STATE OF GEORGIA

BEFORE THE GEORGIA PUBLIC SERVICE COMMISSION

Georgia Power Company's 2019 Integrated Resource Plan and Application for Certification of Capacity from Plant Scherer Unit 3 and Plant Goat Rock Units 9-12 and Application for Decertification of Plant Hammond Units 1-4, Plant McIntosh Unit 1, Plant Estatoah Unit 1, Plant Langdale Units 5-6, and Plant Riverview Units 1-2	)	**DOCKET NO. 42310**

DIRECT TESTIMONY OF BRENDAN J. KIRBY ON BEHALF OF SOUTHERN ALLIANCE FOR CLEAN ENERGY

PUBLIC DISCLOSURE

April 25, 2019

I. Introduction

Q. Please state your name, position and business address.

A. My name is Brendan J. Kirby. I am an electric power systems consultant, and my business address is 12011 SW Pineapple Court, Palm City, Florida.

Q. On whose behalf are you testifying in this proceeding?

A. I am testifying on behalf of SACE.

Q. Please summarize your qualifications and work experience.

A. I am private consultant with numerous clients including the Hawaii Public Utilities Commission, National Renewable Energy Laboratory (NREL), the Energy Systems Integration Group (ESIG), Electric Power Research Institute (EPRI), the American Wind Energy Association (AWEA), Oak Ridge National Laboratory, and others. I retired from the Oak Ridge National Laboratory's Power Systems Research Program. I have 44 years of electric utility experience, and I have been working on restructuring and ancillary services since 1994 and spot retail power markets since 1985.

My interests include electric industry restructuring, bulk system reliability, energy storage, wind and solar power integration, ancillary services, demand side response, renewable resources, distributed resources, and advanced analysis techniques. I have published over 180 papers, articles, and reports. I coauthored a pro bono amicus brief cited by the Supreme Court in their January 2016 ruling confirming FERC demand response authority. I have a patent for responsive loads providing real-power regulation and am the author of a NERC certified course on Introduction to Bulk Power Systems: Physics / Economics / Regulatory

Policy. I served on the NERC Standards Committee and the Integration of Variable Generation Task Force. I have participated in the NERC/FERC reliability readiness reviews of balancing authorities and reliability coordinators, performed field investigations for the US/Canada Investigation Team for the 2003 Blackout, and have appeared as an expert witness in FERC and state litigation. I have conducted research projects concerning restructuring for the NRC, DOE, NREL, EEI, AWEA, ESIG, numerous utilities, state regulators, and EPRI.

I am a licensed Professional Engineer with a M.S degree in Electrical Engineering (Power Option) from Carnegie-Mellon University and a B.S. in Electrical Engineering from Lehigh University.

A copy of my resume is included as Exhibit SACE-BJK-1.

Q. Have you previously filed testimony as an expert witness in a regulatory proceeding?

A. Yes. I have testified in proceedings regarding wind and solar integration, bulk power system reliability, ancillary services, and demand response before Commissions in California, Minnesota, Texas, Wyoming, and Hawaii, as well as before the Federal Energy Regulatory Commission. I was also appointed as the Special Advisor for Demand Response for the Hawaii Commission in 2015.

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to evaluate Georgia Power's proposed reserve margin and related studies, and its cost-benefit studies of utility scale solar, distributed solar, and wind.

I discuss why the analysis results appear to be flawed. I present the following recommendations for the Commission's consideration. The Commission should:

- Direct Georgia Power to reexamine the winter reserve requirements calculations to determine under exactly what conditions the winter reserve requirements have increased.
    - Georgia Power asserts that winter reliability is now challenged based on model results. Once the specific conditions under which its model identifies challenges are known, it will be possible to determine if the assumptions concerning the likelihood of those conditions occurring are reasonable, and if those conditions can be mitigated.
    - Assuming Georgia Power's analysis is correct, and winter reliability is now challenged by very rare but very large reliability events, the Company should determine the most cost-effective resources for mitigating or meeting the increased reserve requirement. Winter-focused demand response, for example, may be more cost-effective than adding large amounts of new combustion turbines that will very rarely have to respond.
- Direct Georgia Power to reexamine the Generation Remix Costs presented in the Cost Benefits studies. These results appear unlikely, adding $[redacted]/MWH to the cost of utility scale solar generation when compared with distributed solar generation.
    - If the study results are confirmed, based on the study assumptions, then direct Georgia Power to change the utility scale solar generation plant

design assumptions to co-optimize energy production and Generation Remix Costs.

- Direct Georgia Power to share the analysis that synthesized solar time-series data with the Commission Staff so that the Staff can be assured that the synthesized solar data is time synchronized with the load data and that aggregation benefits have been fully incorporated.

Q. Are you submitting exhibits along with your testimony?

A. Yes, I am submitting one exhibit along with my testimony, as follows:

- SACE-BJK-1: Resume of Brendan J. Kirby

II. <u>Summary of Findings and Conclusions</u>

Q. Please summarize the results of your review of the Company's winter reserve requirements.

A. The Company is proposing an increase in its estimate of winter reserve requirements, from 24.7%[1] to 26%[2]. Yet the study on which this proposal rests includes findings which, in my professional experience, are very unusual. Graphical results presented in "An Economic and Reliability Study of the Target Reserve Margin for Southern Company System" (TRM Study) are puzzling. Figures III.8 and A.15 (included in my testimony) show that, according to the model, winter reliability is improved only very gradually by adding more generation capacity (in the form of combustion turbines).

[1] "…current approved Target Reserve Margin of 16.25% (which is equivalent to a 24.7% winter reserve margin)" *An Economic and Reliability Study of the Target Reserve Margin for the Southern Company System*, January 2019, page 75.

[2] "The 2018 Reserve Margin Study recommends a long-term Winter TRM of 26%" *An Economic and Reliability Study of the Target Reserve Margin for the Southern Company System*, January 2019, page 12.

In contrast, the summer reserves analysis shows the normal utility pattern of adding reserves having a dramatic improvement on reliability. The minimal winter reliability impact of adding combustion turbine reserves implies that the underlying reliability events that the reserves are designed to mitigate are both unusually rare and unusually large. This calls into question if the model-simulated reliability events are realistic. These large but rare events should be examined in detail to understand if they represent realistic conditions.

Even assuming that the winter reliability events are realistic, there are likely more cost-effective reserve resources than adding large amounts of new combustion turbines that will only be required to respond very rarely.

Q. Please summarize the results of your review of the Company's Renewable Cost Benefit Framework analysis.

A. The Company presented results of the Renewable Cost Benefit Framework (RCB Framework) analysis for utility scale fixed tilt solar generators, distributed solar generators, and wind. One striking result was that the Generation Remix Costs calculated resulted in a roughly $[redacted]/MWH greater credit for distributed solar generators than for utility scale solar generators. This result is counter to the expectation that utility scale solar generation tends to exhibit characteristics that are more favorable to utility integration than distributed solar generation.

The reasons for this unusual result are unclear. In response to cross-examination, the Company's witness Mr. Bush stated that the distributed solar generation had a higher Generation Remix value because it has "a non-optimized profile" (April 9, 2019 hearing cross-examination of Mr. Bush, transcript page 575). I also examined the underlying hourly solar generation profiles and hourly forecast error profiles, but the data failed to suggest why utility scale solar generators should be penalized by the Generation Remix model results. The Commission should direct Georgia Power to review the Generation Remix Costs calculations and fully explain the results.

There are steps that can be taken by solar developers to improve solar generation output alignment with the Company's resource needs, if they are aware of the problem. If, contrary to the usual experience in similar analyses, the utility scale solar hourly profiles are worse than distributed generation solar hourly profiles in terms of Generation Remix Costs, then utility scale developers could adjust their project design. Utility scale solar generators have significant capability to adjust the hourly solar generation profiles they present to the utility by, for example, changing the east-west tilt for fixed tilt generators or by employing single axis tracking. With such a large ~$[redacted]MWH impact on potential net benefits, potential bidders should be informed about the Generation Remix characteristics so that they can optimize their proposals to maximize system benefits. This will benefit both the solar generators and the utility.

Q. Do you have additional observations and recommendations?

A. Yes. Georgia Power provided few details concerning how the time series data for solar generators for use in the production cost modeling was synthesized. It is critical that the time series solar generation data and wind generation data be time synchronized with the load data. Weather drives solar generation, wind generation, and load. Similarly, the variability and uncertainty of solar generation and wind generation declines significantly as the generation fleet grows. Aggregation benefits are as important for variable renewables as they are for load. Linear scaling of existing solar plant data, for example, is inappropriate for synthesizing time series data to represent a larger future solar generation fleet. The Commission should direct Georgia Power to share with Commission Staff the data and analysis methods used to synthesize the time series solar and wind generation data that was then synchronized with load data for integration analysis.

III. Winter Reserve Effectiveness

Q. Do you have concerns with the effectiveness of the reserves that were added to address winter reliability?

A. Yes, the system reliability results presented in the TRM Study exhibit an odd behavior that calls into question either the study itself or the selected method of addressing winter reliability.

Q. How were reserve requirements determined?

A. The analysis methodology described in Southern Company's TRM Study used production cost modeling to examine power system costs as solar generation was added to the power system. Reserves were added to maintain reliability and allow for a fair comparison of costs with and without additional solar generation.

Q. What did the study find concerning winter reserve effectiveness?

A. The study found that adding winter reserves is puzzlingly ineffective. Confidential Figure III.8 shows how adding reserves (expressed as a percentage of summer peak load) improved annual reliability in three studies: 2012, 2015, and 2018.[3] The 2012 study showed the expected pattern where reliability was low with few reserves but improved dramatically as reserves were added. In this case, which is typical for most reliability studies, reliability improved so dramatically that adding reserves beyond about [redacted]% would make no sense.

Figure III.8: TRADE SECRET – Loss of Load Expectation by Summer Reserve Margin

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An Economic and Reliability Study of the Target Reserve Margin for the Southern Company System, (January 2019).

[3] Reserve margins in these studies were expressed as a percentage of summer load though the focus was also on winter reserves. As Mr. Weathers explained on April 9, 2019 in his cross-examination testimony "We do – our study's for an annual period. We're looking at every hour of the year. We can look – we can state it in terms of summer reserve margin, we can state it in terms of winter." (Tr. 545)

Figure A.15 for the 2018 study showed that adding reserves in the summer still provided the expected dramatic reliability benefit but that adding reserves in the winter only improved LOLE very slowly.

Figure A.15 TRADE SECRET – Seasonal LOLE by Reserve Margin

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An Economic and Reliability Study of the Target Reserve Margin for the Southern Company System, (January 2019).

In 2015, and more so in 2018, Southern Company found that adding winter reserves was relatively ineffective at improving reliability, out to very high reserve margins. Summer reserves continued to exhibit the expected beneficial behavior. The reason for this change in reserve effectiveness is not clear and may be important.

Q. Why might the analysis be finding that adding winter reserves is ineffective at restoring reliability?

A. There are several possible explanations as to why the analysis found winter reserves to be ineffective. For example, the report says that CTs are the added reserve resource. Mr. Weathers stated that the added CTs have dual fuel capability (Tr. 546), so loss of natural gas fuel supply is not the reason the added reserves are ineffective.

Possibly the added reserve CTs are modeled with high cold-weather failures such that they tend to fail at the same time the rest of the generation fleet is experiencing weather related failures. The TRM Study, states:

> "Extreme cold-weather conditions often result in increased unit outage rates. History has demonstrated that as temperatures continue to decrease the outage rate tends to increase exponentially. While the causes (i.e., the components impacted by the cold weather) may be different for each, steam generators, CCs, and **CTs** all have vulnerabilities to extreme cold temperatures." (page 96, emphasis added)

Possibly it is extreme load spikes that are only hypothesized to occur under rare conditions.

Figure A.15 clearly shows that the winter Loss of Load events are rare, barely exceeding the 1-day-in-10-yeads threshold even with a [redacted]% reserve margin.

Mr. Weathers voiced a similar conclusion when he stated that the reason that adding reserves is so ineffective at improving winter reliability is that winter risks are characterized by a small number of higher magnitude events while summer risks are characterized by a larger number of smaller magnitude risks. "So as you continue to add reserves, you can mitigate a number of those really small instances in the summer, but not as many of those in the winter time." (Tr. 548) This makes sense, smaller magnitude risks are easier to mitigate with reserves, even if they are more frequent.

Q. Did the Reserve Margin Study discuss reasons why winter reliability risks are changing?

A. Yes, but only in a limited way. On page A-4 the study discusses six "drivers" that Georgia Power states are resulting in decreased winter reliability for the power system:

> "Currently, there are six primary determinants … that have been identified as key drivers affecting the winter reliability risk concerns on the System, including
>
> - the narrowing of summer and winter weather-normal peak loads,
> - the distribution of peak loads relative to the norm,
> - cold-weather-related unit outages,
> - the penetration of solar resources,
> - increased reliance on natural gas, and
> - market purchase availability."

Q. Why do you say the discussion of winter reserve drivers is only limited?

A. The discussion is limited in the sense that the *specific* reasons for declining winter reserve effectiveness were not quantified. Mr. Weathers reiterated that Southern Company has identified the six drivers that result in greater winter reliability concerns. He also stated "there's really not a good way to quantify which one of those is most impactful to winter reliability risk. In fact, all six of those drivers, they work in conjunction with each other." (Tr. 541) Only the net impact on reliability has been quantified. As Southern Company's analysis clearly shows, the chosen solution of adding CTs to supply additional reserves, while still very effective in maintaining summer reliability, is ineffective at addressing winter reliability. The analysis does not explain why.

With no analysis of the specific conditions that result in winter reserve ineffectiveness it is not possible to tell if the analysis is credible or, if the analysis is correct, why adding CTs is no longer an effective solution or what alternative measures might be more cost effective.

Q. Is it important to determine which of the six "drivers" actually contribute to winter reliability concerns? If so, is it possible to distinguish between the impacts of the six "drivers"?

A. Yes and yes. It is important because the most cost-effective measures for mitigating the causes of winter unreliability or of responding with additional reserves if the underlying causes cannot be reduced or eliminated are likely very different, depending what the underlying cause(s) actually is (are). It is possible to determine what is actually driving the underlying reliability concern by examining the simulated conditions that resulted in the simulated LOLE events. As Figure A-15 shows, there are only a few winter reliability events creating the need for a higher winter TRM.

Q. Please give an example of different actions that would be taken depending on which "driver" is associated with winter reliability events.

A. Cold-weather-related unit outages provide an example. If extreme-cold-weather generator outages account for most or all of the simulated winter LOLE reliability events the underlying assumption of exponentially increasing unit outages at sub-zero temperatures should be studied further and confirmed before significant investments are made in new CTs or decisions concerning renewables expansion are adversely impacted.

Appendix A in the TRM Study has two seemingly contradictory statements. The report first states that efforts have been underway for five years to improve unit reliability under extreme cold conditions:

> "After the 2014 Polar Vortex event, the Operating Companies began implementing measures to improve the performance of its resources under extreme conditions. … System plant performance experts are confident that these efforts to improve cold-weather performance will ultimately result in a reduction in cold-weather outages relative to historical trends." (page 97)

This is immediately followed by a statement that appears to say that there never will be improved cold-weather performance:

> "there will always remain an exponentially increasing probability of performance risk as system-weighted temperature reach the more extreme cold levels."

Additionally, Figure A.6, which shows the assumed exponential increase in extreme-cold-weather EFOR is not clearly supported by the scattered historic EFOR data presented in Table A.1, where all of the outage rates above [redacted]% occurred before 2000.

Q. What do you recommend the Commission do?

A. The Commission should direct Georgia Power to reexamine the detailed case results to determine why adding winter reserves is exhibiting this odd, ineffective behavior. **Based on my review of the report and the Company's witness panel testimony, there are not**

many events to examine. Each reliability event should be explicitly quantified in terms of occurrence frequency, timing (time of day, day of week, etc.), duration, load conditions, weather conditions, outages of other generators, hydro conditions, specific case assumptions (economic growth, imports/exports, etc.).

Once the driving conditions are understood it will be possible to assess if the concerns are real (versus being a modeling issue) and, if real, how best to mitigate them. Additional demand response may be a much more effective solution. Additional research is required to determine if the assumption that outages increase dramatically with extreme temperatures drops is valid. If the reliability events are found to be credible, additional demand response may be a much more effective solution than adding large numbers of combustion turbines. Alternatively, additional efforts to improve cold weather generator reliability may be a more effective solution. It is impossible to know until the exact reasons for the reliability events are understood.

Q. Are there other indications that combustion turbines – or any form of peaking generation – are not an appropriate or cost-effective winter reserve resource for Georgia Power?

A. Yes. Figure A.15 shows the loss of load expectation in days per year for a range of reserve margins. For example, summer reserves are required to respond at least [redacted] at the [redacted]% reserve level (LOLE = [redacted] day/year). Though the graph does not show lower reserve levels (the horizontal axis starts at [redacted]%) the shape of the summer curve indicates that the first [redacted]% of summer reserves will likely be required to respond much more often than [redacted] per year. Conversely, winter reserves are required to respond much less often. The LOLE for [redacted]% winter reserves is only about [redacted] days per year and the curve does not appear to be rising sharply as the reserve margin declines. All of this means that while both the summer and winter reserve margins are set based on a LOLE of one day in ten years, and the last increment of both the summer and winter reserves will theoretically only need to respond once in ten years, the bulk of the summer reserves will be required to respond more than [redacted] while the bulk of the winter reserves will only be required to respond once every [redacted] years.

It seems wasteful to purchase, install, and maintain brand new combustion turbines that are only required to respond once every [redacted] years.

Q. Are there potentially other more appropriate reserve resources?

A. Yes. Georgia Power should first carefully examine the reserve shortfall events to determine if the events themselves can be reduced or eliminated. More appropriate winter load forecasts may eliminate some events. Better cold weather preparations for conventional generators may also reduce outages. Appropriate mitigation measures cannot be identified until the problem is more precisely defined. Assuming that additional reserves are required, and the frequency of required response is in line with that shown in figure A.15, demand response may offer a lower cost resource.

Since the 26% winter reserve requirement calculated by the company will require deployment roughly once every [redacted] years, a winter-focused demand response program would require infrequent response, and should not lead to customer fatigue. Converting the capital cost, maintenance cost, and operating cost for the combustion turbines into a potential $/MWH for actual demand response would likely attract ample reserves beyond those of existing demand response programs.

III. <u>Cost & Benefits Framework: Generation Remix Costs</u>

Q. Do you have concerns with the Generation Remix Costs?

A. Yes. There is a puzzling result when comparing results from the three RCB Framework case studies:

- The Cost and Benefits of Utility Scale Fixed Tilt Solar Generation in Georgia (1/17/2019)
- The Cost and Benefits of Distributed Solar Generation in Georgia (1/17/2019)
- The Cost and Benefits of Fixed and Variable Wind Delivered to Georgia. (1/17/2019)

The results from each study are presented in Table 1 for comparison. Both Wind and Distributed Solar (PV DS) have a high "Generation Remix Costs" *benefit* while Utility Scale Solar (PV US) has a small *cost*. Other costs and benefits appear to be reasonably related.

Table 1 TRADE SECRET - Levelized Costs and Benefits ($/MWH)

	PV US	PV DS	Wind
Avoided Energy Costs	[redacted]	[redacted]	[redacted]
Deferred Generation Capacity Costs	[redacted]	[redacted]	[redacted]
Deferred Transmission Investment	N/A	[redacted]	N/A
Reduced Distribution Losses	N/A	[redacted]	N/A
Distribution Operations Costs			
Ancillary Services - Reactive Supply and Voltage Control			
Generation Remix Costs	[redacted]	[redacted]	[redacted]
Support Capacity (Flexible Reserves)	[redacted]	[redacted]	[redacted]
Bottom Out Costs			
Long Term Service Agreement (LTSA) Costs			
Program and Administration Costs			
Total Net Avoided Cost	[redacted]	[redacted]	[redacted]

Values from: The Costs and Benefits of Utility Scale Fixed Tilt Solar Generation in Georgia, (PV US), Published: 1/17/19, The Costs and Benefits of Distributed Solar Generation in Georgia, (PV DS), Published: 1/17/2019, The Costs and Benefits of Fixed and Variable Wind Delivered to Georgia, (Wind), Published: 1/17/19

Specifically, the $[redacted]/MWH difference between the Generation Remix Costs for utility scale solar generation and distributed solar generation represents a roughly [redacted]% reduction in the value of utility scale solar generation.[4] This result is odd for two reasons.

First, it is odd that utility scale solar and distributed solar have such different results, even though they are very similar resources. Second, in my experience, utility scale solar has characteristics that better align with utility needs than distributed solar and, consequently,

[4] Solar generators are paid based on their successful energy bid prices. The avoided energy cost represents an upper limit on potential compensation. To the extent that successful solar energy price bids are lower than the assumed ~$[redacted]/MWH avoided energy cost the $[redacted]/MWH difference in Generation Remix Costs becomes a greater percentage concern.

an equal or lower integration cost. In fact, at first glance, I thought these results might be a typographical error.

Q. How was the Generation Remix Costs category described?

A. The Generation Remix Costs category appears to be a re-examination of the larger scale generation fleet optimization when large amounts of solar generation are added. Few details were provided. Impacts on both capital costs and operating costs of the Georgia Power conventional generation fleet were calculated. Page 36 of the "A Framework for Determining the Costs and Benefits of Renewable Resources in Georgia" says that capital cost impacts were determined by running the Strategist model to calculate future generation expansion plans with and without renewables. Previously credited benefits were subtracted out. Production cost impacts were also determined through production cost modeling. Previously credited Avoided Energy Cost benefits were subtracted out. There are also unexplained "extra" production cost impacts.

In spite of the lack of details the methodology sounds reasonable. It is unclear, however, why utility scale solar would have such a different, and adverse, impact on generation expansion or production costs when compared with distributed solar.

Q. Did Georgia Power explain why utility scale solar generation was assessed much higher Generation Remix Costs than distributed solar generation?

A. The reasons for this unusual result are unclear. In response to cross-examination, the Company's witness Mr. Bush stated that the distributed solar generation had a higher

Generation Remix value because it has a diverse and "non-optimized profile" when compared to utility scale solar generation (Tr. 575). An examination of the solar profiles on which the Generation Remix Costs were based does not seem to bear this out, however.

Both the utility scale and the distributed solar generation cost and benefits reports have tables that list the hourly solar generation profile for each month that the Generation Remix Costs analysis was based on. Figure 1 compares the annual average hourly profiles for utility scale solar generation and distributed solar generation from these tables. These comparisons could be done monthly but the results are similar and for simplicity only the annual averages are shown here.

Figure 1 TRADE SECRET – Average Hourly Utility Scale Solar and Distributed Solar Generation Profiles

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From Table 2: Generation Profile for Utility Scale Fixed Tilt Solar: *The Cost and Benefits of Utility Scale Fixed Tilt Solar Generation in Georgia*, (1/17/2019) and Table 2: Generation Profile for Distributed Generation Solar: *The Cost and Benefits of Distributed Solar Generation in Georgia*, (1/17/2019)

Comparing the utility scale solar generation hourly profile and the distributed solar generation hourly profile, it is difficult to see why the utility scale solar generation profile should result in higher Generation Remix Costs. One would think that solar generation peaking later in the afternoon would better match the utility load peak, and thus offset more costly resources. Taking more costly resources offline should not result in a remix cost, but rather a greater remix benefit. The overall shapes are not significantly different. The greater peak generation ([redacted]% maximum for utility scale solar generation versus [redacted]% maximum for distributed solar generation) impacts the net size of the resource, not its integration characteristics.

Q. If the analysis is correct, could utility scale solar generation be designed to improve the Generation Remix Costs?

A. Yes. Most importantly, *<u>if</u>* the assumed solar generation profile does actually result in significantly higher Generation Remix Costs, the utility scale solar generators could be designed to co-optimize energy production and Generation Remix Costs. $[redacted]/MWH is a significant cost (or benefit). Solar generation owners would have a strong incentive to optimize the design of their plants, including the tilt of the panels, to maximize their total revenue. This would also maximize the benefits and minimize the costs for Georgia Power.

Q. Are there differences in the forecast errors assumed for utility scale solar generation and distributed solar generation?

A. Yes. The Cost and Benefits of Utility Scale Fixed Tilt Solar Generation in Georgia and The Cost and Benefits of Distributed Solar Generation in Georgia both contained tables of the assumed hourly solar forecast error for each month. Figure 2 compares the annual average hourly results.

Figure 2 TRADE SECRET – Average Hourly Utility Scale Solar and Distributed Solar Generation percentage forecast errors

REDACTED

From Table 13: Hourly Solar Forecast Error: *The Cost and Benefits of Utility Scale Fixed Tilt Solar Generation in Georgia,* (1/17/2019) and Table 17: Solar Forecast Error: *The Cost and Benefits of Distributed Solar Generation in Georgia,* (1/17/2019)

Figure 2 may be a little deceiving, however. Forecast errors early in the morning or late in the afternoon when solar generation is low are not as significant as forecast errors in the middle of the day when solar generation is high. Figure 3 presents the forecast error in terms of solar generation output, assuming a 1000 MW solar fleet.

Figure 3 clearly shows that forecast error is reasonably low for all solar generation but that it is slightly lower for utility scale solar generation than it is for distributed solar generation.

Forecast error is not a reason that Generation Remix Costs are higher for utility scale solar generation than for distributed solar generation.

Figure 3 TRADE SECRET – Average Hourly Utility Scale Solar and Distributed Solar Generation MW forecast errors

REDACTED

Developed from *The Cost and Benefits of Utility Scale Fixed Tilt Solar Generation in Georgia,* (1/17/2019) and *The Cost and Benefits of Distributed Solar Generation in Georgia,* (1/17/2019)

Q. What do you recommend the Commission do?

A. The Commission should direct Georgia Power to reexamine the detailed case results of the cost and benefits analysis, especially the Generation Remix Costs, to determine if the results for utility scale solar generation and distributed solar generation are correct. Any significant differences in costs and benefits calculated for each generation type should be fully explained.

If the analysis is found to be correct and there are significantly higher Generation Remix Costs for utility scale solar generation than for distributed solar generation the exact reasons should be fully documented. Then, potential bidders should be informed about the Generation Remix characteristics so that they can optimize their proposals to maximize system benefits. Assumed solar profiles used in the analysis should match solar plant designs that are co-optimized for energy production and Generation Remix benefits.

Q. More generally, could the Generation Remix Costs analysis method be improved?

A. Yes. It appears that the goal of Generation Remix Costs analysis is to adjust the avoided costs defined by the base plan. The Generation Remix Costs analysis is a correction patch added to enable the retention of the avoided cost methodology.

A more straightforward approach is to incorporate renewables directly into the production cost modeling and generation expansion analysis, eliminating the need for most off-model cost and benefits analysis for wind and solar generation. As SACE Witness Mark Detsky describes occurs in Colorado, rather than adding renewables to an already optimized generation mix, it is better to include renewables in the process for optimizing the system resource mix.

On a much more detailed level, the calculation of increased Regulating Reserves requirement [a component of the Support Capacity (Flexible Reserves) in Table 1] is in error. *A Framework for Determining the Costs and Benefits of Renewable Resources in Georgia* (Revised: 5/12/17) explains that variable renewable generators increase the power system's need for regulating reserves:

> "As the output of VERs fluctuate (e.g., as clouds pass over solar resources or as wind starts/stops blowing), other dispatchable resources must adjust to account for

> these fluctuations. This affects the generation fleet as if it were a fluctuation in load. Because many of these fluctuations occur over a short period of time (i.e., seconds to minutes), these moment to moment swings in the generation ramping requirements must be managed by Regulating Reserves" (Page 42)

The Framework document goes on to state:

> "Assuming no definitive correlation between load volatility and VER volatility, it must be assumed that **these fluctuations are additive** in nature, resulting in a need for additional Regulating Reserves than would otherwise be required." (Emphasis added) (Page 43)

Short-term variations of loads and variable renewable generators are typically uncorrelated among themselves and with each other. Consequently, regulation requirements are not arithmetically additive but instead increase with the root mean square. The document is not entirely clear but if Georgia Power is linearly adding regulation requirements of variable renewables and load it is greatly overstating the total system regulation requirement. Further, if Georgia Power is linearly increasing the assumed regulation requirements as the solar fleet grows it is also greatly overstating the overall regulation requirements.

IV. Solar Synthesis Data Concerns

Q. Do you have concerns with how the solar data used in the analysis was generated?

A. Yes. Solar generation data must be synthesized in order to study higher solar penetrations than currently exist. This creates two problems. First, the synthesized solar data must be synchronized to the load data used in the study. Georgia Power has a great deal of load data available spanning many years, and load is growing relatively slowly. The field of load forecasting is well developed through decades of experience. Adjusting historic hourly load data to represent different weather conditions and different economic conditions (greater load growth, for example) is relatively straightforward.

Creating hourly (and sub-hourly) solar data that accurately matches differing weather conditions from different years is much more difficult. It is critical that the solar data be time synchronized with the load data since weather drives both load and solar generation.

Second, the solar data must be extrapolated from lower values of actual installed solar generators and/or from meteorological measurements. As with load, relative short-term variability declines substantially as an aggregation of solar generators or loads increases in size. It is not clear from the materials Georgia Power supplied how the time series solar data for the study was generated. Commission staff should be given access to the detailed solar generation time series data so that they can determine if it was synthesized properly, both synchronizing with the time series load data and incorporating the appropriate diversity benefits as the data is extrapolated to represent the larger solar generation fleet.

V. Representing the Capabilities of Current Solar Generators

Q. Does the analysis adequately reflect the capabilities of current solar generators?

A. No. All new solar plants greater than ~1 MW could easily be placed on automatic generation control.[5] This is not a technology or implementation cost issue. Georgia Power

[5] Energy and Environmental Economics Inc., *Investigating the Economic Value of Flexible Solar Power Plant Operation* (October 2018).

is in control of the interconnection process and simply has to develop technically justified requirements with fair compensation to encourage or require solar generator control capability.

Similarly, single axis tracking can provide cost-effective benefits in terms of increased energy production as well as better matching of the hourly solar generation profile to the hourly utility load shape.

Solar generators with battery storage are fully dispatchable. They impose no regulation or forecast error burdens on the power system. They should be evaluated along side all other generation options with no additional charges or concerns.

All parties should benefit when the power system is economically optimized and reliably operated. System expansion planning and production cost modeling should include cost-effective solar generation capabilities.

Q. Does this conclude your testimony?

A. Yes.

Curriculum Vitae

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Professional Experience:

2008-Present: **Consulting**, Consulting privately with numerous clients including the Florida Power and Light, NextEra, Hawaii PUC, National Renewable Energy Laboratory, ESIG, AWEA, Oak Ridge National Laboratory, EPRI, and others. He served on the NERC Standards Committee. He has 44 years of electric utility experience and has published over 180 papers, articles, and reports on ancillary services, wind integration, restructuring, the use of responsive load as a bulk system reliability resource, and power system reliability. He coauthored a pro bono amicus brief cited by the Supreme Court in their January 2016 ruling confirming FERC demand response authority. He has a patent for responsive loads providing real-power regulation and is the author of a NERC certified course on Introduction to Bulk Power Systems: Physics / Economics / Regulatory Policy.

1994-2008: **Sr. Researcher,** Power Systems Research Program, Oak Ridge National Laboratory. Research interests included electric industry restructuring, unbundling of ancillary services, wind integration, distributed resources, demand side response, energy storage, renewable resources, advanced analysis techniques, and power system security. In addition to the research topics listed above activities included: NYISO Environmental Advisory Council, assignment to FERC Technical Staff to support reliability efforts including NERC/FERC reliability readiness audits, Technical Advisory Committee for the 2006 Minnesota Wind Integration Study, DOE Investigation Team for the 2003 Blackout, the IEEE SCC 21 Distributed Generation Interconnection Standard working group, DOE National Transmission Grid Study, staff to the DOE Task Force on Electric System Reliability, and NERC IOS Working Group. Conducted research projects concerning restructuring for the NRC, DOE, EEI, numerous utilities, state regulators, and EPRI.

Consulting, Consulted privately with utilities, renewable generators, AWEA, ISO/RTOs, IPPs, loads, interest groups, regulators, manufacturers and others on power system reliability, ancillary services, responsive load, wind integration, electric utility restructuring and other issues. Testified as an expert witness in FERC and state litigation.

1991 to 1994: **Power Analysis Department Head,** Technical Analysis and Operations Division. Primary responsibility was to support the Department of Energy in the management of 7000 MW of uranium enrichment capacity. The most significant feature of this load was that 2000 MW were procured on the spot energy market from multiple suppliers requiring rapid response to changing market conditions. Support included technical support for power contract negotiations, development of the real-time energy management strategy, managing the development of a computer based operator assistant to aid in making real-time power purchase decisions. Conducted computer based simulations of the loads and the interconnected network which supplies them. Simulations included large scale load flows, short circuit studies, and transient stability studies. They also included extensive specialized modeling for analysis of electrical, mechanical, and thermal performance under balanced and unbalanced conditions. Responsible for maintaining close ties with technical personnel from the various utilities which supplied power to the diffusion complex to exchange data and perform joint studies.

Provided consultation services on a large range of power system concerns including: cogeneration opportunities, power supply for the Lawrence Livermore National Laboratory M.F.T.F. facility, capacity at EURODIF, power supply for the Strategic Petroleum Reserve, power supply for large pulsed fusion loads, and wheeling.

1985 to 1991: **Electric Power Planning Section Head,** Enrichment Technical Operations Division with substantially the same responsibilities as stated above.

1977 to 1985: **Technical Computing Specialist,** Electrical Engineering and Small Computing Section, Computing and Telecommunications Division. Time was evenly divided between power system studies as described above and minicomputer work. The minicomputer work supported laboratory data collection and experiment control.

1975 to 1976: **Engineer,** Electrical Engineering Department, Long Island Lighting Company, Hicksville, New York. Responsible for electrostatic and magnetic field strength modeling as well as sound level testing and analysis.

Education:

1977 - M.S.E.E., power option, Carnegie-Mellon University, Pittsburgh, Pa.
Worked under a Department of Transportation contract studying more efficient means of energy use in rail systems.

1975 - B.S.E.E., Lehigh University, Bethlehem, Pa., cum laude, Eta Kappa Nu, the Electrical Engineering Honorary, and Phi Eta Sigma, the freshman Honorary.

Professional Affiliations and Awards:

- Licensed professional engineer
- Patent 7,536,240: Real Power Regulation For The Utility Power Grid Via Responsive Load
- 1985, 1986, 1987, 1990, and 1992 Awards for power system related work
- Life Senior Member of the IEEE
- Former DOE Q clearance

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