CHAPTER 2

2.0 ALTERNATIVES INCLUDING THE PROPOSED ACTION

The purposes of the proposed action are to (1) obtain extended licenses to operate SQN Units 1 and 2 to help meet the identified need for power between 2020 and 2031; (2) maximize use of existing assets; and (3) support TVA's efforts to reduce the carbon emissions of its generating system.

In addition to continuing the operation of SQN, TVA screened a broad range of options to identify feasible alternatives available to achieve those purposes. The purpose of this section is to describe the options that were reviewed and discuss why the alternatives evaluated were chosen. A description of the alternatives development process is found in Section 2.1. The Action and No Action alternatives are described in Section 2.2. A comparison of alternatives is provided in Section 2.3. Section 2.4 provides a summary of impacts, and Section 2.5 provides a brief discussion of the preferred alternative. References for this chapter are provided in Chapter 8, Literature Cited.

2.1. Development of Alternatives

To begin the process of identifying, considering, and narrowing down the alternatives to those reasonably addressing the purpose and need of this proposed action, TVA began with the broad range of supply-side and demand-side actions identified in TVA's IRP. TVA reviewed options that would require new generating capacity (Section 2.1.1), options that would not require new generating capacity (Section 2.1.2), and a combination of those alternatives (Section 2.1.3).

The following criteria were applied to select feasible alternatives to evaluate in detail in this SEIS:

- The option must substantially meet the stated purpose and need.
- Supply-side resource options must be capable of delivering capacity and energy comparable to that provided by SQN (either individually or in combination) without substantially greater environmental impacts.
- Resource options must utilize a developed and proven technology, or one that has reasonable prospects of becoming developed and proven in time to deliver sufficient power in 2020.

In the IRP process, TVA used similar thresholds for technology feasibility, availability, and performance as criteria for selecting future energy resource options (TVA 2011a). Energy resource options dismissed from consideration in the IRP were not considered viable sources to meet the purpose and need for this project. Those options considered in the IRP were further screened using the above criteria to determine whether they meet the purpose and need of this project. The results of that screening are reported in Sections 2.1.1., 2.1.2., and 2.1.3.

Additionally, TVA conducted a resource planning study using a similar approach and methodology as used to develop TVA's IRP. The study develops a future generation plan that evaluates factors including unit capacity factors; fuel costs, operating costs, power

purchase costs, and other economic factors; and air pollutant emissions allowances. The study is designed to identify the mix of generating resources that would minimize the cost of providing power. In other words, study results show how the TVA generation system could be dispatched over time to provide the least-cost option for providing power.

All portfolio strategies evaluated in the IRP assumed that SQN operating licenses would be renewed. Figure 2-1 shows the existing (below bold black line) and planned (above bold black line) generation resources under the spring 2010 reference case for the IRP planning period (2010 – 2029). Under the recommended planning direction, the decline of existing thermal resources and the identified expansion of renewable and EEDR programs would be slightly greater than under the spring 2010 reference case. As shown in the IRP EIS, the amount and timing of implementation would vary depending upon the future scenario. However, as described in Section 1.3.1 above, these variations from the spring 2010 reference case would not materially change the outcome of the system generation portfolio shown. In this SEIS, forecasts for 2030 through 2041 are extrapolated beyond the IRP planning period assuming that the generation from TVA's existing and planned resources through the end of the SQN license renewal term (2040 – 2041) would be similar to the trends shown in the later years of Figure 2-1.

Figure 2-1 shows that, throughout the planning period, SQN generation is about 18,000 GWh annually, and that a significant generation contribution of about 26,000 GWh annually is provided by renewable resources. The addition of WBN 2 and the combined-cycle plant at JSF contribute to increases in energy provided by existing thermal (coal, gas, and nuclear) resources between 2012 and 2013. Conversely, energy provided by existing thermal resources decreases after about 2015 due to TVA's plans to idle fossil plants. Additional resources needed to meet future energy needs (Figure 1-6) consist of the planned nuclear expansion, planned gas expansion, and avoided generation from new EEDR expansion programs that are part of the IRP portfolio. In this discussion, planned resources are those identified as feasible options in TVA's existing capacity plan, but are not authorized or proposed. These additional resources would be needed even if SQN continues to operate for another 20 years.

TVA also developed future resource planning studies using the spring 2010 reference case and the assumption that SQN units are shut down in 2020 and 2021. Results of this study show the likely means for generating power using a least-cost planning strategy, if TVA takes no action to renew SQN operating licenses. Two scenarios were evaluated in the study. In the first scenario, all resource options that exist in the IRP portfolio were available to meet the need for power. The second scenario was used to model a circumstance where TVA would not construct additional nuclear power plants. In other words, additional nuclear expansion, beyond that already planned in the IRP, was not available to compensate for the loss of SQN. Results of the planning studies are described in Sections 2.1.1.1 and 2.1.1.2.

2.1.1. Alternatives Requiring New Generating Capacity

TVA considered whether building new capacity would address the forecasted need for power. Energy options were examined alone and in combination to determine if the system power requirements could be met by other energy options. Sources discussed in this section are located in the TVA power service area. Sources located outside the TVA power service area are discussed in Section 2.1.2.1.

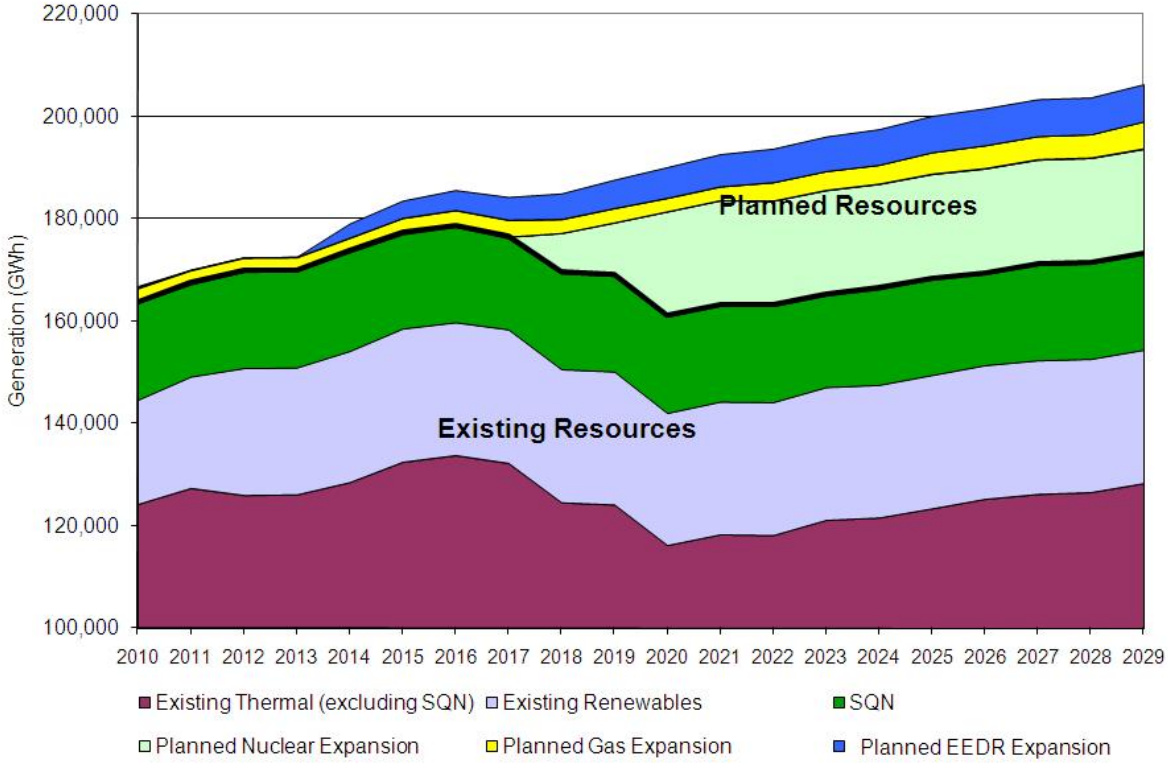

Figure 2-1. TVA System Generation Including Alternative 1 – License Renewal

2.1.1.1. New Nuclear Source

Construction of new nuclear generating capacity is a feasible alternative because nuclear plants produce base load power and have similar environmental impacts during operation as the existing SQN units.

Nuclear expansion is already part of TVA's capacity expansion plans. As described in Section 1.3 above, because the TVA Board has approved construction of WBN Unit 2, it is considered an existing thermal resource in power supply forecasts. In May 2010, TVA issued its final SEIS for the construction and operation of an 1,100 to 1,260 MW nuclear unit at the BLN site. In August 2010, the TVA Board authorized staff to continue engineering activities and the procurement of long-lead time components of BLN Unit 1. TVA's IRP shows that BLN Unit 1 and a second unit (BLN Unit 2) are identified as the least-cost resource options in many of the scenarios (plausible futures) tested in that study, except where there is no forecasted load growth. As in the BLN SEIS, TVA's IRP included the continuing operation of SQN through 2029. Therefore, this SEIS assumes that the proposed BLN Unit 1 will be in operation beginning in 2018, that BLN Unit 2 is needed to meet load even if SQN continues to operate, and therefore neither BLN Unit 1 or 2 is available as an alternative to license renewal at SQN. The IRP EIS also evaluated options for adding nuclear units in addition to a single unit at BLN.

Results of the resource planning study also demonstrated that, given the absence of relatively inexpensive power from SQN, the least-cost option for providing power would

include additional nuclear expansion beyond BLN Unit 2. Figure 2-2 shows the generation from existing and planned resources for the IRP planning period (2010 – 2029) with the assumption that SQN is shut down in 2020 – 2021. As before, this assumes that the generation from TVA's existing and planned resources through 2041 would be similar to the trends shown in the later years of Figure 2-2. Figure 2-2 shows that generation from new nuclear units grows to about 18,000 GWh annually by 2027. Between 2020 and 2027, generation would come primarily from existing thermal resources, and to a lesser extent, from gas-fired generation that would be brought online earlier than planned in the spring 2010 reference case because this is the lowest cost means of meeting capacity and energy needs during this initial period. As demand grows and energy prices increase, nuclear units become the lowest cost option and are added. Other resources already planned in the IRP resource portfolio (planned nuclear expansion, planned gas expansion, and avoided generation from new EEDR expansion programs) would contribute about the same amount of energy as they would under Alternative 1.

2.1.1.2. Fossil Fuel Energy Sources

The primary fossil fuel alternatives to nuclear-powered electrical generation at the SQN site are coal-fired generation and natural gas-fired generation. Generation using fuel oil was

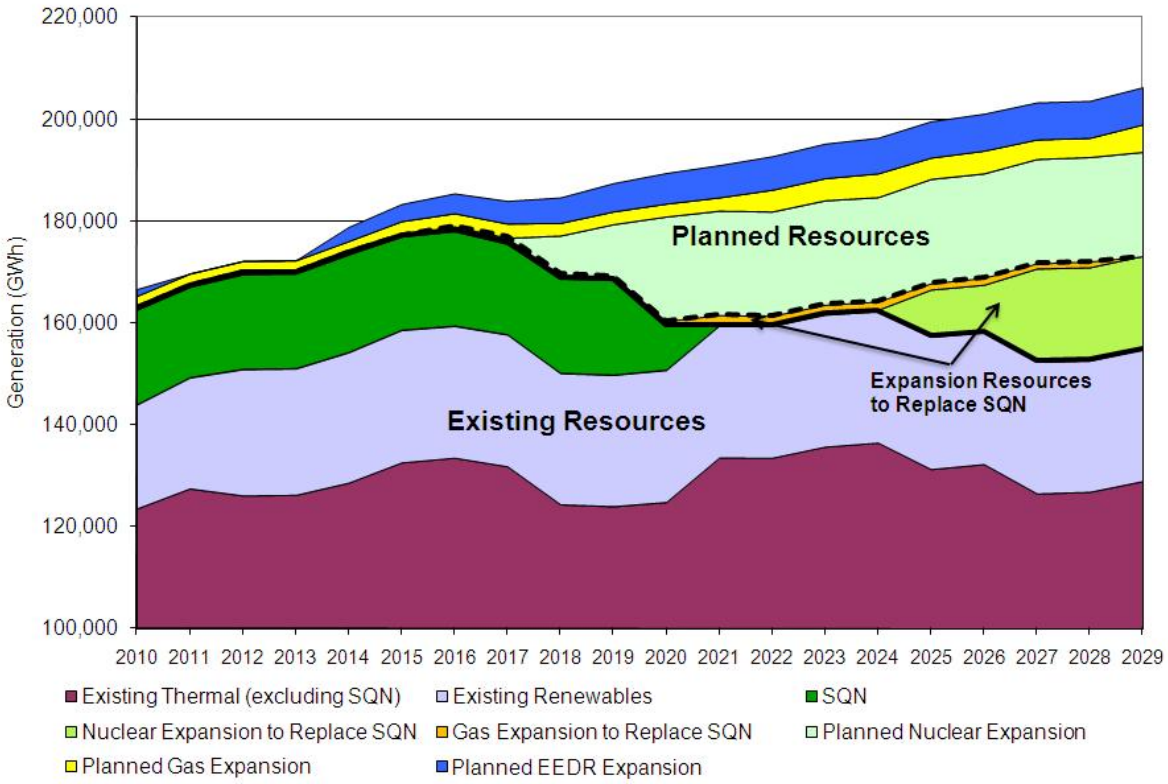

Figure 2-2. TVA System Generation Including Alternative 2a – SQN Shutdown and New Nuclear Generation

not considered a reasonable alternative to SQN license renewal in this SEIS because of higher emissions of nitrogen oxides (NO_x), carbon dioxide (CO_2), and other pollutants (TVA 2011a).

In the IRP EIS, TVA assessed several types of impacts for coal and natural gas-fired plants: air quality, waste management, land use, water use and quality, human health, ecology, socioeconomics, aesthetics, historic and cultural resources, and environmental justice. The potential environmental impacts and merits of coal-fired or gas-fired generation have not changed materially since these options were evaluated in the earlier Energy Vision 2020 IRP.

A coal-fired plant without carbon capture and storage (CCS) would contribute significantly higher amounts of emissions to the air compared to a nuclear plant.

As a means to reduce greenhouse gas (GHG) emissions from coal-fired plants, it may be possible in the future to integrate CCS technologies into conventional pulverized coal, supercritical pulverized coal, and integrated gasification and combined-cycle units. While the capture of CO_2 from a coal-fired facility is conceptually feasible, TVA does not foresee that CCS technology will be developed soon enough for use at coal-fired plants constructed in the time frame of this decision. Consequently, a coal-fired alternative using CCS technology was not considered a reasonable alternative in this SEIS.

The IRP EIS also considered both simple and combined-cycle natural gas-fueled alternatives. Combined-cycle plants direct the exhaust gas from the gas turbine of the simple cycle to a heat recovery steam generator, which feeds an additional steam turbine that drives an additional electric generator. NO_x emissions from the combined-cycle combustion turbine can be controlled, and sulfur dioxide (SO_2) emissions from the natural gas fuel are essentially zero. Their high efficiency and natural gas fuel combine to produce lower CO_2 emissions, and it is possible to construct combustion turbine or combined-cycle units as quickly as three years. Consequently, natural gas-fueled generation was evaluated in more detail in this SEIS.

Results of the resource planning study demonstrated that, without relatively inexpensive power from SQN or the option of additional nuclear expansion, the least-cost option for providing power would include construction of additional natural gas-fired facilities beyond those identified in many of the IRP resource portfolios. Figure 2-3 shows the generation from existing and planned resources for the IRP planning period (2010 – 2029) with the assumption that SQN is shut down in 2020 – 2021 and there is no additional expansion of nuclear units (beyond that already planned in the IRP). As before, it is assumed that the generation from TVA's existing and planned resources through 2041 would be similar to the trends shown in the later years of Figure 2-3. In addition to operating existing and planned resources, new (expansion) natural gas-fired units would be necessary to fully meet forecast generation needs. Generation from existing thermal resources would be increased, primarily by increasing operation of existing coal and natural gas-fired plants that otherwise would not have been operating at maximum capacity. About the same amount of energy would be generated from other resources already planned in the IRP resource portfolio (planned nuclear and gas expansion, and avoided generation from EEDR expansion programs).

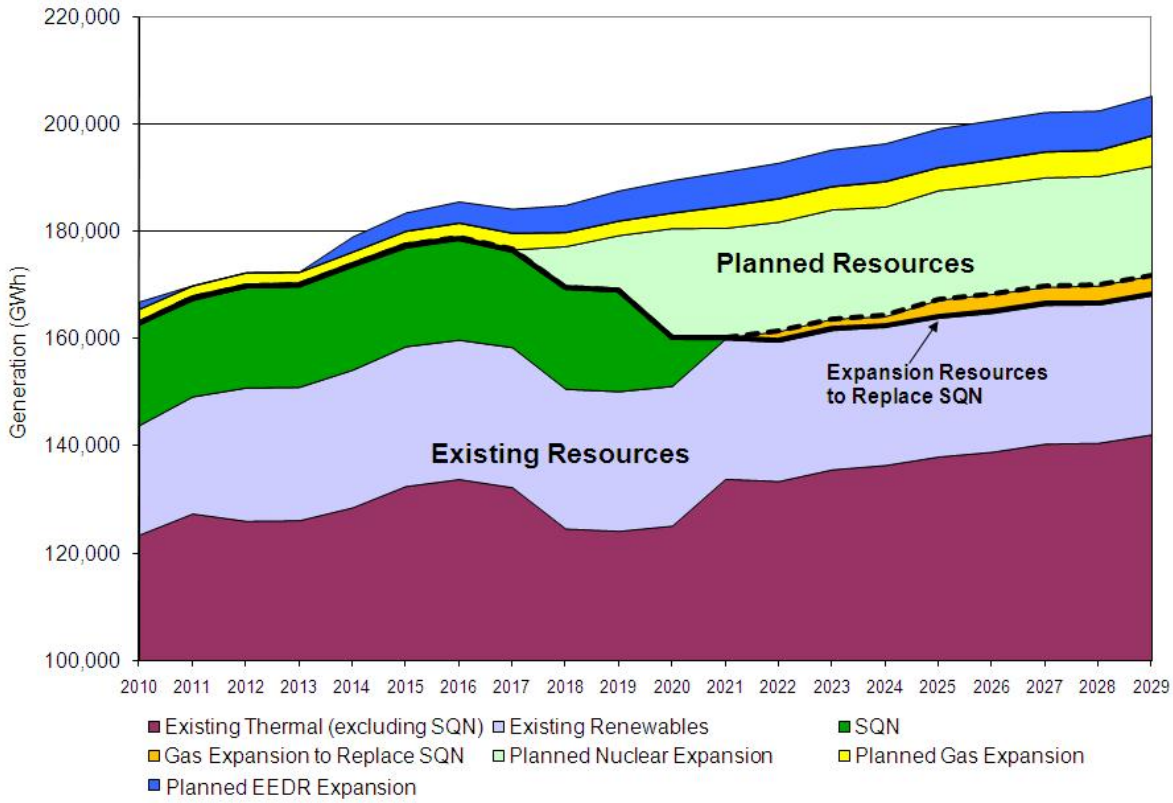

Figure 2-3. TVA System Generation Including Alternative 2b – SQN Shutdown and New Natural Gas-Fired Generation

2.1.1.3. Wind

According to state-by-state wind maps and resource potential estimates from the DOE's Office of Energy Efficiency and Renewable Energy (DOE 2010), approximately 4,200 MW of wind power capacity in the TVA power service area is available at a gross capacity factor of 25 percent or greater, based on turbine hub heights of 80 meters (m). Most current turbine installations have turbine hub heights between 50 to 80 m. However, at a turbine height of 100 m, estimates of the amount of wind capacity in the TVA power service area are as high as 5,700 MW. Hub heights of 100 m are technically feasible with current wind turbine technology, and taller turbines can help make wind power more economically feasible in low wind areas such as the TVA power service area.

Taking into account electrical losses, environmental factors, and wake effects (of surrounding wind turbines), the net capacity factor for the TVA power service area is projected to be 22 percent, which is near the low end of the typical range of net capacity factors for modern utility-scale wind power projects of 20 to 40 percent. Using wind to generate power in the Tennessee Valley is not as efficient as in other regions of the country.

Wind turbines ranging from approximately 250 watts to 5 MW are commercially available today. The average size of wind turbines installed in the United States in 2008 was 1.65 MW. Using the average turbine capacity and above capacity factor for the TVA power service area, approximately 48,200-MW wind projects, each consisting of 121 wind

turbines, would be required to generate the annual power generation needed to substantially meet the purpose and need of this project (about 9,600 MW, due to the low capacity factor associated with wind generation). The 48 projects (approximately 5,808 wind turbines) in total would require an estimated 900 sq mi of land, of which 5 percent would be occupied by turbines, access roads, switchyards, and other equipment. The remainder would be required for adequate spacing to minimize wake effects of surrounding turbines. The required area is about the size of the Great Smoky Mountains National Park. Moreover, the expected capital cost increase for installing 100-m hub height wind turbines is 5 – 10 percent over 80-m wind turbines. A substantive increase in capacity factor would be required to recover the higher investment costs. In addition, there are current infrastructure limitations such as erection crane capabilities and tower transportation limitations that present uncertainty in the practical feasibility of 100-m hub heights. Therefore, due to the amount of land, the lack of availability to produce the equivalent annual energy, and the visual impacts of 100-m hub heights, wind power alone is not a reasonable alternative to meet the project purpose and need.

Because the potential and economics for wind energy development in the TVA region are not as great as in other parts of the U.S., TVA anticipates a large portion of wind energy it obtains in the future will be generated outside the TVA region. In addition, because TVA is not eligible for investment and production tax credits available to private developers, TVA assumes future additions of wind generating capacity will be through PPAs (TVA 2011a). Section 2.1.2 below addresses PPAs as an alternative to renewing SQN operating licenses.

2.1.1.4. Solar

Generation from solar power is available in two different technologies: concentrating solar power (CSP) and PV. Due to the low rate of delivery of solar radiation within the TVA power service area, CSP technologies (i.e., solar thermal plants using parabolic troughs, power tower, etc.) were not considered a reasonable alternative in TVA's analysis. For example, direct solar radiation in Memphis, Tennessee, located in the region of the state where solar radiation is highest, is approximately 4.4 kilowatt hours per square meter per day (kWh/m^2/day) (NREL 2010), which is below the minimum level of 6.75 kWh/m^2/day required for a viable CSP generating facility (Balir 2006). Solar PV can make use of both direct solar radiation and diffuse horizontal radiation, which is one reason PV is technically feasible in more areas of the United States than CSP technologies.

The average solar radiation for PV technology was estimated from National Renewable Energy Laboratory's (NREL) solar radiation map for the western portion of the TVA power service area as 4.9 kWh/m^2/day (NREL 2010). The solar PV capacity factor in the western portion of the TVA service area is calculated at 17 percent, which is equivalent to approximately four hours of usable solar radiation available each day. Some days have more or less solar radiation available, but this assumption is used to simulate base load operation in the discussion below.

Solar PV generation is assumed to be stored in batteries that generate electricity during periods of no or low solar radiation. Battery storage systems used for energy management are those that have a deployment duration exceeding one hour. Commercially available systems come in standard unit sizes, ranging from 250 kilowatts (kW) to 2 MW. Systems of batteries are assembled to meet the needs of a particular project. One of the largest battery storage systems installed for energy management applications has a 34-MW power capacity with six hours of storage capacity (Mizutani 2009). A sodium sulfur (NaS) standard battery size of 2 MW with six hours of storage capacity and an electrical efficiency

of 70 percent was used for the purposes of this evaluation. The battery system would be recharged from the PV modules during daylight and discharged when the PV power is not available. A solar-to-electric efficiency of 8.6 percent is typical for the complete PV panel and battery system.

The total installed land area required for commercial PV on a fixed 30-degree tilt support structure with appropriate spacing between panels for roads and to avoid shadow effects is estimated to be 5.9 acre/MW. Using the above-calculated capacity factor, approximately 351 50-MW PV facilities with a total land area of 103,000 acres (about 161 sq mi) would be required to meet this project's purpose and need. The estimate of land area does not include new transmission lines that would be required and would further increase land use impact. Because a large land area is required to develop such a PV system, this option does not meet the criteria for a reasonable alternative.

2.1.1.5. Biomass

Biomass power plants use organic matter to generate electricity. Biomass is one of the few renewable power options that can be operated at a relatively high capacity factor (85 percent) and is "dispatchable," meaning that its generation can be planned and scheduled much like a conventional fossil-fueled unit. TVA is performing biomass fuel availability surveys in the region, and a comprehensive study is underway to assess the feasibility of converting one or more coal-burning units to biomass fuel. Biomass generation was a qualifying technology in TVA's request for proposal issued in 2008 for renewable resources. However, very few competitive bids sourced from biomass were received. This may suggest doubt in the marketplace about the sustainability of biomass generation in the TVA power service area at reliably competitive prices.

Agricultural and forest resources provide the most prevalent form of biomass fuel available in the TVA power service area. These include agricultural "crop" residues (i.e., by-products of harvest), dedicated energy crops (e.g., switchgrass on Conservation Reserve Program [CRP] lands), forest residues (i.e., waste products from logging operations), and methane gas by-products from livestock manure. Biomass resources such as primary milling residues (i.e., by-products of commercial mills), secondary milling residues (i.e., by-products of woodworking and furniture shops), urban wood residues (i.e., waste wood products from construction, demolition, and residential), and methane gas by-products from landfills and wastewater treatment facilities are not as prevalent in less densely populated regions such as the TVA power service area. Estimates of agricultural residues by state and county were obtained from the U.S. Department of Agriculture's (USDA) National Agricultural Statistics Service (USDA 2009a). Dedicated energy crops by state and county were estimated from data obtained from the Farm Service Agency of the USDA (USDA 2009b). Forest and primary milling residues by state and county were obtained from the U.S. Forest Service Southern Research Station's timber product output reports (USFS 2007). Secondary milling residues, urban wood residues, and methane gas amounts by state were obtained from an NREL report (Milbrandt 2005) and scaled to the area of each state within the TVA power service area.

The capacity and energy from each biomass fuel source was estimated by assuming the most likely generation technology to be used. A stoker or bubbling fluidized bed technology with a heat rate of 15,000 British thermal units (BTU)/kWh was assumed for solid fuel. For methane gas as fuel, an internal combustion engine at a heat rate of 12,500 BTU/kWh was assumed. Approximately 2,500 MW of biomass generation is estimated from agricultural and forest resources. Some 210 MW of biomass generation is estimated from nonutilized

primary and secondary mill residues and urban wood residues. Another 60 MW is estimated from landfill and wastewater treatment methane sources. While there is enough biomass available to produce the required base load capacity, the feasible capacity is much lower. There are substantial environmental impacts from converting all CRP land to produce energy crops and removing agricultural residue from the cropland.

Whether based on agricultural or forest resources, or population-based sources, biomass fuel is dispersed and must be collected and processed for use in biomass generating units. Consequently, the cost of collection system infrastructure and diesel fuel generally limits biomass collection to a 50-mile radius, which in turn limits plant capacity to a maximum of 30 – 50 MW. Biomass generating units with required emissions controls provide about the same capacity factor and environmental impacts as a small coal plant. In the context of the purpose and need, a biomass-fired plant does not meet the criteria for a feasible alternative due primarily to impacts on air quality, waste management, and the impacts of biomass fuel collection infrastructure, and is therefore not evaluated in detail in this SEIS.

2.1.1.6. Hydropower

The DOE's Office of Energy Efficiency and Renewable Energy study (DOE 2006) was used to develop an estimate of hydropower resources feasible for development within the TVA power service area. The DOE report estimates the annual average power available for development and, of available, how much would be feasible to develop. Available annual average power is based on those sites not located in zones where hydropower development is unlikely, and not co-located with existing hydropower plants. The determination of availability also did not consider ownership or control of available sites. The project feasibility criteria included such factors as land use and environmental sensitivities, prior development, site access, and load and transmission proximity.

The TVA power service area encompasses much of the state of Tennessee and portions of neighboring states. The portion of available annual average hydropower in each state was determined by estimating the number of sites within the TVA power service area for that state as compared to the number of sites in the entire state. The amount of feasible annual average power in each state was estimated to be in the same proportion as the feasible to available power in that state. Additionally, the annual average power was converted to capacity using state-specific, 30-year average capacity factors reported by the DOE's Idaho National Laboratory (DOE 2003). Using this approach, the total feasible hydropower capacity is 1,770 MW. None of the feasible capacity estimated in the TVA power service area is categorized as large power (greater than 60 MW). Seventy percent of the feasible capacity was categorized as small hydro (less than 60 MW and greater than 2 MW), and 30 percent was low power resources (less than 2 MW). Low power resources include conventional technology, ultra-low head and kinetic energy turbines, and micro-hydro power. Compared to nuclear generation, new hydropower has lower capacity factors and more severe environmental impacts. Therefore hydropower development in the TVA power service area is not a feasible alternative for meeting the project purpose and need.

2.1.1.7. Geothermal

Geothermal energy is the conversion of heat from within the earth to electricity. Electric power generation from geothermal resources has been a commercial reality in some parts of the United States for several decades. The advantage of geothermal power is the ability to be dispatchable with no emissions. However, there are very few accessible geological

formations in the TVA region, making this an unlikely source for renewable energy in the region. Therefore, geothermal alternatives are not considered reasonable alternatives.

2.1.2. Alternatives Not Requiring New Generating Capacity

TVA considered several alternatives that would not require construction of new facilities in the TVA power service area to meet the projected system needs. The alternatives below were evaluated using the criteria listed in Section 2.1, but for the reasons discussed below, were rejected from detailed consideration.

2.1.2.1. Power Purchases

TVA regularly reviews purchased power options (buying energy, capacity, or both from other suppliers for use on the TVA system) and has entered into long-term contracts to obtain firm capacity. TVA has a long-term base load purchase from the Red Hills coal-fired plant for 432 MW, a long-term lease of the Caledonia combustion turbine plant for about 900 MW, a long-term hydroelectric purchase of 362 MW from the Southeastern Power Administration, a long-term hydroelectric purchase of 330 MW from Alcoa Power Generating Inc., long-term PPAs, some of which are conditional, for wind energy resulting from the December 2008 request for proposals for renewable or clean energy sources totaling 1,350 MW, and short-term purchases from the wholesale power market. All long-term purchases continue through at least 2029. Therefore, the use of purchased power is already included in TVA's current and future capacity estimates. Purchasing additional power from other generators was not addressed further because it (1) is already part of TVA's resource portfolio, (2) transfers environmental impacts to another location, and (3) involves additional potential impacts on transmission if sources are outside the TVA power service area. There is also risk that purchased power will not be delivered. As described in Section 1.3.4, TVA must plan total generating reserves to accommodate the potential for undelivered purchased capacity.

2.1.2.2. Repowering/Uprating Electrical Generating Plants

Repowering electrical generating plants is the process by which utilities update, change the fuel source, or change the technology of existing plants to realize gains in efficiency or output. Power uprates would be a potential alternative source of base load electricity. NRC has approved power uprates for TVA's BFN and WBN since 1998, and TVA is seeking additional uprates for its BFN units. However, power uprates are not sufficient by themselves to generate the capacity and energy provided by the SQN units. TVA continues to modernize its hydrogeneration, which increases its hydrogeneration capacity by 90 MW through 2029 as indicated in the IRP. Neither the additional capacity nor additional energy available from hydropower modernization projects is sufficient to provide necessary capacity and energy in the absence of SQN. Also, TVA is considering converting some fossil units to biomass, and studies are underway to support this. Such conversions would change the operational characteristics of converted units, but would not materially address TVA's base load needs. Moreover, TVA is considering laying up additional coal-fired units. Such lay-ups increase the need to acquire resources beyond those that might be needed if SQN operating licenses were not renewed. Therefore, TVA does not consider uprates and other repowering options as feasible alternatives to meet the project purpose and need.

2.1.2.3. Energy Efficiency and Demand Response

As part of the IRP, TVA has developed program initiatives to focus on reducing energy consumption as well as decreasing peak demand. These EEDR program initiatives include the following elements:

- Residential programs for new site-built and manufactured homes, energyright® home evaluations and in-home energy assessments, heat pump and high-efficiency air-conditioning installation and maintenance, and weatherization assistance.

- Commercial and industrial programs providing technical assistance, efficiency advice, incentives, and audits for new and existing facilities.

- Demand response programs for interruptible loads, direct load control, and conservation voltage regulation.

This SEIS incorporates an EEDR program into the reference case and all other portfolios considered, and reflects the energy efficiency that can result from TVA's programmatic efforts. These reductions are in addition to naturally occurring energy savings due to existing legislation and policies, and the independent programs of its distributors. The spring 2010 reference case includes an EEDR program that reduces required energy needs by about 6,300 GWh in the 2020 – 2021 time period.

The IRP evaluates several alternative strategies for the EEDR portfolio. The three highest ranked strategies in the IRP include EEDR alternatives that reduce energy needs by up to an additional 8,500 GWh per year above the reference case — almost the equivalent of one SQN unit. However, the IRP also shows that the need for power in 2020 – 2021 is approximately 39,000 GWh, whereas the largest EEDR portfolio has projected energy savings of about 14,500 GWh in that same time frame. Therefore, even if this EEDR portfolio were implemented successfully, additional resources would still be required to meet the need for power caused by the shutdown of SQN. Some of that need could potentially be met by even more EEDR programs, but implementation challenges (i.e., participation rates, maturity of technology, external economic conditions), may reduce the effectiveness of such additional programs. So EEDR, by itself, would likely not be sufficient to meet or offset the base load power provided by SQN.

2.1.3. Combination of Alternative Sources

Combining alternatives could achieve an energy profile similar to base load operation. There are many possible combinations of the coal, gas, solar, wind, biomass, and hydro alternatives described above. Combinations can utilize storage technology with wind or solar technology, or augment the variability of wind and solar power with the responsive availability of fossil generation (coal and gas) or biomass generation.

Storage technology such as compressed air energy storage (CAES) could be combined with wind generation. TVA has an existing 1,600-MW pumped storage plant at Raccoon Mountain, near Chattanooga, Tennessee. Excess energy from lower-cost generating resources is used to pump water from Nickajack Reservoir to the upper reservoir during periods of low power demand. The pumps are reversible and utilized as turbines to produce power using water from the upper reservoir during periods of high demand. Additional pumped storage sites are available in the TVA power service area and could be developed in place of CAES to store excess wind energy from off-peak periods and produce power in periods when wind power is not available. Pumped storage plants require 2,000 to 3,000 acres for the upper pool, the generating plant, and a lower pool if another reservoir is not available. The environmental impacts associated with construction of a pumped storage plant are typical of projects of this scope and size, including recreation and scenic impacts, potential disruption of terrestrial and aquatic habitats, cultural resource impacts, and socioeconomic impacts.

A CAES facility combines features of pumped hydro storage and combustion turbines. It uses off-peak (i.e., lower cost) energy to compress air, inject it into wells, and store it in an underground reservoir such as an underground salt cavern or aquifer. During periods of high demand, the stored, pressurized air is released, heated, and passed through natural gas-fired turbines which drive the motor/generator. Development of CAES would require identification of a suitable storage location and likely would require construction of a new natural gas-fired plant.

Renewable generation also could be combined with fossil generation instead of a storage technology to provide energy when renewable resources are not available. A natural gas-fired plant generally has fewer environmental impacts than a coal-fired plant. But the natural gas-fired facility alone has environmental impacts greater than nuclear, particularly those related to the emissions of air pollutants and greenhouse gases. As a result, the combination of a natural gas-fired plant and wind, solar, or hydro facilities would have environmental impacts equal to or greater than those of SQN.

Each of the potential combinations discussed above requires large land areas and/or has impacts to air quality due to combustion of natural gas or biomass. Therefore, the environmental impacts of combinations of alternatives are substantially greater than those of the proposed operating license renewals.

2.1.4. Conclusion

TVA concluded in Section 1.3 that new generating capacity between 2020 and 2040 is necessary to maintain system reliability. TVA's existing generating supply consists of a combination of existing TVA-owned resources, budgeted and approved projects (such as new plant additions and uprates to existing assets), and PPAs. This supply includes a diverse combination of coal, nuclear, hydroelectric, natural gas and oil, market purchases, and renewable resources designed to provide reliable, low-cost power while reducing the risk of disproportionate reliance on any single resource.

TVA has considered alternatives to providing capacity and energy in 2020 – 2041, including renewing SQN operating licenses and other alternatives requiring or not requiring new generating capacity. Purchasing additional power from other generators was not addressed further because it is already part of TVA's portfolio of resources, transfers environmental impacts to another location, involves additional potential impacts on transmission if sources are outside the TVA power service area, and has increased risk components to TVA-owned and controlled resources. Power uprates are not sufficient by themselves to meet forecasted capacity needs. Even with substantial energy demand reduction through conservation measures, TVA must still add new generation to balance resources with the projected load requirements.

The addition of other types of generating capacity as an alternative to SQN operating license renewals was also evaluated and included fossil fuel energy sources as well as nuclear and renewable energy sources.

Coal-fired power was found to be least preferable environmentally due primarily to impacts on air quality, waste management, and aesthetics. A coal-fired alternative using CCS technology was not considered a reasonable alternative due to the high capital investment and operating costs and the overall implementation risk of CCS at this stage of development. Oil-fired generation was not considered a reasonable alternative due to high

emissions. None of these options are able to substantially meet the purpose and need for the proposed action.

Compared to a nuclear facility, renewable energy sources such as wind and solar have substantial land requirements for generating electricity. Additionally, to provide generation profiles similar to a nuclear unit, they must be coupled with energy storage capacity, which further increases the land requirement to compensate for additional efficiency losses, or with fossil-fueled generation, which increases the impact on air quality. Biomass as a renewable fuel can be used to provide base load power, provided an adequate fuel supply exists; however, the air quality impacts are much greater than with nuclear resources. New hydroelectric power is less environmentally preferable given its lower capacity factors, environmental impacts, and the limited availability of feasible new sites in the TVA territory.

Furthermore, when the system resources study was conducted, none of the resources above, either individually or in combination, were shown to provide the lowest-cost option for operating the TVA system. In the circumstance where SQN was not available to provide capacity and energy, the least-cost option for providing power included construction of new nuclear units, or when nuclear expansion was not an option, construction of new gas-fired combined-cycle units.

New nuclear units are an alternative in this SEIS because they produce base load power and have similar environmental impacts during operation as the existing SQN. Several features of simple cycle combustion turbines, including their relatively low capital cost, short construction times, low emissions, and rapid start-up times, make them attractive for generating peaking power during short periods of high demand, but their lower efficiencies make them unreasonable for generating base load power. Combined-cycle plants are a more feasible alternative in this SEIS because they provide higher efficiency than simple cycle plants and produce relatively low CO_2 emissions, albeit emissions that are still higher than nuclear generation.

2.2. Alternatives

As described in Section 2.1, TVA has considered a wide range of actions to supply approximately 2,400 MWe of base load power generation between the years 2020 and 2041 and to meet the other identified purposes of this proposed action. Relative to SQN, taking action to continue operation would result in pursuing renewal of the operating licenses. Taking no action to renew the SQN operating licenses would result in ceasing operation of SQN Unit 1 in 2020 and Unit 2 in 2021. Subsequently, TVA would need to rely on alternate means to provide adequate capacity and energy in the absence of SQN. As described above, alternatives sufficient to meet the project purpose and need include construction of new generating capacity along with changes in utilization of existing and planned resources. Therefore, in this SEIS, changes in the utilization of TVA power generation assets and the system energy dispatch to compensate for the loss of SQN are key components of implementing a No Action Alternative.

2.2.1. Alternative 1 – SQN Units 1 and 2 License Renewal, Action Alternative

Alternative 1 is to seek renewal of operating licenses to allow for the continued operation of Units 1 and 2 for an additional 20 years. Under Alternative 1, TVA would submit the LRA to the NRC. Assuming the NRC approves the LRA, SQN would be available as a reliable base load generation plant until midnight on September 17, 2040, for Unit 1 and until midnight of September 15, 2041, for Unit 2.

Continued Operation During the License Renewal Period

Under Alternative 1, the two Westinghouse-designed PWRs would continue to operate within the approved design basis and operational limits as allowed by the NRC licenses. Routine operations would include operation at full power for extended periods of time (approximately 18 months for a fuel cycle). Chapter 1 provides a detailed description of the SQN plant.

Under Alternative 1, the SQN nuclear reactors would continue to produce steam in the steam generators and produce electrical power by steam-driven turbine generators. The cooling water needed to support SQN power generation would be drawn from Chickamauga Reservoir. Once-through cooling would be used for the majority of the year, with cooling towers in a helper mode for approximately 112 days per year to ensure SQN complies with regulatory thermal limits. Water from the circulating water system would continue to be discharged into Chickamauga Reservoir in accordance with SQN's NPDES permit. As discussed in Section 3.1, water withdrawal and discharge would continue to be approximately 1,540 millions of gallons per day (MGD) for both units; there is very little consumptive water loss (0.1 MGD) with this method of operation.

Solid LLRW would continue to be generated during the license renewal term. During the license renewal term, the quantity of dry active waste (DAW) processed and shipped off site annually would be expected to be consistent with current annual generation volumes; for example, approximately 121 cubic meters of DAW was generated at SQN in 2008. Routine releases of small amounts of radioactive liquids and gases would also continue during the period of license renewal and would continue to be controlled in accordance with federal regulations to ensure the health and safety of the public. Section 3.18 provides a detailed discussion of radioactive wastes.

Operation of SQN during the period of license renewal would continue to support TVA's goal of reducing carbon emissions from electrical power generation. Air emissions from nuclear generation are extremely low, with emissions related mostly to the off-site uranium fuel production, transportation, vehicle use, and occasional use of on-site support equipment such as emergency diesel generators and heavy equipment. SQN's emissions are very low in comparison with fossil-fueled electrical power generation, so the continued operation of SQN would support TVA goals. It is reported that a 1,300-MW nuclear power plant would avoid direct annual emissions of about 8.5 million tons of CO_2 when compared to a similarly sized coal plant (NRC 1996); therefore, SQN avoids approximately 16 million tons of CO_2 annually [(2,400 MW/1,300 MW) * 8.5 million tons = 15.69 million tons] compared to a coal-fired plant. For further discussion of air quality, see Section 3.16.

Routine maintenance and upkeep of SQN would continue through the license renewal period to ensure the safe and reliable operation of both units. All programs, procedures, and training of personnel would ensure the units could continue to operate at a high capacity factor (>90 percent) and produce reliable base load generation.

Current work force requirements, approximately 1,144 personnel, would continue during the additional years of operation. No changes in manpower for normal operations or refueling outage support are anticipated. Very little change to current operational needs would be expected.

SQN would shut down each unit for refueling at the end of each fuel cycle. The refueling outage duration per reactor unit is typically 30 to 33 days. During each refueling outage, spent fuel would be removed from the reactor core and new fuel bundles would replace the older and unusable spent fuel. The unusable spent fuel would be stored in the spent fuel storage pools until they could be moved to the on-site ISFSI that uses dry cask storage.

The renewal of the SQN licenses would allow for the extended period of operation of the units under the same requirements, technical specifications, and limits currently in place. Any changes to the provisions of the operating licenses (i.e., license amendments) would require NRC approval in accordance with applicable regulations. No changes would be expected for the permits currently in place. The current programs, procedures, and permits would be followed; no major changes are needed to implement this alternative.

The routine plant operation and maintenance activities that would be performed during the license renewal period are not refurbishments as described in Sections 2.6 and 3.1 of the GEIS (NRC 1996) and would be managed in accordance with appropriate TVA programs and procedures.

Base Load Generation, Reliability, and Grid Stability

During the license renewal term, SQN would continue to supply approximately 2,400 MWe of base load power for a period of 20 additional years. SQN would be expected to continue to supply reliable power by maintaining an average capacity factor of greater than 90 percent. Due to its large and stable generation capacity, SQN would be able to support transmission grid stability, ensuring consistent electrical frequency and voltage.

Uranium Usage and Spent Fuel

Extended operation during the license renewal period would require the use of additional uranium for the nuclear fuel that would be needed between 2020 and 2041. Approximately 13 additional fuel cycles would be needed per reactor unit, resulting in approximately 2,400 acres of additional land being affected by the uranium mining necessary to fuel SQN (the generic calculation of land use is for the lifetime of a nuclear unit, but is conservative for this analysis of only 20 years). An extended termination date for operations would mean that additional spent fuel must be temporarily stored at an approved storage facility until the DOE can take responsibility for the spent fuel and place it in a permanent disposal or storage facility. An expansion of the spent fuel storage capacity for SQN, in addition to the current ISFSI, would be required to provide temporary storage of the additional spent fuel created from the operation of SQN during the license renewal period.

If the license renewal were approved by the NRC, TVA would have to increase on-site spent fuel storage capacity by 2026. TVA determined there were no significant impacts to the environment from construction and operation of the current on-site ISFSI (TVA 2002c). Similarly, the proposed expansion of SQN spent fuel storage capacity is expected to result in minimal disturbance to the environment. The expansion of SQN storage capacity would only require the construction of an additional concrete pad space and potential security measures. Existing on-site structures and equipment used to handle and place spent fuel into the manufactured concrete casks could be used to support the additional storage space. Programs and procedures used in association with the on-site ISFSI would continue to be used.

Spent fuel that has been removed from the reactors and put in the spent fuel pools for a sufficient duration would be moved to concrete storage packs for dry cask storage, as is currently being done. The additional concrete pad site could continue to use Holtec International (HOLTEC) Hi-Storm 100 (S) B casks and would be of sufficient capacity for handling all additional spent fuel. The HOLTEC-designed 32-capacity multipurpose canister (MPC-32) is being used along with the HOLTEC casks, and likely would be used in the future.

A specific site for the additional concrete storage pad has not been determined, but it would likely be located inside the existing security-protected area. Previous environmental assessments screened 13 potential sites to locate the current ISFSI storage pad, and a similar evaluation would be performed to choose the new additional storage pad location. Depending on the location chosen, the expansion would require minor construction activities that could potentially require excavation of concrete and soil to facilitate construction of the storage pad for the storage of the fuel outside in concrete dry storage modules. The new concrete storage pad would be of similar size and thickness to the existing concrete pad (115 feet by 243 feet and 2.5 feet thick) for the current ISFSI. (TVA 2002c)

Waste

On September 15, 2010, in an NRC staff requirements memorandum, the NRC approved the final revisions to the “Waste Confidence” findings and current regulation (10 CFR 51.23), expressing the NRC’s confidence that the nation’s spent nuclear fuel can be safely stored for at least 60 years beyond the licensed life of any reactor and that sufficient repository capacity would be available when necessary (NRC 2010).

Non-radioactive waste (general trash, hazardous waste, and special waste) would be generated at the same annual rates as they are currently generated. In 2009, SQN generated 778.1 tons of municipal solid waste (MSW), of which 59.2 tons were recycled. Hazardous waste generated in 2009 was 1,062.6 pounds. Detailed discussion of non-radioactive waste is provided in Section 3.14.

2.2.2. Alternative 2 – SQN Units 1 and 2 Shutdown – No Action Alternative

The No Action Alternative (Alternative 2) is the decision not to renew the SQN operating licenses in accordance with NRC federal regulations. If Alternative 2 is approved, TVA would have to shut down each unit on or before the current license expiration dates. Under Alternative 2, SQN would continue to operate under current licenses until midnight on September 17, 2020, for Unit 1 and midnight September 15, 2021, for Unit 2.

If SQN is shut down as required by the current licenses, each unit would then be required to enter the long-term process of decommissioning. SQN would be placed in a safe condition and all fuel would be removed from the reactor. Once SQN achieves safe shutdown conditions, the current SQN work force (1,144 permanent and contract workers) would decline over a period of a few years to a minimal maintenance size. Decommissioning activities would begin after the permanent and safe shutdown of the units is achieved and after the formal decommissioning plans are approved by the NRC. At this phase of the project, future land-use decisions would be made. During decommissioning, a new but smaller temporary work force would be employed to deconstruct the radioactive components and structures while stored radioactive waste would be shipped off site for permanent disposal. Based on potential new land-use changes, the work force would remove and clear any of the buildings, land, ponds, etc. that would not be part of the new

land-use plans for the site property. The goal of decommissioning would be to remove all radioactive materials and return the site to a condition that no longer requires any control or oversight by the NRC. The ISFSI would continue to be regulated by the NRC under its separate general license. The ISFSI would be operated as a separate facility until the DOE takes responsibility for the spent fuel and removes it from the site. Eventual decommissioning of the ISFSI would be conducted according to NRC requirements.

Upon achieving shutdown conditions, the base load electrical power generation capacity would be lost, and TVA's ability to provide adequate power could be affected. TVA has the responsibility to ensure that the loss of SQN electrical base load generation does not adversely impact the TVA transmission system and its customers. If the No Action Alternative is adopted, TVA would adjust the utilization of generation assets to meet power demand. Current forecasting and power system planning models show that, if SQN were shut down, TVA would need to build new capacity in addition to operating existing resources, implementing approved new projects (e.g., WBN Unit 2 projected to operate in 2013), and pursuing other planned expansion. Based upon the evaluation process described in Section 2.1 above, TVA has identified two alternatives to providing power in the absence of SQN. The two alternatives include constructing new nuclear generation (Alternative 2a – New Nuclear Generation) or new natural gas-fired generation (Alternative 2b – New Natural Gas-Fired Generation). If the No Action Alternative is adopted, one of those alternative strategies for meeting power demand could be implemented to meet the need for power in the TVA system.

In addition, if the SQN license is not extended and the plant is shut down, there may be impacts on transmission system reliability that require upgrades and changes to some of TVA's transmission lines and infrastructure. This could include upgrading existing lines and, possibly, building additional lines. The scope of such activities would have to be carefully evaluated, including potential environmental impacts, and would depend on constraints and demands on the TVA system in the future. Depending on the significance of any such changes, additional environmental reviews would be conducted and public input sought.

2.2.2.1. Alternative 2a – New Nuclear Generation

Under Alternative 2a, if power were no longer generated by SQN, TVA would change the way its generation system dispatches power in order to meet forecasted demand. Given that the comparatively inexpensive generation from SQN would not be available, TVA's resource planning studies indicate that the least-cost option for generating power could be provided as shown in Figure 2-2 above. This least-cost option is based on an optimized capacity plan that would minimize the cost of providing power, recognizing that the capacity and energy provided by SQN must be replaced to reliably meet future load demand. This optimized plan includes changes to the commercial operation date of resources otherwise planned in the spring 2010 reference case and the addition of new nuclear capacity beginning in 2025. In addition, increased production from existing resources (both coal and gas-fired) that would not have been operating at maximum capacity factor under Alternative 1 is also required to replace the power that would have been provided by the SQN units.

This option would be more expensive than the option of continuing SQN operations. Additionally, as noted in Section 2.1.1.2, use of any of these fossil-fueled thermal resources would produce substantially more air emissions than nuclear generation for that interim period and would slow TVA's move towards lowering carbon and other air emissions.

Nevertheless, this alternative describes a likely result of taking no action to renew SQN operating licenses.

Construction and Operation

TVA would identify a suitable site and make the decision on the type of approved reactor technology. Since 1997, the NRC has certified four new standard designs for nuclear power plants under federal regulations (10 CFR Part 52, Subpart B). These designs are the 1,300-MW U.S. advanced boiling water reactor (BWR) (10 CFR Part 52, Appendix A), the 1,300-MW System 80+ design (10 CFR Part 52, Appendix B), the 600-MW AP600 design (10 CFR Part 52, Appendix C), and the 1,100-MW Advanced Passive 1000 (AP1000) design (10 CFR Part 52, Appendix D). All of these designs are for advanced light water reactors (LWR). Four additional designs are under review and awaiting certification, and three others are undergoing pre-application reviews. Several designs in pre-application review are not LWRs; these include the helium-cooled, pebble-bed modular reactor, and the heavy water-moderated and cooled advanced Candu reactor. Information provided by the NRC as of June 2010 indicates that 18 applications for combined construction and operation licenses, for a total of 28 units, along with six applications for early site permits, have been submitted to the NRC for review. Four early site permit applications have been approved and issued.

TVA would evaluate the various available approved reactor technologies and decide which would best meet the TVA mission and goals. TVA is exploring potential use of the AP1000 reactor technology at BLN. Technology-related specifics used in this SEIS are examples only, and most are examples of the AP1000 technology design.

Construction of a new nuclear power plant at SQN is not considered feasible due to the lack of available land within the site boundaries. Under Alternative 2a, TVA would construct a new nuclear power plant at an alternate site. Construction locations may include a greenfield (i.e., undisturbed) site or a brownfield site. Siting would be conducted in accordance with the Electric Power Research Institute (EPRI) guidance *Siting Guide: Site Selection and Evaluation Criteria for an Early Site Permit Application Final Report* (EPRI 2002), the NRC Regulatory Guide 4.7 *General Site Suitability Criteria for Nuclear Power Stations* (NRC 1998), and TVA procedures that would include a site-specific environmental review.

When planning new generating facilities, TVA uses several criteria to screen potential sites. Generating facilities are often needed in specific parts of the TVA power service area in order to support the efficient operation and reliability of the transmission system. Once a general area is defined, sites are screened by numerous engineering, environmental, and financial criteria. Specific screening criteria include regional geology and local terrain; proximity to major highways, railroads, and barge access; proximity to major natural gas pipelines; proximity to high-voltage transmission lines; land use and land ownership; regional air quality; sources of process water; the presence of floodplains, proximity to parks and recreation areas; potential impacts to endangered and threatened species, wetlands, and historic properties; and potential impacts to minority and low-income populations. Through this systematic process, TVA attempts to minimize the potential environmental impacts of the construction and operation of new generating facilities. (TVA 2011a)

To select a site and complete the permitting and licensing, as well as the construction, would take several years. The required combined operating license application (COLA) would take up to two years to prepare. The NRC review of the application would take two to three years, and the construction could take five to seven years to complete, based upon TVA's experience (TVA 2010b; TVA 2007b).

It is assumed that the new nuclear power plant would have an initial 40-year license term with the opportunity to renew for an additional 20-year license term. The AP1000 plant design is for 60 years (TVA 2010b).

As stated above, construction of the new nuclear facility would take five to seven years. TVA estimated construction of a single AP1000 nuclear unit would require a peak work force of approximately 3,000 (TVA 2010b); construction of a two-unit project working simultaneously could easily require 5,000 workers. The permanent work force needed to support operation of the new nuclear plant would be expected to be approximately 1,000 permanent workers. If the AP1000 technology were chosen, the work force could be as low as 650 permanent on-site staff (TVA 2010b).

Solid LLRW would be generated by the same methods as SQN. The quantity of DAW processed and shipped off site annually would be expected to be consistent with the annual generation volumes of SQN. Routine releases of radioactive liquids and gases would also occur and would be controlled in accordance with federal regulations to ensure the health and safety of the public. Section 3.18 provides a detailed discussion of radioactive wastes.

Operation of a new nuclear plant would support the TVA goal of reducing carbon emissions from electrical power generation. Air emissions are low due to the nuclear generation, with emissions related mostly to off-site uranium fuel production, transportation, vehicle use of personnel, and the occasional use of on-site support equipment such as emergency diesel generators and heavy equipment. Nuclear power plant emissions are very low in comparison with fossil-fueled electrical power generation, so a new nuclear plant would support TVA goals. It is reported that a 1,300-MW nuclear power plant would avoid annual emissions of about 8.5 million tons of CO_2 when compared to a similarly sized coal plant (NRC 1996). Therefore, a new nuclear plant would avoid millions of tons of CO_2 annually compared to a coal-fired plant. Air quality is further discussed in Section 3.16.

Routine maintenance and upkeep of a new nuclear plant would ensure the safe and reliable operation of both units. All programs, procedures, and training of personnel would ensure the units would be able to continue to operate at a high capacity factor (>90 percent) and produce reliable base load generation.

Alternative 2a would shut down each unit for refueling at the end of each fuel cycle. The refueling outage duration per new unit would be typically one to two months. During each refueling outage, spent fuel would be removed from the reactor core, and new fuel bundles would replace the older and unusable spent fuel. The unusable spent fuel would be stored in the spent fuel storage pools.

The new nuclear plant would operate under the appropriate federal regulations and limits. Programs, procedures, and personnel would be similar to SQN. Routine plant operation and maintenance activities would be performed as allowed by regulations and would be managed in accordance with appropriate TVA programs and procedures.

Uranium Usage

The amount of uranium needed to supply the new advanced design nuclear reactors is slightly greater than the older generation units, resulting in slightly greater spent fuel than that produced by older-generation nuclear plants. Under Alternative 2a, each unit would require approximately 26 fuel cycles for the first 40 years of operation (a fuel cycle is approximately every 18 months), which is the same as the current rate of fuel cycles used at SQN.

Land Use

According to the GEIS, an advanced design LWR requires approximately 500 to 1,000 acres, excluding transmission lines (NRC 1996). TVA's existing nuclear plant sites range from about 600 acres (BLN, SQN) to over 1,500 acres (WBN). Under Alternative 2a, TVA would construct two nuclear units on a site approximately 1,000 acres in size.

Additional land would be required to support new transmission lines. New transmission facilities are typically required to transmit power between two defined points or to improve transmission capacity and/or reliability in a defined area. As with generating facilities, potential transmission line routes, substation locations, and switching station locations are screened by numerous engineering, environmental, and financial criteria. Specific screening criteria include slope, the presence of highways, railroads, and airports, land use and land ownership patterns, proximity to occupied buildings, parks, and recreation areas, and potential impacts to endangered and threatened species, wetlands, and historic properties. TVA also encourages participation by potentially affected landowners in this screening process. (TVA 2011a). In addition, it may be necessary to construct a rail spur or barge slip to an alternate site to bring in equipment during construction.

In the GEIS, the NRC staff estimated that approximately 1 acre per MW would be affected for mining and processing uranium during the operating life of a new nuclear power plant. Therefore, approximately 2,400 acres would be affected by the uranium mining necessary to refuel a new two-unit nuclear plant. (NRC 1996)

Surface Water and Groundwater Use

New intake and discharge structures would need to be constructed to provide water needs for the facility. Water used for the new nuclear plant would be expected to come from a major waterbody. TVA is planning to equip all newly constructed power plants with closed-cycle cooling, as discussed in the IRP EIS, and it would be expected that the cooling systems would use mechanical forced-draft or natural-draft cooling tower technology (TVA 2011a). Volumes of surface water used would be dependent on the reactor technology chosen, the characteristics of the site meteorology and the surface waterbody, and the type of cooling system installed. The single AP1000 unit evaluated for BLN would withdraw water from Guntersville Reservoir at the rate of 24,000 gallons per minute (gpm) (34.56 MGD) and consume 16,000 gpm (23.04 MGD) during operations while discharging 8,000 gpm (11.52 MGD) (TVA 2010b). Plant discharges would be regulated by the state in which the plant is located. Thermal and chemical controls would be implemented in accordance with NPDES permitted limits.

Depending on the hydrology of the chosen site, groundwater may be used for sanitary and potable water at the site. It is not expected that groundwater would be considered for cooling water makeup, although this option has been evaluated.

Waste

Construction-related debris common to any large construction project would be generated during construction activities and removed to an appropriate disposal site, either on site or off site. Construction debris includes waste types such as: dirt, concrete rubble, metal, wood, paper, oil, and chemicals. All debris would be recycled in an approved and licensed facility or disposed of in an approved and permitted landfill.

The wastes associated with operation of a new nuclear power plant have been analyzed, listed in various documents (e.g., NRC 1996), and are similar to the wastes generated at SQN. Volumes would vary based on the reactor technology chosen and specific programs used to control waste generation. Waste generation, handling, and shipping would be in accordance with approved procedures similar to existing procedures for SQN.

Non-radioactive waste (general trash, hazardous waste, and special waste) would be generated at rates similar to those at SQN. The AP1000 single unit would be expected to generate 400 tons per year (800 tons per year for two units) of nonhazardous solid waste. Expected hazardous waste generated by a single AP1000 unit is 1,300 pounds per year (2,600 pounds per year for two units). (TVA 2010b) Detailed discussion of non-radioactive waste is provided in Section 3.14.

2.2.2.2. Alternative 2b – New Natural Gas-Fired Generation

Under Alternative 2b, if power were no longer generated by SQN, TVA would change the way its generation system dispatches power in order to meet forecasted demand. Given that the comparatively inexpensive generation from SQN would not be available, and assuming constructing additional nuclear plants would not be an option, TVA's resource planning studies indicate that the least-cost option for generating power could be provided as shown in Figure 2-3 above.

This optimized plan includes changes in the commercial operation date of new resources otherwise planned in the spring 2010 reference case following shutdown of SQN, along with changes in the utilization of existing resources, and the addition of other new natural gas-fired resources in the period 2025 – 2029. In addition, increased production from existing thermal resources (both coal- and gas-fired) that would not have been operating at maximum capacity factor under Alternative 1 is also required to replace the power that would have been provided by the SQN units.

Under Alternative 2b, TVA would identify a suitable site and design new natural gas-fired facilities. For new natural gas-fired generating units, TVA would most likely construct combined-cycle type generation units, because they are more efficient than simple cycle units. In a combined-cycle configuration, the products of combustion, after leaving the combustion turbine, pass through a heat recovery system that converts this useful energy to steam. This steam is used in a steam turbine to produce additional electric power. (TVA 2010c) Combined-cycle systems, with their more complex heat exchange and steam turbine components, are better suited for continuous base load operation (TVA 2010c).

TVA would construct a new natural gas-fired combined-cycle plant at an alternate site. Locations may include a greenfield (i.e., undisturbed) site or brownfield site. It is estimated that the plant site would require between 110 and 132 acres, and additional land for transmission lines and natural gas pipelines could be necessary, depending upon existing infrastructure.

TVA recently evaluated construction and operation of a combined-cycle plant at the JSF facility in Hawkins County, Tennessee (TVA 2010c). For this SEIS, the JSF combined-cycle plant is used as an example of facility design, construction, and potential environmental impacts. Because no decision has been made on generator technology; TVA would evaluate the various available technologies and decide which would best meet TVA goals. Under the potential resource plan shown in Figure 2-3, two additional JSF-type combined-cycle plants would be built and operated to provide sufficient power generation. Much of the following discussion includes generic information based on two plants similar to the JSF combined-cycle plant as provided in the JSF combined-cycle EA.

Construction of a new natural gas-fired plant at SQN is not considered feasible. The SQN site is too small to place gas-fired units on site, especially before decommissioning is complete (decommissioning must be completed within 60 years of permanent cessation of operations), which would not occur in time to compensate for the loss of power generated by SQN. Under Alternative 2b, TVA would construct a new natural gas-fired combined-cycle plant at an alternate site. Construction locations may include a greenfield (i.e., undisturbed) site or a brownfield site. Obtaining permits such as air, water, NPDES, aquatic, construction, and excavation permits along with the required licenses can be a time-consuming process, and the lead time, especially for greenfield sites, can range from 18 – 36 months depending upon attainment status (TVA 2010c). Siting would be conducted in accordance with TVA procedures, which would include a site-specific environmental review. The site-specific environmental review would identify potential impacts to cultural, archaeological, and biological resources, threatened or endangered species, wetlands, floodplains, recreation resources, natural areas, visual quality, and other sensitive resources.

The anticipated lifespan of the natural gas-fired generation units can be as much as 60 years when used as peaking units; use as base load units would tend to decrease the effective lifespan. TVA conservatively assumes a 30-year lifespan for combined-cycle type plants used as base load generation, but this is primarily an accounting assumption (TVA 2010d).

Construction of the natural gas-fired units would conservatively take approximately two to four years if two plants are built at the same time. TVA estimates construction of a single plant at JSF would take approximately 24 – 26 months (TVA 2010c). Based upon data used for the JSF project, a maximum of about 1,200 construction workers would be needed to build a new facility supplying approximately 1,200 MW. Similarly, NRC information indicates peak employment during construction would be approximately 1,440 workers [(1,200 workers/1,000 MW)*1,200 MW] (NRC 1996). It is assumed that construction of the natural gas-fired facility would occur before 2030, but not before the shutdown of SQN. After construction, the new permanent operation work force would consist of approximately 180 workers [(150 workers/1,000 MW) * 1,200 MW] (NRC 1996).

Preliminary estimates indicate that as much as 0.86 million standard cubic feet per day of natural gas would be needed for the JSF plant. Operation of two natural gas-fired

combined-cycle plants as base load resources would emit approximately 1,128 tons of NO_x, 208 tons of SO_2, 576 tons of carbon monoxide (CO), and 274 tons of particulate matter (PM) each year of operation. Air quality standards would have to be met, but the air pollutants for this alternative are far greater than the nuclear alternatives described in this SEIS. (TVA 2010c) On average, a coal-fired plant produces about 2,000 pounds of CO_2 per megawatt hour (MWh) of generation, and natural gas combined-cycle generation produces about 1,000 pounds of CO_2 per MWh. (TVA 2010c)

There would be no radioactive liquids, gases, or solids generated as a result of operation of a natural gas-fired facility.

Land Use

In the GEIS, the NRC estimated that 110 acres are needed for a 1,000-MW natural gas-fired facility (NRC 1996). Assuming 110 acres per 1,000 MW, two natural gas-fired units would therefore require approximately 132 acres. As a rough estimate, construction of two combined-cycle plants could require about twice the 55 acres developed for the JSF combined-cycle plant, or approximately 110 acres (TVA 2010c). For construction at an alternate greenfield site, the full land requirement for a range of 110 to 132 acres for a natural gas-fired facility could be necessary because no existing infrastructure would be available. Additional land would be impacted by construction of transmission lines and natural gas pipelines to serve the plant. The extent of those transmission structures would depend on the characteristics and location of the alternate site. If the plant were constructed on an existing brownfield site near available infrastructure, the amount of land required to be converted to industrial use could be less.

Regardless of where the natural gas-fired plant would be built, additional land would be required for natural gas wells and collection stations. According to NRC data, approximately 4,320 acres [(3,600 acres/1,000 MW)*1,200 MW] would be needed for wells, collection stations, and associated pipelines (NRC 1996). Partially offsetting these off-site land requirements would be the elimination of uranium mining to supply fuel for SQN. In the GEIS, NRC staff estimated that approximately 1 acre per MW would be affected for mining and processing the uranium during the operating life of a nuclear power plant (NRC 1996). Therefore, approximately 2,400 acres of land would no longer be mined to supply fuel to SQN. The final location of the site, pipelines, transmission lines, gas wells, compressor stations, and support equipment would determine the overall impacts on land use.

Surface Water and Groundwater Use

New intake and discharge structures would be constructed to supply cooling water to the new facility. TVA is planning to equip all newly constructed power plants with closed-cycle cooling. Cooling water at an alternate site would likely be withdrawn from a major surface waterbody and be regulated by permit. The JSF combined-cycle plant requires withdrawal of a maximum 7.21 MGD of combined-cycle process water (TVA 2010c), while a plant equal to two JSF plants would require twice that much process water (14.4 MGD). Plant discharges would be regulated by the state in which the plant is located. Thermal and chemical controls would be implemented in accordance with NPDES permitted limits.

Depending on the hydrology of the chosen site, groundwater may be used for sanitary and potable water at the site. It is not expected that groundwater would be considered for

cooling water makeup, although the impacts were reviewed for completeness of the groundwater analysis.

Waste

Construction would be similar to construction of any large industrial facility. Construction-related debris would be generated during construction activities and removed to an appropriate disposal site, either on site or off site. Construction debris includes waste types such as dirt, concrete rubble, metal, wood, paper, oil, and chemicals. All debris would be recycled in an approved and licensed facility or disposed of in an approved and permitted landfill.

There are only small amounts of solid waste products from burning natural gas fuel. The waste generation from gas-fired technology would be minimal. Gas firing results in very few combustion by-products because of the clean nature of the fuel. Waste generation would essentially be limited to typical office wastes, waste treatment plant waste, and waste oil.

The primary wastewaters generated by the proposed combined-cycle alternative are cooling tower blowdown, clarifier sludge from the raw water treatment system, reverse osmosis reject from the makeup demineralizer plant, and a combination of heat recovery steam generator (HRSG) blowdown and evaporative cooler blowdown to the blowdown sump. Compressor wash water would be collected and normally disposed off site at an approved wastewater treatment facility.

2.3. Comparison of Alternatives

In this section, proposed actions anticipated under Alternatives 1, 2a, and 2b are compared based upon the information and analysis provided in Section 2.2 and Chapter 3. Alternatives 2a and 2b include changing the way TVA would use existing resources, as well as constructing new generation units. Impacts associated with future deployment of existing resources and expansion resources planned in the spring 2010 reference case are described in the IRP. Chapter 3 and Table 2-1 below provides a comparison of the construction and operational characteristics of SQN as described under the Action Alternative, and the new generation units as described under the No Action Alternative.

Table 2-1. Construction and Operational Characteristics of the Alternatives

Characteristics	Alternative 1 – SQN License Renewal	Alternative 2a – SQN Shutdown and New Nuclear Powered Generation	Alternative 2b – SQN Shutdown and New Natural Gas-fired Generation
Years for license application	One – two years to review license renewal application.	Three years for NRC review and approval of a COLA.	18 – 36 months depending on existing air quality and location.
Years for construction	NA - Operational	Five – seven years with simultaneous construction of both units at the same time.	Two – four years with simultaneous construction of all units at the same time.

Characteristics	Alternative 1 – SQN License Renewal	Alternative 2a – SQN Shutdown and New Nuclear Powered Generation	Alternative 2b – SQN Shutdown and New Natural Gas-fired Generation
Electrical output	2 units = approximately 2,400 MWe	2 units range from 2,000 MWe to 3,400 MWe based on technology chosen.	2 plants = approximately 1,046 MWe
Cooling system	Once-through with cooling towers available to assist when needed to comply with thermal limits.	Closed-cycle	Closed-cycle
Land use	630 acres (525 industrial area and 105 training area peninsula) already in use. No new land is needed for license renewal. Land use can be changed following decommissioning.	Approximately 1,000 acres for 2 new units sited on greenfield site converted from original condition to industrial use, or an existing brownfield site. Land use can be changed following decommissioning.	Range of 110 – 132 acres needed for 2 new plants sited on greenfield site converted from original condition to industrial use, or an existing brownfield site. Land use can be changed following retirement of the plant.
Supporting land use	2,400 acres for mining and manufacture of nuclear fuel.	2,400 acres for mining and manufacture of nuclear fuel.	Up to 4,320 acres for wells, pipelines, compressor stations, etc. (4,320 acres minus 2,400 acres offset for uranium mining elimination results in a net of 1,920 acres).
New transmission, pipelines, ROWs needed	No, already in place.	Substantial acreage could be required depending upon location of the plant.	Substantial acreage could be required depending upon location of the plant.
Construction work force	None, no major construction needed.	5,000 peak work force.	1,200 – 1,440 peak work force.
Operational work force	1,144 current work force.	650 – 1,000 permanent work force.	Approximately 180 permanent work force.

Characteristics	Alternative 1 – SQN License Renewal	Alternative 2a – SQN Shutdown and New Nuclear Powered Generation	Alternative 2b – SQN Shutdown and New Natural Gas-fired Generation
Surface water use	Withdrawal and discharge to Chickamauga Reservoir on the Tennessee River. Withdrawal = 1,540 MGD (open cycle) Discharge = 1,540 MGD (open cycle) Consumptive loss = 0.1 MGD (open cycle) NPDES permit regulates discharge volume and quality.	Likely withdrawal and discharge to a major waterbody using closed-cycle cooling. Withdrawal (AP1000) = 34.56 MGD Discharge (AP1000) = 23.04 MGD Consumptive loss (AP1000) = 11.52 MGD Needs new intake and discharge structures. NPDES permit regulates discharge volume and quality.	Likely withdrawal and discharge to a major waterbody using closed-cycle cooling. Withdrawal (JSF * 2) = 14.4 MGD Discharge of wastewater and cooling tower blowdown for the plant goes to a process pond. Needs new intake and discharge structures. Uses less consumptive water than other alternatives. NPDES permit regulates discharge volume and quality.
Groundwater use	No groundwater is pumped from the area of the site; all potable water comes from off-site sources.	Potential use of groundwater for sanitary and potable uses. Groundwater use for makeup water is not probable.	Potential use of groundwater for sanitary and potable uses. Groundwater use for makeup water is not probable.
Quantities of solid, hazardous, and radioactive waste generated	SQN produces waste in several forms. Solid LLRW generated in 2009 = 121 cubic meters DAW. Municipal solid waste generated in 2009 = 778.1 tons. Hazardous waste generated in 2009 = 1,062.6 pounds. Regular trash from offices and maintenance is contracted for disposal off site. SQN has a RCRA permit for hazardous waste but is often a small quantity generator. Radiological waste,	A new nuclear plant produces waste in forms similar to SQN. Solid LLRW generated would be similar to SQN. Municipal solid waste (AP1000) expected to be 800 tons per year. Hazardous waste (AP1000) expected to be 2,600 pounds per year. Major volumes of dirt, fill, wood, concrete, during construction. Once operational, regular trash from offices and maintenance is normally contracted for disposal off site.	No radioactive waste. Very minor waste volumes. Major volumes of dirt, fill, wood, concrete, during construction. Only normal office, wastewater treatment and oily type waste normally.

Characteristics	Alternative 1 – SQN License Renewal	Alternative 2a – SQN Shutdown and New Nuclear Powered Generation	Alternative 2b – SQN Shutdown and New Natural Gas-fired Generation
	resins, and DAW, and radioactive trash such as rags and clothing are easily handled and packaged for temporary storage and shipment. Spent fuel is stored on site in spent fuel pools and an ISFSI until a permanent DOE repository is created.	A new nuclear plant would require an RCRA permit for hazardous waste, but will normally be a small quantity generator. Radiological waste, resins, DAW, and radioactive trash such as rags and clothing would be easily handled and packaged for temporary storage and shipment. Spent fuel would be stored on site in spent fuel pools and eventually in an ISFSI until a permanent DOE repository is created.	
Air emissions	SQN avoids 16 million tons of CO_2 annually (compared to a coal plant). Nuclear power generation is not a major contributor to air pollutants. Exhaust emissions from machinery and vehicles. Minor air emissions when diesel generators and intermittent sources operate.	A new nuclear plant would be expected to avoid 16 million tons of CO_2 annually (compared to a coal replacement plant). Fugitive dust emissions during construction. Exhaust emissions from machinery and vehicles. Minor air emissions when diesel generators and intermittent sources operate. The nuclear fission process does not contribute to the pollutants or greenhouse gas.	1,128 tons of NO_x, 208 tons of SO_2, 576 tons of CO, and 274 tons of PM produced each year. Natural gas produces approximately 1,000 pounds of CO_2 per MWh. Exhaust emissions from machinery and vehicles. Minor air emissions when diesel generators and intermittent sources operate.
Air emissions of TVA Generating System SO_2 (kTons)	75	89 (2020 – 2024) 78 (2027 – 2029)	92

Characteristics	Alternative 1 – SQN License Renewal	Alternative 2a – SQN Shutdown and New Nuclear Powered Generation	Alternative 2b – SQN Shutdown and New Natural Gas-fired Generation
NO_x (kTons)	35	41 (2020 – 2024) 37 (2027 – 2029)	42
CO_2 (MTons)	74	85 (2020 – 2024) 77 (2027 – 2029)	88
Mercury (lbs)	562	695 (2020 – 2024) 587 (2020 – 2029)	734
Radioactive emissions	Radiation dose to workers and the public within limits specified by federal regulation. SQN radiation dose impacts are currently less than 1 percent of all off-site public dose limits.	Health effects are similar to SQN operation. A new nuclear plant would operate within federal limits and compliance ensures safety of public.	None.

2.4. Summary of Impacts

Table 2-2 below provides a summary of the potential environmental impacts of the Action and No Action Alternatives. As a general guide to the evaluation of impacts for this SEIS, significance is used as a subjective interpretation of the intensity of the impact. As used here, the term **minor** means so small that there will be no alteration of the resource. **Moderate** is used as a term for impacts that can be observed and must be considered as causing some change to the resource. A **substantial** or **major** impact clearly produces an observable impact, and the impact would clearly need to be evaluated for mitigation or producing an impact that may eliminate it from consideration due to a definite negative impact. The terms minor, moderate, and substantial or major are used to evaluate impacts throughout this SEIS.

The Action and No Action alternatives vary significantly in cost. Implementing the No Action Alternative would increase costs by about $4 billion. To determine relative costs associated with implementing the Action and No Action alternatives, TVA calculated the present value of revenue requirements (PVRR), which is the discounted sum of the costs of constructing and operating all existing and planned generating units for 2010 – 2029 (as shown in Figures 2-1, 2-2, and 2-3). Under Alternative 1, the PVRR is $60.33 billion. Under Alternatives 2a and 2b, the PVRR is $64.41 billion and $64.48 billion, respectively. In other words, generation costs between 2010 and 2029 would be between $4.08 billion and $4.15 billion greater if SQN operating licenses were not renewed (as described under the No Action Alternative) than if SQN operating licenses were renewed (as proposed under the Action Alternative).

There are also substantial differences between the alternatives concerning air emissions. Projections of system-wide emissions of SO_2, NO_X, CO_2, and mercury between 2020 and 2029 are show for each alternative in Table 2-1 above. Should TVA decide to take no action to renew SQN operating licenses, the likely increased use of existing gas and coal-

fired units, as well as the construction of additional gas units, would increase emissions from those sources. Under Alternative 1, continued operation of SQN helps reduce emissions of carbon and air pollutants, consistent with TVA's environmental policy.

2.5. The Preferred Alternative

TVA has identified Alternative 1 – SQN Units 1 and 2 License Renewal as the preferred alternative. Implementing the preferred alternative would provide the Tennessee Valley with an additional 20 years of reliable base load power while promoting TVA's efforts to reduce carbon emissions, make beneficial use of existing assets, and deliver power at the lowest feasible cost. As an existing plant, continued operation of SQN would not result in additional environmental impacts while contributing to meeting the demand for base load energy sources on the TVA system in the future.

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Table 2-2. Summary of the Environmental Impacts of the Action and No Action Alternatives

Resource	Attribute/Potential Effects	Alternative		
		1 – SQN License Renewal	2a – SQN Shutdown and New Nuclear Generation	2b – SQN Shutdown and New Natural Gas-Fired Generation
Surface Water	Chemical or thermal degradation of surface water quality.	There would be no major construction activities. All releases to surface water would be controlled as per NPDES permits and remain minor. SQN complies with current NRC and TDEC regulations. No change anticipated regarding potential impacts from the current level of minor impacts anticipated. Direct, indirect, and cumulative effects of chemical and thermal discharges would be minor.	Temporary and minor impacts from sedimentation and erosion during construction. No cumulative construction impacts are anticipated. Compliance with NPDES permit would limit potential impacts. Cooler discharge due to closed- cycle cooling. Thermal impacts would be minor and would be mitigated by derating if necessary. Direct, indirect, and cumulative effects of chemical discharges would be minor.	Alternative 2b would be similar to Alternative 2a and would have similar impacts on surface water.
	Changes to hydrology and consumptive use of surface water.	No change in current level of minor impacts to water supply. No cumulative effects to water supply are expected.	Impacts would depend on the volume of water withdrawn for makeup and the source of water. A new plant would be built with a closed-cycle cooling system, increasing surface water consumption. Overall impacts of water use could be minor during normal flows and possibly substantial during extreme low-flow conditions.	Effects on water supply would be similar to Alternative 2a, but on a smaller scale. Impacts would be minor.

Resource	Attribute/Potential Effects	Alternative		
		1 – SQN License Renewal	2a – SQN Shutdown and New Nuclear Generation	2b – SQN Shutdown and New Natural Gas-Fired Generation
Groundwater	Chemical and radiological impacts to groundwater quality.	Minor impacts.	Minor radiological impacts on groundwater quality.	No radiological impact on groundwater.
	Groundwater use.	No groundwater use. No impact anticipated.	If used for sanitary and potable water, there could be a minor impact. If used for makeup water and/or cooling water, then impacts could be moderate to substantial.	Alternative 2b would be similar to Alternative 2a and would have similar impacts on the groundwater resource.
Floodplain and Flood Risk	Construction or modification of the floodplain.	No increase in flood risk in the Chickamauga Reservoir watershed.	All proposed construction would be evaluated to ensure consistency with Executive Order 11988. Dredging would be a repetitive action with minor impacts.	Alternative 2b would be similar to Alternative 2a and would have similar impacts on the floodplain.
	Flooding of the plant site from the river, lake, or probable maximum precipitation.	No cumulative effects to flood risk.		

Resource	Attribute/Potential Effects	Alternative		
		1 – SQN License Renewal	2a – SQN Shutdown and New Nuclear Generation	2b – SQN Shutdown and New Natural Gas-Fired Generation
Wetlands	Destruction of wetlands or degradation of wetland functions.	No impact.	Impacts due to construction, including transmission lines, would range from minor to substantial. Consistent with Executive Order 11990, a new plant would not be constructed in wetlands unless there were no practicable alternative.	Alternative 2b would be similar to Alternative 2a and would have similar impacts on any wetlands.
Aquatic Ecology	Destruction of aquatic organisms; degradation or destruction of aquatic habitat.	No new impact. No change from current minor impacts on fish populations from impingement and entrainment. Thermal impacts to aquatic species in Chickamauga Reservoir would continue to be minor.	Impacts could range from minor to substantial depending on plant design, organisms present, source water, and receiving water. Dredging would have minor direct and indirect effects. An NPDES permit regulating discharge and temperature of toxic substances would be required.	Alternative 2b would be similar to Alternative 2a and would have similar impacts on the aquatic ecology.

Resource	Attribute/Potential Effects	Alternative		
		1 – SQN License Renewal	2a – SQN Shutdown and New Nuclear Generation	2b – SQN Shutdown and New Natural Gas-Fired Generation
Terrestrial Ecology	Removal or degradation of terrestrial vegetation, wildlife habitat, and/or wildlife.	No substantial change from current SQN operations. No indirect effects.	Substantial direct impacts could occur from clearing and construction operations if a greenfield site is selected. Minor indirect impacts may occur. Likely to result in minor cumulative impacts due to potential collective habitat loss, habitat fragmentation, and decreased biological diversity. Construction of associated transmission lines could result in minor cumulative impacts. Impacts less likely if construction occurs on a brownfield site.	Alternative 2b would result in impacts similar to those associated with Alternative 2a, but would be smaller in scale due to smaller size.

Resource	Attribute/Potential Effects	Alternative		
		1 – SQN License Renewal	2a – SQN Shutdown and New Nuclear Generation	2b – SQN Shutdown and New Natural Gas-Fired Generation
Endangered and Threatened Species	Mortality, harm, or harassment of federally listed or state-listed species including impacts to their critical habitat.	No new direct impacts. No indirect or cumulative impacts.	Clearing and construction could result in substantial direct impacts, depending upon the location chosen. Minor to substantial indirect impacts associated with potential habitat loss and fragmentation, and decreased biological diversity could occur. Site-specific environmental review would identify protected species and their habitats. TVA would comply with the Endangered Species Act, and evaluate measures to avoid or minimize impacts.	Alternative 2b would result in impacts similar to those associated with Alternative 2a.
Natural Areas	Degradation of the value or quality of natural areas.	No new direct impacts. No indirect or cumulative impacts.	Direct impacts are unlikely. New plant would be constructed at a distance from most natural areas. Minor indirect and minor to substantial cumulative impacts may occur because of habitat loss and fragmentation, and decreased biodiversity.	Alternative 2b would result in impacts similar to those associated with Alternative 2a.

Resource	Attribute/Potential Effects	Alternative		
		1 – SQN License Renewal	2a – SQN Shutdown and New Nuclear Generation	2b – SQN Shutdown and New Natural Gas-Fired Generation
Recreation	Degradation or elimination of recreational facilities or opportunities.	No impacts.	Impacts could range from minor to moderate, depending upon site location. Potential adverse impacts resulting from construction and operation would be evaluated.	Alternative 2b would result in impacts similar to those associated with Alternative 2a.
Archaeology and Historic Structures	Damage to archaeological sites or historic structures.	No direct, indirect, or cumulative effects within SQN site or vicinity are expected.	Depending on the site, the effects could range from minor to substantial. Direct, indirect, and cumulative impacts would be evaluated, with historic properties identified and managed per the National Historic Preservation Act Section 106 process.	Alternative 2b would result in impacts similar to those associated with Alternative 2a.
Visual	Effects on scenic quality, degradation of visual resources.	No new impacts.	Potential removal of SQN structures would make the SQN site less visible. The level of impact anticipated during construction and operation would range from minor to moderate.	Alternative 2b would result in impacts similar to those associated with Alternative 2a.

Resource	Attribute/Potential Effects	Alternative		
		1 – SQN License Renewal	2a – SQN Shutdown and New Nuclear Generation	2b – SQN Shutdown and New Natural Gas-Fired Generation
Noise	Generation of noise at levels causing a nuisance to the community.	Impacts would be minor; no change from the current condition.	Noise associated with construction would be minor for the surrounding communities, and minor to moderate for the nearest residents. Noise associated with operation of a new plant is expected to be minor. Construction noise associated with new transmission systems is expected to be minor.	Alternative 2b would result in impacts similar to those associated with Alternative 2a.
Socioeconomics and Environmental Justice	Changes in local population, employment, and incomes.	No changes in operating employment levels. No new impacts to population, local employment, or income.	Impacts range from minor to moderate, depending upon the size of the population and existing amenities near the selected site. The action could result in the creation of new direct and indirect jobs during construction. The closure of the SQN plant and subsequent loss of operational jobs would have a negligible effect on the socioeconomic conditions in Hamilton County.	Alternative 2b would result in impacts similar to those associated with Alternative 2a, but on a smaller scale.

Resource	Attribute/Potential Effects	Alternative		
		1 – SQN License Renewal	2a – SQN Shutdown and New Nuclear Generation	2b – SQN Shutdown and New Natural Gas-Fired Generation
	Disproportionate effects on low-income and/or minority populations.	No disproportionate effects on low-income or minority populations.	Potential effects might disproportionately impact minority or low-income communities depending on location. Negligible socioeconomic impacts expected with the closure of SQN; therefore, no disproportionate impacts to minority and low-income populations.	Alternative 2b would result in impacts similar to those associated with Alternative 2a, but on a smaller scale.
	Changes in availability of housing.	No changes or new impacts.	Impacts on local and regional housing markets would be location dependent and range from minor to substantial. Potential short-term, minor negative effects on the housing market, specifically in Hamilton County.	Alternative 2b would result in impacts similar to those associated with Alternative 2a, but on a smaller scale.

Resource	Attribute/Potential Effects	Alternative		
		1 – SQN License Renewal	2a – SQN Shutdown and New Nuclear Generation	2b – SQN Shutdown and New Natural Gas-Fired Generation
	Effects on water supply and wastewater.	No changes or new impacts.	Interconnecting to existing systems could require the development of additional capacity. Increased population could require the development of additional capacity. Demand on the Hamilton County water and wastewater systems would lessen, but impact would be negligible.	Alternative 2b would result in impacts similar to those associated with Alternative 2a, but on a smaller scale.
	Police, fire, and medical services.	No changes or new impacts.	Support from local emergency service providers would be necessary during construction and operation. Demand for emergency services near SQN may lessen, but impact would be minor and temporary due to growth trend in the county.	Alternative 2b would result in impacts similar to those associated with Alternative 2a, but on a smaller scale.

Resource	Attribute/Potential Effects	Alternative		
		1 – SQN License Renewal	2a – SQN Shutdown and New Nuclear Generation	2b – SQN Shutdown and New Natural Gas-Fired Generation
	Schools and education.	No changes or new impacts.	The costs of providing education for additional students should be offset by the increase in tax revenues and plant-equivalent payments. Demand for school services near SQN may lessen, but impact would be minor and temporary due to growth trend in the county.	Alternative 2b would result in impacts similar to those associated with Alternative 2a, but would be on a smaller scale.
	Changes in land use, land acquisition, land conversion, or road locations.	No changes in on-site land use and no new off-site impacts.	No change in land use at SQN is anticipated. Depending on the location of the new plant site, ROWs, the transmission inter-tie connection, and rail spur could result in potentially substantial land-use impacts.	There could be a resulting decrease in off-site land-use impacts due to decreased demand for uranium supplies.
	Local government revenues.	No impact on local government revenues.	In-lieu-of tax payments would have a positive and beneficial impact on local government revenues. The amount of in-lieu-of tax payments Hamilton County receives likely would not be impacted if SQN were shut down.	Alternative 2b would result in impacts similar to those associated with Alternative 2a, but on a smaller scale.

Resource	Attribute/Potential Effects	Alternative		
		1 – SQN License Renewal	2a – SQN Shutdown and New Nuclear Generation	2b – SQN Shutdown and New Natural Gas-Fired Generation
	Elevated levels of traffic from construction work force and deliveries.	No changes or new impacts expected.	Mitigation of potential transportation impacts due to the location of a facility may be necessary due to expected increases in construction and operation traffic. Traffic would decline on SQN access roads.	Alternative 2b would result in impacts similar to those associated with Alternative 2a, but on a smaller scale.
Solid and Hazardous Waste	Generation and disposal of solid and hazardous waste.	No impacts from construction. Minor indirect impact of off-site disposal in permitted landfills.	Minor indirect impact during construction and operation from off-site disposal in permitted landfills are likely. Minor cumulative impacts expected.	Alternative 2b would result in impacts similar to those associated with Alternative 2a.
Seismology	Seismic adequacy.	No changes or new impacts are expected.	No adverse seismic effects anticipated. Extensive seismic analysis required prior to choosing a location. Impacts related to seismic activity would be minor.	Alternative 2b would result in impacts similar to those associated with Alternative 2a. Seismic evaluations would not be as rigorous as required for a new nuclear plant.

Resource	Attribute/Potential Effects	Alternative		
		1 – SQN License Renewal	2a – SQN Shutdown and New Nuclear Generation	2b – SQN Shutdown and New Natural Gas-Fired Generation
Air Quality	Emissions resulting in increases of air pollutants.	SQN is not a significant source of pollutants, and the impact of operation for an additional 20-year period would be minor.	Construction impacts are short term and can be mitigated in many cases. The overall impacts to air quality would be minor if there were no existing air quality issues; however, the impacts could be potentially large if the site were in a nonattainment area. Small indirect impacts off site and no cumulative impacts due to construction. Impact of a nuclear plant on air quality would be minor. TVA would obtain appropriate permits and maintain air emissions in compliance with regulatory limits.	Construction impacts of a new natural gas-fired plant would be expected to be similar to Alternative 2a. Depending on the chosen location, operation of typical combined-cycle combustion turbine gas-fired generation plants have minor to moderate impacts on air quality. Air emissions would meet all required regulations.
	Local meteorology and meteorological conditions.	Operation of SQN has no noticeable effects on the local meteorology, with the exception of a slight increase in frequency, duration, and intensity of steam fogs forming at the river surface.	A new nuclear plant is not expected to adversely affect local meteorological conditions.	A new natural gas-fired plant is not expected to adversely affect local meteorological conditions.

Resource	Attribute/Potential Effects	Alternative		
		1 – SQN License Renewal	2a – SQN Shutdown and New Nuclear Generation	2b – SQN Shutdown and New Natural Gas-Fired Generation
	Climatology and effects due to climate change.	The impacts from global climate change and greenhouse gas emissions upon SQN would be expected to be minor. Cumulative impacts over an additional 20 years of operation would offset millions of tons of greenhouse gases that otherwise would be produced by fossil fuel-fired generation. License renewal would provide TVA flexibility in reducing greenhouse gas emissions from its portfolio of generating assets.	Impacts from global climate change and greenhouse gas emissions would be expected to be minor.	A natural gas-fired plant would contribute a considerable amount of greenhouse gas emissions for the life of the plant. The impacts are direct and indirect, as well as potentially cumulative.
	Radiological gaseous emissions.	All radioactive effluents would be released in accordance with applicable regulations, and the impact from those effluent releases would be minor. Indirect and cumulative impacts would be minor.	There would be no radioactive effects during the construction of a new nuclear plant. There would be no expected observable direct or indirect impacts from radioactive gaseous releases from a new nuclear facility during normal operations.	There would be no radioactive impacts from the construction or operation of a new natural gas-fired plant.
	Gasoline and diesel emissions from vehicles and equipment.	No changes or new impacts would occur.	Minor impacts from vehicular and equipment emissions, controlled to meet applicable regulatory requirements.	

Resource	Attribute/Potential Effects	Alternative		
		1 – SQN License Renewal	2a – SQN Shutdown and New Nuclear Generation	2b – SQN Shutdown and New Natural Gas-Fired Generation
Radiological Effects	Effects to humans and nonhuman biota from normal radiological releases.	Annual doses to the public are well within regulatory limits; no observable health impacts are expected. No changes or new impacts are expected. Doses to nonhuman biota would be well below regulatory limits; no noticeable effects are expected.	Radiological effects to humans and biota would be similar to SQN and within all applicable release limits.	Radiological effects not applicable to natural gas-fired turbines.
Uranium Fuel Effects	Radioactive waste volumes and disposal.	Low-level radioactive waste would remain a minor impact on the available landfill capacity. The indirect and cumulative impacts on licensed landfills would be minor.	Operating nuclear power plant would produce low-level radioactive waste similar to SQN and would be a minor impact.	No radioactive waste generated.
	Radioactive gaseous and liquid releases.	By maintaining radioactive gaseous releases within regulatory limits, the impact to the public would be minor. The impact from radioactive liquids released from SQN is minor.	Releases of radioactive liquid and gaseous effluents would be in accordance with applicable federal regulations, resulting in minor impact.	No release of radioactive effluents.

Resource	Attribute/Potential Effects	Alternative		
		1 – SQN License Renewal	2a – SQN Shutdown and New Nuclear Generation	2b – SQN Shutdown and New Natural Gas-Fired Generation
	Radioactive waste transportation.	The impact to members of the public resulting from processing, storage, and transportation of solid low-level radioactive waste is minor.	Impacts from transportation of low-level radioactive waste would be minor, similar to SQN.	No radioactive waste would be transported.
	Spent fuel.	Minor impacts from the operation of the ISFSI, as it is operated in accordance with all applicable regulations.	Minor impacts from spent fuel storage.	No spent fuel generated.
Plant Safety	Postulated design-basis accidents.	In all cases, the doses to an assumed individual at the exclusion area boundary and low population zone are a fraction of the regulatory dose limits. Environmental risks due to postulated radiological accidents are minor. If a design-basis accident occurred, impacts would be minor, and limited by plant design and the emergency actions of trained TVA personnel.	The new nuclear plant would be designed specifically for the selected technology, which would be approved by the NRC and would meet all design-basis accident criteria.	This section is not applicable to Alternative 2b.

Resource	Attribute/Potential Effects	Alternative		
		1 – SQN License Renewal	2a – SQN Shutdown and New Nuclear Generation	2b – SQN Shutdown and New Natural Gas-Fired Generation
	Severe accidents.	Severe accident analysis indicates that the risk is minor and meets all safety goals.	The new nuclear plant would be designed specifically for the selected technology, which would be approved by the NRC and would meet all severe accident criteria.	This section is not applicable to Alternative 2b.
	Plant security.	Notwithstanding the very remote risk of a terrorist attack affecting operations, TVA increased the level of security readiness, improved physical security measures, and increased its security arrangements with local and federal law enforcement agencies at all of its nuclear generating facilities, and TVA is in compliance with all regulations on plant security.	Security requirements would be met as directed by federal requirements similar to SQN.	TVA would maintain appropriate security at a natural gas-fired plant. However, the requirements and standards for plant security at such a facility would be less than required for a nuclear-powered facility.