SACE Questions

1. A document or documents showing TVA's assumed capital costs in the base case strategy for all storage, solar, and wind resource options for each year of the forecast (2019-2038). Although footnote 5 to the Table A-1 on pages A-4 and A-5 of the draft IRP states that "The capital costs for solar and wind assume that tax credits expire/decrease per current federal law," and that "Solar capital costs are assumed to decline over time per recent trajectories and wind capital costs increase at less than the rate of inflation," The actual trajectories that TVA incorporated into the IRP and EIS have not been included in the public IRP documents.

   Total Overnight Capital Costs in $/kW are provided in Table A-1 within Appendix A, and additional detail on the forecast trajectory for both solar and storage overnight capital costs are shown in Figure C-7. Please see related posted information for the data behind these graphs, as well as for the forecast for wind overnight capital costs. Capital costs for other resources are projected to escalate with the Handy Whitman Index.

2. A document or documents showing the incentives (in dollars per kW, dollars per kW-year, or dollars per MWh that TVA assumed for each "case" in the IRP and EIS, where a case is defined as each combination of a strategy and scenario (for a total of 30 cases in the draft IRP) for all types of the following resource options: energy efficiency, solar, storage, wind, and small modular reactors.

   Incentives are discussed in Appendix F, page F-2. To promote adoption of a resource, a moderate or high incentive is applied. A base incentive represents business as usual, or no additional incentive beyond continuation of existing programs. A moderate incentive represents 50% of marginal cost, and a high incentive represents 100% of marginal cost. Please see related posted information on TVA's power price forecast, which is the basis for marginal cost. Storage was not selected based on economics, but it is promoted in several strategies based on the level of distributed or utility-scale solar incented in a portfolio at a 10% match for a moderate incentive and a 25% match for a high incentive. Small modular reactors (SMRs) receive a moderate promotion in Strategy C, where 1,200 MW of SMRs are promoted in the No Nuclear Extensions scenario as part of that strategy.

3. A document or documents showing the assumed hourly generation (i.e. the "solar shape" assumption mentioned on pages 4-9 and A-9) for all types of solar resource options (there are five listed in Table A-1 on page A-5) and location(s) used in the Intermittent Resources study, the Flexibility study, and the capacity expansion modeling for the IRP.

   Clean Power Research (CPR) provided TVA with solar energy profiles for 26 sites across the Tennessee Valley, shown on Page A-9. TVA incorporated capacity factors and hourly generation patterns from TVA solar PPAs and revised the dataset. For any subsequent PPA, the generation pattern is assumed to match the closest solar site. The solar shape, or pattern of generation across the days and seasons, is described in Appendix A. Figure A-5 illustrates capacity factors throughout the year for both fixed axis solar and utility tracking solar. Figure A-6 illustrates the net dependable capacity by hour for summer and winter. Please see related posted information on solar generation patterns.

4. A document or documents showing the formula and data used for calculating the 2020 $/MWh column for energy efficiency costs in Figure B-9 on page B-10.

   Capacity impacts for each EE program tier is shown at TVA's system peak for both summer and winter. The $/MWh for each program tier is calculated using the Levelized Cost of Energy (LCOE) formula. Subsequent to publication of the Draft IRP, TVA discovered that there was an error converting model inputs to the table shown in Figure B-9. Figure B-9 EE impacts have been revised to appropriately reflect model inputs and also include the Tier Volume, Total Cost ($) and Generation (kWh/install) that were used to calculate the 2020 $/MWh that was modeled. The update to this table will be reflected in the final 2019 IRP. Please see related posted information for more detail on energy efficiency costs.

   Energy shapes for each program tier are informed by TVA's partnership with DNV-GL, who provides insight on best practices, measure values, modeling, and ultimately the evaluation of program results. Finally, TVA conducts a Residential Saturation Survey and a Business & Industry Saturation Survey every other year to understand market depth and potential reach of programmatic efforts.

5. A document or documents showing all annual and cumulative capacity limits, in terms of MW per year, total MW, or as a percent of capacity or energy, placed on the capacity expansion modeling for the IRP for all of the types of the following resource options: energy efficiency, solar, storage, and wind.

   As stated in Appendix B, a three-tiered approach was taken to develop EE program offerings for selection. Revised Figure B-9 includes EE capacity limits. Before releasing the final 2019 IRP, TVA plans to run a sensitivity analysis on expanded EE and DR market depth, as explained in Chapter 8. Solar additions are capped at 500 MW per year, with a cumulative limit of 10,000 MW over the study period. It should be noted that there are limitations on the timing of other resource additions as well, such as how many new thermal builds can be planned for a given year, to reflect the practicality of when TVA has knowledge of the need and other project management considerations. Additionally, as mentioned in Chapter 8 of the draft 2019 IRP, a sensitivity analysis is planned to evaluate accelerated solar to meet customer demand. The final IRP will also include sensitivities around removing annual and cumulative solar caps. No annual or cumulative limits are placed on storage additions, but storage was not selected based on economics, even with promotion. As explained in the draft IRP, storage was promoted by matching either 10% or 25% of the solar resources added at the same scale (i.e. utility or distributed), as described in Appendix C. Using this manner of promotion based on matching storage to solar additions, the amount of solar selected for a given portfolio had a secondary effect on limits for storage additions in certain strategies. Wind additions were capped at 2,000 MW annually and 20,000 MW cumulatively.

6. A document or documents showing all assumed costs and outages related to the assumed relicensing of existing nuclear power plants in Scenarios 1-5, including the magnitude of those costs and outages and the year(s) they occur.

   Based on preliminary industry estimates, TVA expects that nuclear relicensing costs for the three-unit Browns Ferry Nuclear Plant may range from $1 billion to 3 billion and ultimately landed on using $2 billion as the modeling assumption. Work related to relicensing would take place as much as feasible during standard refueling outage schedules for a number of years ahead of relicensing.

7. A document or documents showing all assumptions related to TVA's distributed solar program that were used in the distributed generation forecast model, as mentioned on page C-6.

   TVA's distributed generation modeling methodology is discussed in Appendix C. Please see related posted information on assumptions related to TVA's distributed solar program used in the distributed generation forecast model.

8. Copies of the final Intermittent Resources Study, Flexibility Study, and Reserve Margin Study described in the IRP on pages D-6, D-10, and D-2, respectively. Note that in its response to SACE's FOIA requests #5347 and #5348 TVA indicated that "Information from the studies will be available for public review and comment in early 2019 in connection with the issuance of the draft IRP." The information in the draft IRP from these studies is insufficient for complete public review.

   The studies can be found in Appendix D: Modeling Framework Enhancements, which covers the purpose, background, scope and approach, inputs, results, and conclusions for each study. Please see related posted information for specific inputs and data behind the graphs in Appendix D related to each study.

9. A document or documents describing the changes TVA staff made to capital cost assumptions for resource options after review of initial capital cost assumptions by Navigant Consulting, Inc. We are particularly interested in how many resource capital cost assumptions were changed, for which resource options were changes made, and in what direction were the changes.

   On July 13, 2018 Navigant submitted an Excel spreadsheet and summary memo as the deliverables for their review of TVA's 2019 IRP Parameters. Following collective review of these deliverables, several minor updates were made by Navigant, and a final updated version of the spreadsheet was submitted to TVA on August 8, 2018. As stated in the summary letter in Appendix A, Navigant concludes that "overall, the majority of TVA values were determined to be consistent with recommended values, and otherwise reasonable." Please see related posted information for a copy of TVA's Final IRP resource costs and Navigant's recommended resource costs.
   Final combined cycle and combustion turbine overnight capital cost estimates were informed by recent TVA gas builds. Navigant deferred to TVA on SMR costs. All other

differences were generally within 10% and were deemed reasonable. After publication of the draft IRP, TVA noticed that the solar values ($/kW) in table A-1 were listed in AC while the footnote states in DC. For the final 2019 IRP, table A-1 will be revised to include DC values for all solar options. The solar options listed in the Navigant workbook are listed in DC.

10. The Microsoft Excel workbook from Navigant summarizing the Resource Estimates and related assumptions and notes from their work delivered to TVA on July 13, 2018, as described in the Summary Letter on page A-1.

    Please see response to Question 9 for information related to final TVA resource estimates.

11. All document or documents informing TVA's assumption that regulations in the Decarbonization scenario would make the US less competitive globally.

    As described in Appendix E, TVA developed five different future environments with robust input from the IRP Working Group which, coupled with the TVA's Current Outlook, constitute the six scenarios in the 2019 IRP. The overarching principle in the design of scenarios was to ensure a wide range of possible outcomes. The Decarbonization scenario represents a plausible future in which a CO_2 emission penalty is applied to the utility industry in an effort to curb greenhouse gas emissions. A CO_2 penalty would very likely result in an increase in natural gas units, and consequently demand for natural gas, as higher CO_2 emitting plants such as those fired by coal become uneconomic. Demand and price for natural gas would rise, leading to an increase in electricity prices. Based on information from the US Bureau of Economic Analysis, US Bureau of Labor Statistics, and US Energy Information Agency, there is an inverse correlation between the real price of electricity and labor productivity. Please see related posted information for a comparison of U.S. Labor Productivity vs. Price of Electricity.

12. All document or documents informing TVA's assumption that solar and storage prices would be higher in the Economic Downturn scenario than in the Base Case scenario.

    As described in Appendix E, TVA developed five different future environments with robust input from the IRP Working Group which, coupled with the TVA's Current Outlook, constitute the six scenarios in the 2019 IRP. The overarching principle in the design of scenarios was to ensure a wide range of possible outcomes. The Economic Downturn scenario represents a plausible future in which a prolonged, stagnant economy results in weak growth and delayed expansion of new generation. The scenario assumes tariffs on imports and exports, resulting in increased prices for all goods. Increased prices combined with a stagnant economy, present an affordability issue for customers leading to a reduction in technology adoption. As technology adoption slows, efficiency gains and price reductions typically slow down as well.

13. All document or documents informing TVA's assumed CO2 prices used in the Valley Load Growth and Decarbonization scenarios.

As described in Appendix E, TVA developed five different future environments with robust input from the IRP Working Group which, coupled with the TVA's Current Outlook, constitute the six scenarios in the 2019 IRP. The overarching principle in the design of scenarios was to ensure a wide range of possible outcomes. The Decarbonization scenario represents a plausible future in which a CO_2 emission penalty is applied to the utility industry in an effort to curb greenhouse gas emissions.

The CO_2 penalty used in the Decarbonization scenario was developed based on the Minnesota PUC *Notice of Updated Environmental Externality Values* (June 16, 2017). The notice states "the Commission established an estimate of the likely range of costs of future carbon dioxide regulation on electricity generation of $9/ton to $34/ton for CO2 emitted in 2022 and thereafter." Several other states (CO, NY, IL) made decisions to integrate social cost of carbon estimates into utility planning around this same time period. TVA's 2019 IRP Scenario development began in November 2017, shortly after this information became available. Based on this information, TVA used an average of $22/ton derived from the $9/ton and $34/ton but used 2025 as the starting year based on regulatory development timelines from introduction of legislation to effective date of final regulation. Since the scenario was originally developed, the Minnesota PUC published an updated order on January 3, 2018. The updated CO2 cost values in 2025 are from $10.07 to $46.96/ton (2015$). Due to comments received from the IRP Working Group and the public at large, TVA is conducting a sensitivity on the carbon penalty in the Decarbonization scenario by doubling the $22/ton to $44/ton beginning in 2025. This sensitivity aligns to the latest update from the Minnesota PUC which is largely based on the Federal Social Cost of Carbon. Please see related posted information on Minnesota PUC notices and updates.

The Valley Load Growth scenario represents a plausible future in which rapid economic growth, technology-driven investments, and a rapid pace of electric vehicle adoption raise electricity use and result in higher energy sales. The CO_2 penalty used in the Valley Load Growth scenario is roughly one-third of the Decarbonization scenario and represents a proxy for policy actions that future administrations may undertake as the robust economic situation provides the means to pay for the societal preference for lower emissions.

14. All document or documents informing TVA's decision to decrease the assumed capital costs associated with small modular reactors compared to the assumed capital costs for this resource option used in TVA's 2015 IRP.

TVA worked in conjunction with the US Department of Energy (DOE) in developing cost estimates for current Small Modular Reactor (SMR) designs. Since the 2015 IRP, the leading SMR developer has changed along with SMR design and associated capital costs. Additionally, recommended costs from Navigant Consulting aligned very closely with TVA estimates for the latest SMR designs. Even with the lower assumed capital costs, it should be noted that none of the cases in the 2019 IRP selected an SMR. As noted in Chapter 7 of the draft 2019 IRP, case 6C includes two SMRs totaling 1,200 MW forced in as part of Strategy C (Promote Resiliency) to replace one of three Browns Ferry units. All three Browns Ferry units were retired in all strategies in Scenario 6. Strategy C promotes small, agile capacity to maximize system flexibility and promote the ability to respond to short-term power disruptions. Additionally, as mentioned in Chapter 8 of the draft 2019 IRP, a sensitivity analysis is planned to evaluate SMR capital costs and reduction needed for the resource to become economic.