity of commodities needed and scope of work remaining.

The final ETC, with its new calculations for project cost and schedule, will be presented to the TVA board for approval as required under TVA's project management procedures.

Cost and Schedule Issues

TVA began a root cause analysis of Watts Bar Unit 2's schedule and costs when it became clear in 2011 that fuel load could not be accomplished before September 2012. TVA reported in its third-quarter financial filing to the Securities and Exchange Commission on Aug. 11, 2011, that "current and past estimates of the construction project cost and schedule for Watts Bar Nuclear Plant Unit 2 are currently being reviewed by TVA. The project's schedule has experienced some delays as a result of lower than expected construction productivity, and the construction of Watts Bar Unit 2 will take longer than originally planned."

The TVA analysis, independently verified by an outside firm, cited four major factors that led to an extended schedule and higher costs to complete Watts Bar Unit 2: project leadership, original estimate, project execution and project oversight.

Leadership — The capabilities of management and the project organization were not adequately matched with the unique characteristics of the Watts Bar Unit 2 project, resulting in an improper understanding and evaluation of the complexity of the project. Further, warning signs about schedule and costs did not appear to have been recognized or heeded due to insufficient oversight.

The Watts Bar Unit 2 project plan relied on lessons learned from the restart of Browns Ferry Unit 1 in 2007 rather than the completion of Watts Bar Unit 1 a decade earlier. Although the five-year, $1.8 billion Browns Ferry Unit 1 project came in on time and just slightly over budget, the experience didn't translate entirely to Watts Bar Unit 2 because:

- Browns Ferry and Watts Bar have different reactor designs. *
- Watts Bar has a smaller, tighter work environment.
- Watts Bar 2 is a construction project; restarting Browns Ferry 1 was a maintenance project.

* *Browns Ferry is a boiling water reactor in which the steam that drives the turbine-generators that make the electricity is produced in the reactor.*

Watts Bar is a pressurized water reactor in the which 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.

Estimate — An inadequate understanding of the work required on Watts Bar Unit 2 led to a significant underestimate of the project scope and complexity in terms of planning, contingencies and risks. Walk-downs to confirm plant condition, construction quantities and work to be performed were not fully completed.

Cost estimates did not account for declines in productivity (recognized in the industry) and the challenges of working in cramped places in Watts Bar Unit 2. The 2007 Detailed Scoping Estimating and Planning (DSEP) study was, in certain cases, an order-of-magnitude estimate rather than an estimate based on specific details. It presented a target cost and schedule rather than a range of potential outcomes, leading to overly optimistic projections of cost and schedule.

Execution - The DSEP was an example of inadequate, front-end project planning and incomplete definition of the scope of work. Construction was allowed to begin in some cases before engineering was complete. The ability to effectively forecast progress or plan the work was limited because the project was managed primarily through financial metrics rather than through commodity or system completion indicators that track actual engineering and field progress.

Oversight — Early warning signs of project problems were not recognized and corrective actions were not properly identified due to a lack of sufficient oversight. Project teams did not effectively use established processes that could

have addressed project deficiencies and helped make sure project goals were achieved. Project reports were unreliable and provided inconsistent information on the status of the project.

Improving Performance

As a result of the root cause analysis, the work to prepare the new "estimate to complete" and leadership changes, several corrective actions have occurred at Watts Bar Unit 2 to realign the organization and improve project management capabilities.

Process and oversight improvements were made and more detailed project monitoring tools were established to track performance. The plant established a "War Room," a dedicated room for specialists to review results and drive actions to ensure work is performed safely with high quality and in a cost-efficient manner. In addition, processes were implemented to better control changes in the scope of work projects.

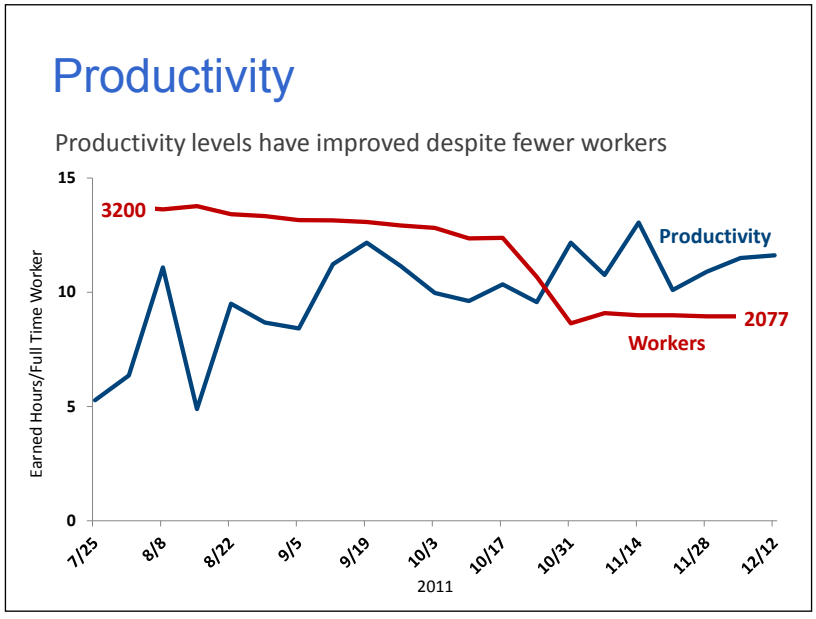
Some examples:

- Work packages which could fill a larger binder with details on specific tasks were simplified, shortened, divided and made more manageable.

- TVA and contractors created work teams for each engineering discipline – mechanical, electrical and civil — consisting of supervisors, project leads, design and field engineers, and project control specialists. TVA actively participated and provided management oversight, improving communications.

- "Tiger Teams," an industry term for a focused group of individuals assigned specific goals or initiatives, were created to investigate and solve technical and systematic problems that could impact performance. In one case, a team's recommendation resulted in saving workers several hours on each and every single weld.

- Watts Bar Unit 2's new ETC uses work rates and performance measures that are based on the actual experience at Watts Bar Unit 2.



Adjacent to an operating nuclear unit, Watts Bar Unit 2 offers limited space and cramped working conditions. TVA decided in October 2011 to reduce the work force (by about 600 craft workers and 200 support staff) to improve productivity. Results (at left) show productivity rose sharply, based on the earned-hour accomplishments of full-time workers. When 3,200 workers were on the job in August, workers were completing assignments at the rate of about five earned hours a day. By December, when about 2,100 workers were on site, the rate had more than doubled.

In January 2012, about 1,000 craft workers were sent home as a safety reminder after two on-the-job incidents occurred that could have caused injuries. The Knoxville News Sentinel praised the action in an editorial. "Nuclear power will be a growing part of the region's fabric in the coming years, replacing aging coal-burning plants and reducing our reliance on fossil fuels. But there is no margin for error at nuclear

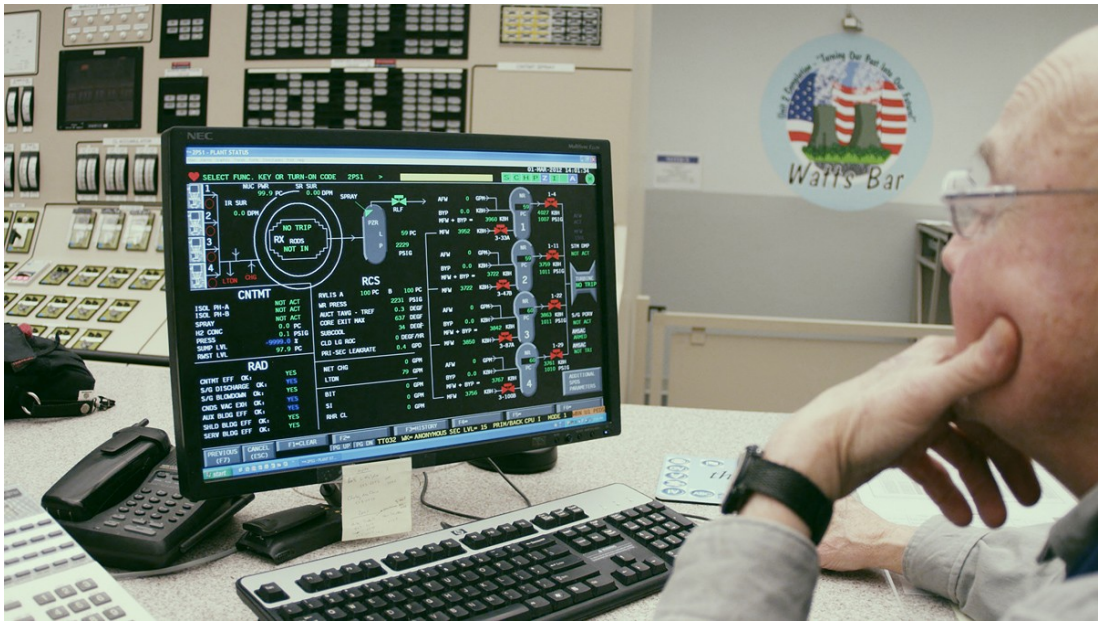
power plants. Safety, both during construction and while the plants are operating, is paramount. TVA seems to recognize that, and its leadership is taking steps to eliminate workplace dangers," the newspaper wrote.

The issue for Watts Bar Unit 2 is not the quality of the work, but the pace of the work. Corrective actions are showing improved productivity. In early August 2011, about 60 percent of scheduled work was being accomplished on a weekly basis. By January, the work force was producing weeks of 100 percent performance.

Compared with the 2007 Detailed Scoping, Estimating and Planning Project (DSEP) analysis of the Watts Bar Unit 2 project, about 70 percent of the overall project had been completed by February 2012, with instrumentation and electrical work slightly ahead of that schedule and mechanical work slightly behind.

Major Areas of Work

Much of the concrete and structures were complete when work resumed on Watts Bar Unit 2 in 2007. Here is a brief discussion of work accomplished on the plant's components since then.



An operator in the new Watts Bar Unit 2 control room reviews information from operating Unit 1.

- The control room is the command center for the plant. Each reactor has its own controls and some controls are shared in common. The Unit 2 portion of the control room has been redesigned as an ergonomically friendly space and controls are being added as new equipment is installed.

- The turbine/generator, part of the system that turns steam from the plant into electricity, was disassembled and new turbine rotors (turbine blades) were installed to improve efficiency and reliability. The generator also was refurbished to improve its reliability.

- New moisture separator re-heaters were installed. These large components take excess moisture out of the steam to prevent turbine blades from wearing out prematurely.

- The condenser in which steam is turned back into water to be re-used in the generation cycle contains more than 27,000 tubes that carry the cooling water. These tubes were replaced to ensure no leaks and long condenser life.

- Before water that isn't recycled into the generating system is released to the river, it is sent through the plant's cooling towers, where the water flows over a filter-like substance that allows the water to rapidly cool. The filter-like substrate was replaced in the Unit 2 cooling tower to bring it into new condition and ensure the river stays at a healthy temperature for fish and other aquatic animals.

- The pumps that draw in water from the river to cool safety-related plant equipment were completely reworked and tested for safe two-unit operation.

- The reactor pressure vessel, where the nuclear reaction takes place that heats the water, was treated with a structural stress reduction process. On most reactors this is done after the plant has operated for a time. At Watts Bar Unit 2, TVA was able to perform this treatment before the unit was put in service.

- The reactor coolant pumps that circulate water into the reactor pressure vessel were not in place when the decision was made to complete Unit 2. The pumps have now been installed with completely refurbished motors.

Built to withstand tornadoes and rising floodwaters, this fortified building houses four emergency diesel generators that can provide backup power to Watts Bar Unit 2.

Natural Disasters/Fukushima

On March 9, 2012, the Nuclear Regulatory Commission issued its first round of orders regarding safety enhancements in response to the earthquake and tsunami that crippled the Fukushima nuclear plant in Japan in 2011. The order requires existing nuclear plants, plants under construction (Watts Bar Unit 2) and all new plants to install more portable emergency equipment — from diesel-driven water pumps and electric generators to ventilation fans, hoses, fittings, cables and communications gear.

TVA will make these enhancements both to its operating plants (Sequoyah Units 1 and 2 , Watts Bar Unit 1 and Browns Ferry Units 1, 2 and 3) as well as its under-construction plant (Watts Bar Unit 2).

The items Watts Bar Unit 2 will receive include satellite phones, portable electric generators, portable water pumps, fire hoses and necessary fittings, portable battery carts, spare electric equipment (cable, breakers, insulators), emergency kits and radiation monitoring devices. TVA also has ordered a 3-megawatt, diesel-powered electric generator (used as a

backup to existing onsite diesel generators) and one 150,000-watt diesel generator for recharging the plant's backup battery banks.

Leadership Changes

Leadership changes are guiding the completion of Watts Bar Unit 2, beginning with the naming of Mike Skaggs, former site vice president at the Sequoyah Nuclear Plant, as senior vice president for Nuclear Generation Development and Construction in August 2011.

Three months later, TVA and main contractor Bechtel Power Corp. amended their contract to give TVA greater responsibility for the overall management of Watts Bar Unit 2 completion, including making decisions on the course of the project and establishing completion milestones.

In February, the leadership teams at Bellefonte and Watts Bar Unit 2 were realigned, with Watts Bar Unit 2 Vice President Dave Stinson moving to Bellefonte and his counterpart at Bellefonte, Ray Hruby, coming to Watts Bar Unit 2. Also joining the Watts Bar Unit 2 team was retired TVA President/COO and former chief nuclear officer Ike Zeringue.

In a corporate reorganization in February, Skaggs became a direct report to President and CEO Tom Kilgore and his organization's title and responsibility changed to simply Nuclear Construction, emphasizing the importance of nuclear power to TVA's energy mix. In this capacity, Skaggs is responsible for Watts Bar Unit 2, the Bellefonte Unit 1 completion project and other major construction undertakings, including the steam generator replacement at Sequoyah Nuclear Plant Unit 2.

Potential Value

Nuclear power is expensive and complex to build, but can generate power much more cheaply than fossil sources, second only to hydroelectric in TVA's power fleet in terms of lowest cost of operation.

In 2007, TVA determined that completing Watts Bar Unit 2 offered the best "levelized all-in cost of generating options" when compared to constructing a new nuclear plant from the ground up, an efficient coal-fired plant or a combined cycle natural gas plant. The 2012 "estimate to complete" still finds Watts Bar Unit 2 to be a lower cost option for baseload generation, compared with building a combined cycle natural gas plant.

Nuclear power has proved to be around-the-clock reliable. Watts Bar Unit 1 ranked No. 6 among the nation's 104 commercial reactors in highest capacity in 2010 , according to Electric Light & Power Magazine. The reactor's operating capacity factor since it opened in 1996 is 93 percent.

Watts Bar Unit 1, which set a mark for continous operation of 513 days in 1999-2000, has generated about 140 billion kilowatt-hours of electricity since 1996. That much electricity would be worth more than $9.5 billion at 2011 average wholesale prices.

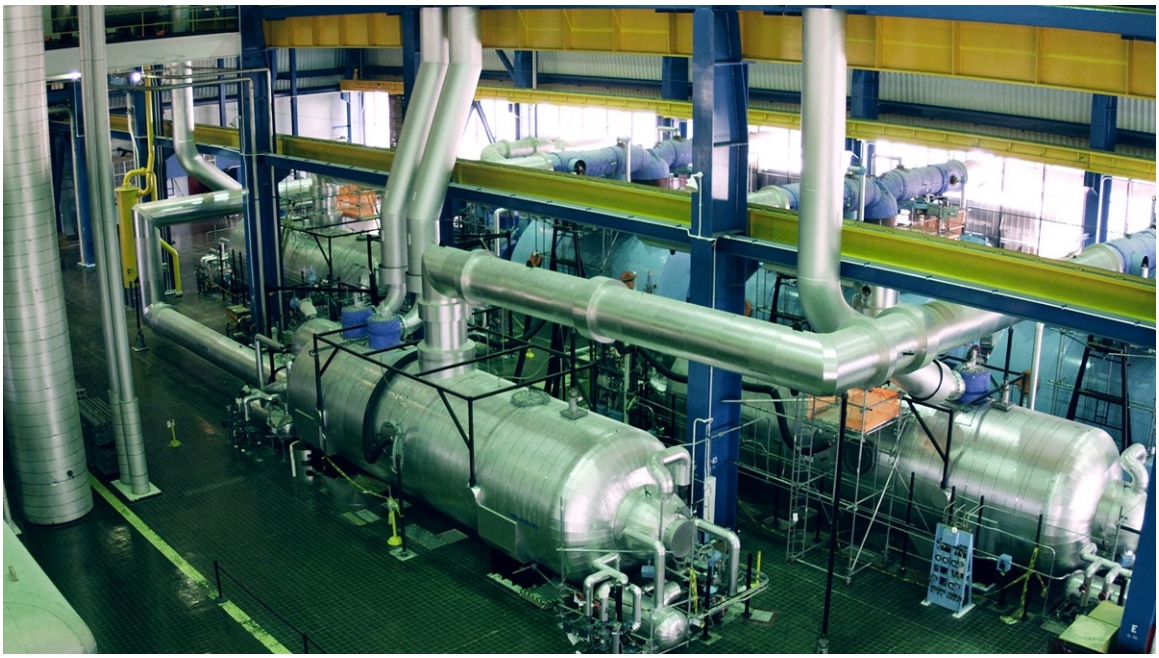
Nuclear power also generates power without carbon emissions. TVA estimates Watts Bar Unit 2 could help TVA avoid coal-fired emissions of 6 million to 8 million tons of carbon dioxide a year.

Watts Bar Unit 1 was completed 16 years ago at a total cost of about $7 billion. Cost estimates today are being given as about $9.8 billion for SCANA's two AP1000 units in South Carolina, without financing costs, and $14 billion for Southern Company's two AP1000s in Georgia, including financing costs.

About $1.7 billion was invested in Watts Bar Unit 2 before construction halted in 1985. That is already built into TVA's rates, and completing the plant unlocks the value of that investment for TVA's customers. The $2.5 billion approved in 2007 for Watts Bar Unit 2 can be compared with the $4.9 billion authorized by TVA in 2011 to complete Bellefonte Unit 1. Additional investment in Watt Bar Unit 2 will be funded through TVA debt, which, in line with TVA's financial guiding principles, will be retired over the life of the asset.

Conclusion

A new leadership team is in place. Shortcomings that led to schedule delays have been identified. New processes and management systems are being installed to better track the progress. The size of the work force is more manageable. Productivity is rising. The updated "estimate to complete" is a sound plan to bring Watts Bar Unit 2 online and deliver its energy to the region. TVA's vision is to lead the way in cleaner, low-cost power, and Watts Bar Unit 2 will play a significant role in helping TVA get there.



A view of the turbine floor in Watts Bar Unit 2 shows new moisture separator reheaters (silver) in the foreground and light blue turbines in the background.