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April 22, 2021

VIA ELECTRONIC FILING

Ms. Kimberley A. Campbell
Chief Clerk
North Carolina Utilities Commission
4325 Mail Service Center
Raleigh, North Carolina 27699-4300

**Re: Duke Energy Carolinas, LLC and Duke Energy Progress, LLC's
Fourth Joint 45-Day Progress Report
Docket No. E-100, Sub 167**

Dear Ms. Campbell:

Enclosed please find the Fourth Joint 45-Day Progress Report for Duke Energy Carolinas, LLC and Duke Energy Progress, LLC for filing in the above-referenced docket.

If you have any questions, please do not hesitate to contact me.

Sincerely,

Kendrick C. Fentress

Enclosure

cc: Parties of Record

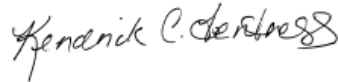
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CERTIFICATE OF SERVICE

I certify that a copy of Duke Energy Carolinas, LLC and Duke Energy Progress, LLC's Fourth Joint 45-Day Progress Report, in Docket No. E-100, Sub 167, has been served by electronic mail, hand delivery, or by depositing a copy in the United States Mail, 1st Class Postage Prepaid, properly addressed to parties of record.

This the 22nd day of April, 2021.



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STATE OF NORTH CAROLINA
UTILITIES COMMISSION
RALEIGH

DOCKET NO. E-100, SUB 167

BEFORE THE NORTH CAROLINA UTILITIES COMMISSION

In the Matter of:)	
)	
Determination of Avoided Cost Rates for)	FOURTH JOINT 45-DAY
Electric Utility Purchasers from Qualifying)	PROGRESS REPORT OF DUKE
Facilities – 2020)	ENERGY CAROLINAS, LLC
)	AND DUKE ENERGY
)	PROGRESS, LLC

NOW COME Duke Energy Carolinas, LLC (“DEC”) and Duke Energy Progress, LLC (“DEP” and together with DEC, “Duke” or the “Companies”) by and through counsel, and pursuant to the *Order Granting Continuance and Establishing Reporting Requirements (“Reporting Order”)*, issued by the North Carolina Utilities Commission (“NCUC” or “Commission”) on October 30, 2020, in the above-captioned docket and hereby respectfully provide this fourth 45-day report on their progress in addressing certain additional issues for the November 2021 avoided cost proceeding. Specifically, the Reporting Order directed the Companies to file by December 7, 2020, and every 45 days thereafter, a proposal, including a timeline, of how the Companies intend to address each of the “Sub 158 Additional Issues,” as discussed in the Reporting Order and further detailed herein. The Companies’ progress report to the Commission on the Sub 158 Additional Issues is as follows:

Background

On August 13, 2020, the Commission issued an *Order Establishing Biennial Proceeding, Requiring Data, and Scheduling Public Hearing*, which initiated the 2020

biennial proceeding for determining each utility's avoided costs with respect to rates for purchases from qualifying facilities pursuant to the provisions of Section 210 of the Public Utility Regulatory Policies Act of 1978 ("PURPA") and the Federal Energy Regulatory Commission's ("FERC") regulations implementing those provisions, as well as North Carolina's PURPA implementation statute, N.C. Gen. Stat. § 62-156 ("Scheduling Order").

The Scheduling Order noted that the Commission's April 15, 2020 *Order Establishing Standard Rates and Contract Terms for Qualifying Facilities* issued in Docket No. E-100, Sub 158 ("Sub 158 Order") set forth a number of additional issues to be addressed by the utilities in their initial November 1, 2020 filings in Docket No. E-100, Sub 167. These issues include:

- Real-time pricing tariffs;
- Cost increments and decrements to the publicly available combustion turbine cost estimates;
- The use of other reliability indices, specifically the Equivalent Unplanned Outage Rate ("EUOR") metric, to support development of the performance adjustment factor ("PAF");
- The extent of backflow at substations;
- The potential for qualifying facilities ("QFs") to provide ancillary services and appropriate compensation; and
- The results of an independent technical review of the Astrapé Study solar integration services charge ("SISC") methodology.

("Sub 158 Additional Issues")

On October 20, 2020, DEC, DEP, and Virginia Electric and Power Company, d/b/a Dominion Energy North Carolina ("DENC") filed a Notification of Intended Compliance with N.C. Gen. Stat. § 62-156(b), Request for Continuance of Compliance with Certain 2020 Filing Requirements and Request to Prospectively Modify Timing of Biennial Proceedings ("Continuance Motion"). In their Continuance Motion, the Companies and DENC noted FERC's issuance of Order No. 872 on July 16, 2020, as potentially identifying

new avoided cost rate setting methodologies and addressing a number of issues that have the potential to impact the Companies', DENC's and the Commission's implementation of PURPA in North Carolina, once the amended regulations become effective December 31, 2020. The Companies proposed undertaking a critical and comprehensive analysis of the FERC's recently amended PURPA regulations to be able to more fully comment on them in an avoided cost filing.¹ Accordingly, the Companies and DENC requested, among other things, a continuance for addressing the Sub 158 Additional Issues until November 1, 2021. Through its Reporting Order, the Commission allowed the request and directed the Companies to file their plans to address the Sub 158 Additional Issues in the November 2021 avoided cost filing through an initial filing on December 7, 2020, and to thereafter provide updates on their progress on the Sub 158 Additional Issues at least every 45 days until the issues are fully addressed.

The Companies made their December 7, 2020 filing and have been working on responding to data requests in the ongoing avoided cost proceeding over the past 45 days. The Companies have focused on meeting the milestones proposed in the December 2020 report for the Technical Review Committee.

Update on Activities to Address Sub 158 Additional Issues

- **Real-Time Pricing Tariffs**

The Companies intend to discuss the issue of real-time pricing avoided cost rate options with the Public Staff within the next 45 days. Order No. 872's modifications to

¹ See Order No. 872, 172 FERC ¶ 61,041, *clarified in part*, Order No. 872-A, 173 FERC ¶ 61,158 (Nov. 19, 2020). Order No. 872's revisions to FERC's regulations implementing PURPA became effective December 31, 2020, which is 120 days after publication of the final rules in the Federal Register (85 FR 54638, published Sept. 2, 2020). See Order No. 872, at ¶ 753; PURPA then provides state regulatory authorities with one year to determine how to implement the new regulations for Utilities for which it has ratemaking authority. See 16 U.S.C. § 824a-3(f)(1).

FERC's regulations establishing approved methodologies under 18 C.F.R. 292.304 for calculating avoided cost rates potentially impact this discussion. The Companies continue to review Order No. 872 to inform the proposals that the Companies will discuss with the Public Staff with respect to real-time pricing tariffs. The Companies also intend to engage North Carolina Sustainable Energy Association ("NCSEA"), Southern Alliance for Clean Energy ("SACE"), and Carolinas Clean Energy Business Alliance ("CCEBA") in the June-August timeframe on this issue.

- **Cost Increments and Decrements to the Publicly Available Combustion Turbine Cost Estimates**

The Companies held an initial discussion with the Public Staff on April 6, 2021 to discuss the Commission's prior directives on this issue, and proposed options for potential increments and decrements to combustion turbine cost estimates that should be considered in developing avoided capacity rates under the peaker methodology. The Companies understand that the Public Staff is reviewing these options and, after the Public Staff's review, they intend to discuss this issue further with the Public Staff within the next 45 days. The Companies also intend to engage NCSEA, SACE, and CCEBA in the June-August 2021 timeframe on this issue.

- **The Use of Other Reliability Indices to Support Development of the PAF**

In its Sub 158 Order, the Commission concluded that the PAF calculations proposed by the Companies in their November 1, 2018 Joint Initial Statement were consistent with the Commission's October 11, 2017 *Order Establishing Standard Rates and Contract Terms for Qualifying Facilities* in Docket No. E-100, Sub 148 and appropriate for purposes of that proceeding. The Commission, however, also accepted the Public Staff's recommendation to consider other reliability metrics, specifically the EUOR.

Accordingly, the Commission directed the Companies and the Public Staff to address the appropriateness of using EUOR as an alternative to the Equivalent Availability (“EA”) method. The Companies held an initial discussion with the Public Staff on March 11, 2021, to discuss the Commission’s prior directives on this issue, and proposed options for developing the PAF for use in the upcoming 2021 avoided cost proceeding. The Companies plan to discuss this issue further with the Public Staff within the next 45 days. The Companies also intend to engage NCSEA, CCEBA, and SACE in the June-August timeframe on this issue.

- **The Extent of Backflow at Substations**

The Companies addressed this issue in their Joint Initial Statement filed in this docket on November 2, 2020, at pages 23-25, as well as in their Reply Comments filed March 5, 2021, at pages 14-15. As addressed in the Companies’ Reply Comments, the Companies plan to further analyze the geographical concentrations of back-feeding substations on their systems and whether an updated rate design with and without a line loss adder based on the amount of back-feeding at a substation would be appropriate in order to provide appropriate market-based signals to QFs regarding the value of the energy at the selected location. The Companies intend to discuss the issue of line losses and geographical concentration of back-feeding substations on their systems with the Public Staff within the next 45 days.

- **The Potential for QFs to Provide Ancillary Services and Appropriate Compensation**

The Companies previously addressed the complexity of this issue, in part, in the Joint Report that they filed with DENC on the Storage Retrofit Stakeholder Meetings in Docket No. E-100, Sub 158 on September 16, 2020 (“Stakeholder Report”). In that

Stakeholder Report, the Companies cited regulation and balance ancillary services for offsetting solar volatility as the only quantified ancillary services eligible for payment in North Carolina. These two ancillary services were quantified for purposes of quantifying solar integration costs only after a contentious and lengthy proceeding in Docket No. E-100, Sub 158. To date, no QFs have demonstrated their ability to avoid imposing increased ancillary costs by operating as controlled solar generators. Therefore, the Companies continue to contend that this complex issue requires additional technical, legal and regulatory review. Primarily, with respect to the potential of QFs providing ancillary services, the Companies will continue to consider how to hold their customers harmless from costs incurred by the Companies from the addition of intermittent QFs and any potential provision of ancillary services from QFs. The Companies had preliminary discussions of this issue with the Public Staff in the context of the recent Storage Retrofit Stakeholder Meetings, and they intended to have preliminary discussions on this complex issue with the Public Staff in the January-March 2021 timeframe. Due to their focus on the other pressing issues, however, the Companies intend to have preliminary discussions with the Public Staff on this complex issue in the next 45 days. The Companies also will engage with stakeholders as previously planned in the June-August 2021 timeframe.

- **The Results of an Independent Technical Review of the Astrapé Study SISC Methodology**

Since filing the Companies' Third Report on March 8, 2021, the Companies have completed formation of the SISC independent technical review committee ("TRC"), as directed by the Sub 158 Order.

As discussed in the Third Report, the Companies have engaged technical experts from the Pacific Northwest National Laboratory ("PNNL") and the National Renewable

Energy Laboratory (“NREL”), to participate in the TRC for the purpose of supporting an in-depth technical review of the SISC study methodology and modeling. A third technical expert from Lawrence Berkeley National Lab (“LBNL”) has now also joined the TRC. The PNNL, NREL, and LBNL representatives will act as the TRC “Technical Leads.” The Companies have also coordinated with the Public Staff and the South Carolina Office of Regulatory Staff (“SC ORS”) to facilitate their participation in the TRC as “regulatory observers,” as well as engaged The Brattle Group (“Brattle”) to act as the TRC Principal consultant. Brattle will coordinate the TRC meetings, incorporate feedback from the TRC Technical Leads, and author the TRC report for the Companies to incorporate into their 2021 avoided cost filings in North Carolina and South Carolina.

The Companies held the TRC “kickoff” meeting on March 2, 2021, and the TRC is now underway with meetings being held bi-weekly.

On March 19, 2021, Duke and Brattle held a stakeholder engagement meeting to update stakeholders on the formation of the TRC and the timeline for completing the TRC’s review of the SISC study methodology and modeling. During this meeting, the Companies and Astrapé discussed the scope of work to be undertaken and also provided an opportunity for interested stakeholders to offer comments for the TRC’s consideration.

The March 19, 2021 presentations to stakeholders are included herewith as Attachment 1 to the Companies’ fourth progress report for the Commission’s information.

- **FERC’s Order No. 872**

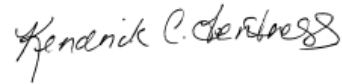
The Companies are continuing to review Order No. 872 and its impact on PURPA implementation in North Carolina. As they committed to do in their Continuance Motion, the Companies intend to develop their positions on Order No. 872’s impact on PURPA implementation in North Carolina and to engage the Public Staff and other stakeholders on

their positions in advance of their November 2021 filing, likely during the months of June-August 2021.

Conclusion

As set forth above, the Companies plan to engage the Public Staff on the outstanding Sub 158 Additional Issues and to continue to facilitate the work of the SISC TRC. The Companies also commit to engage with stakeholders on the Companies' positions with respect to the other Sub 158 Additional Issues in the June-August 2021 timeframe. The Companies will also continue to look for areas where consensus could be achieved with the Public Staff and the other stakeholders as they continue to develop their 2021 avoided cost filing.

Respectfully submitted, this the 22nd day of April 2021.



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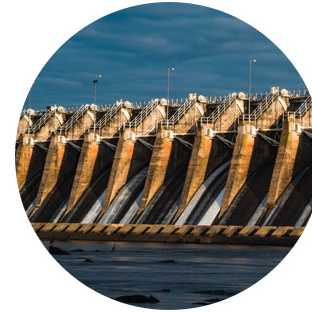
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and Duke Energy Progress, LLC*

Duke Energy Carolinas / Duke Energy Progress

Solar Integration Services Charge Technical Review Committee
Stakeholder Information Meeting



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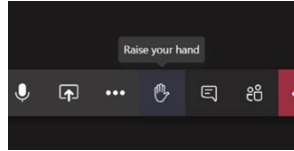
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March 19, 2021

Friendly Reminders / Safety Moment / Opening Remarks



- Everyone is muted
- Please use the Raise your Hand function in Teams if you have a question, we will call on you
- Participants may also submit questions throughout the forum via the messaging button next to the hand.
- Email: ravi.mujsmdar@duke-energy.com

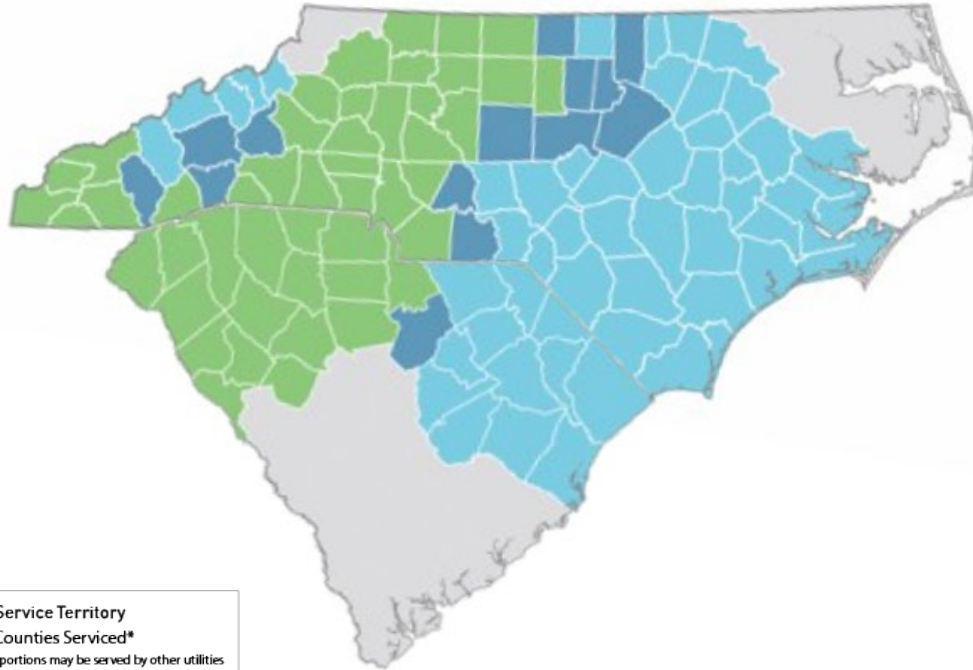
- Safety Moment
- Opening Remarks

- As we will discuss in more detail today, both the SC Commission and the NC Commission have directed Duke to undertake, organize, and coordinate a Technical Review Committee to review the modeling, inputs and assumptions of the Integration Services Charge.
- We will describe how, with input from both the Public Staff of the NCUC and ORS, Duke assembled this Technical Review Committee consistently with the directives of the NC and SC Commission Orders.



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DEC & DEP Service Territories



- In North and South Carolina, Duke Energy has two regulated electric utilities, Duke Energy Carolinas (“DEC”) and Duke Energy Progress (“DEP”), that operate in both states and are responsible for PURPA implementation
- DEC operates approximately 23,200 megawatts of electric capacity serving 2.7 million customers
- DEP operates approximately 13,700 megawatts of owned electricity capacity to serve 1.6 million customers



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**Duke Energy Carolinas and Duke
Energy Progress Solar Ancillary Service
Study**

11/2018

PREPARED FOR

Duke Energy

PREPARED BY

Kevin Carden
Nick Wintermantel
Alex Krasny
Astrapé Consulting

- Headquartered in Hoover, Alabama, Astrapé Consulting LLC (“Astrapé”) has provided electric system planning services and resource adequacy studies for many of the largest utilities and regulators in the U.S. and Europe.
- In 2018, Astrapé completed an Ancillary Service Study which analyzed and quantified the ancillary service impact of integrating existing and future solar generation on both the DEC and DEP systems.
- The Companies used the Solar Ancillary Service Study to develop the Solar Integration Services Charges (“SISC”) applied to intermittent solar generation facilities requesting to sell power to DEC and DEP.

Independent Technical Review of the Solar Ancillary Service Study

- The NCUC directed Duke to organize and coordinate an independent technical review of the Astrapé Study, stating:
 - *. . . the Commission directs Duke to assemble a technical review committee to provide a review of the Astrapé Study. The technical review committee shall be comprised of individuals, not otherwise affiliated with Duke or any of its affiliates or organizations in which Duke is a member, who have technical expertise, knowledge, and experience related to the integration of solar generation as well as the development of complex research, development, and modeling. The committee should include personnel employed by the National Laboratories with relevant experience and expertise. The purpose of the work with a technical review committee is to provide an in-depth review of the study methodology and the model used for system simulations. The technical review committee should provide specific comments or feedback to Duke in the form of a report, which report is to be included in the initial filing made in Duke's 2020 biennial avoided cost proceeding.*
- 2020 biennial Avoided Cost proceeding moved to 2021

- The Companies, with input from the NC Public Staff and SC Office of Regulatory Staff (“ORS”), have retained The Brattle Group (“Brattle”) as TRC Principal consultant who will coordinate the TRC meetings, incorporate feedback from the TRC Technical Leads, and author the TRC report for the Companies to incorporate into their 2021 regulatory filings.
- Brattle will be responsible for coordinating the work of the TRC and delivering a report to Duke Energy summarizing the TRC’s review, findings and recommendations.
 - Hannes Pfeifenberger, Principal
 - Stephanie Ross, Associate



Appendix: Independent Technical Review of the Solar Ancillary Service Study

- On April 15, 2020, the North Carolina Utilities Commission (“NCUC”) issued a final Order Establishing Standard Rates and Contract Terms for Qualifying Facilities in Docket No. E-100, Sub 158. On page 12 of the Order, the NCUC made the following ruling regarding the SISC proposed by DEC and DEP:
 - *(34) The determinations based upon the results of the Astrapé Study demonstrate that an additional 26 MW of load following reserves are required to integrate 840 MW of solar-QF capacity in DEC at an average cost of **\$1.10/MWh** and that an additional 166 MW of load following reserves are required to integrate 2,950 MW of solar-QF capacity in DEP at an average cost of **\$2.39/MWh**, and are reasonable for use in this proceeding.*
 - *(36) It is appropriate to apply the integration services charge as a fixed amount of **\$1.10/MWh** for DEC and **\$2.39/MWh** for DEP during the term of the contracts for those QFs that establish a LEO (“Legally Enforceable Obligation”) during the availability of the rates established in this proceeding as a decrement to and included in DEC’s and DEP’s respective avoided energy rates.*

Appendix: Independent Technical Review of the Solar Ancillary Service Study

- The Public Service Commission of South Carolina (“PSCSC”) approved the Companies’ proposed SISCs based on the Astrapé Study, and directed Duke to undertake “an independent technical review of the underlying modeling, inputs, and assumptions of the Integration Services Charge prior to the next avoided cost proceeding.”
 - See PSCSC Order No. 2019-881-A, at 31, 121
 - Duke agreed to complete the independent technical review in a Partial Settlement Agreement filed with the PSCSC on October 21, 2019, in Docket Nos. 2019-184-E and 2019-185-E
 - That Partial Settlement Agreement, which was approved by the SCPSC in Order No. 2019-881-A, provided, in pertinent part, that:
 - *The Astrape Study used to calculate the SISC presents novel and complex issues that warrant further consideration. Duke shall submit the study methodology and inputs to an **independent technical review** and include the results of that review and any revisions in its initial filing in the next avoided cost proceeding. To the maximum extent practicable the independent review of the study methodology shall take into consideration the South Carolina Integration Study called for by S.C. Code Ann. § 58- 37-60.*

Technical Review Committee for the Solar Integration Service Charge (SISC)

PRESENTED BY

Stephanie Ross

Hannes Pfeifenberger

APRIL 19, 2021



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About the Brattle team

The Brattle team assists electric utilities, independent system operators, generation and transmission developers, electricity customers, regulators, and policymakers with planning, regulatory, and market design challenges in the electricity industry. Relevant experience also includes addressing renewable integration challenges, power system simulations, applications of the SERVVM simulation tool, and collaborations with national labs.



Hannes Pfeifenberger
Principal, Boston



Stephanie Ross
Associate, Boston

Technical Leads on the TRC

Three technical leads from the National Labs with relevant experience and expertise are serving on the TRC.



**Lawrence Berkeley
National Laboratory**

Regulatory Observers on the TRC

- Observers from the NC Public Staff
 - Jeff Thomas (primary)
 - Dustin Metz (alternate)
- Observers from the SC Office of Regulatory Staff
 - Robert Lawyer
 - O’Neil Morgan
 - Gretchen Pool
- The participation of the NC Public Staff and SC ORS Regulatory Observers is designed to encourage **open dialogue and ensure the transparent nature** of the TRC review process.
- The positions or perspectives raised by the Regulatory Observers in those discussions do not, however, limit the ability of those agencies to ultimately agree or disagree with the findings of the TRC or to take positions in later proceedings that do not align with the TRC’s findings and recommendations.

TRC Work Plan

Conduct independent technical review of the methodology and assumptions used by Astrapé to develop the SISC, with substantial input from technical experts and regulatory observers

- Provide technical review of the SISC analysis' inputs, methodology, and outputs
 - Review input assumptions. For example:
 - ▶ Intra-hour renewable generation uncertainty
 - ▶ Changes since the 2020 Duke IRP, particularly early generation retirements (e.g., Allen Unit 3 which will be retired nine months early on March 31, 2021)
 - Review methodology. For example:
 - ▶ Compare Astrapé's approach with similar methodologies developed by the National Labs
 - ▶ Ensure consistency with changes in market fundamentals (e.g., natural gas prices, wholesale power markets, Southeast Energy Exchange Market (SEEM))
 - Review results
- Provide input and feedback to Astrapé throughout the review process so that it can be incorporated into the analysis in a timely manner
- Prepare TRC report with input from technical experts and regulatory observers

Timeline

March – June 2021

- TRC will meet bi-weekly through June 25, 2021
 - TRC Kickoff Meeting: March 2, 2021
 - TRC Meeting #2: March 12, 2021
 - TRC Meeting #3: March 26, 2021
 - Bi-weekly meetings thereafter

Milestones

- March/April – Astrapé develops draft set of results by end of March / early April to TRC
- April – TRC reviews results and provides feedback
- May – Astrapé performs any additional analysis to finalize study
- June – TRC finalizes recommendations and Brattle compiles final report

Revised SISCs for DEC/DEP will be included in both states' 2021 Avoided Cost filings

- July 2021: South Carolina – Filed with the Companies' Avoided Cost proceeding
- November 2021: North Carolina – Filed with the Companies' Avoided Cost proceeding

Written Comments for TRC

Duke has opened a channel for written comments to inform the TRC's review of the SISC

- sisctr@outlook.com
- All comments due by April 2, 2021

Our Practices and Industries

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Electric Transmission
Electricity Market Modeling
& Resource Planning
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Energy Storage
Environmental Policy, Planning
and Compliance
Finance and Ratemaking
Gas/Electric Coordination
Market Design
Natural Gas & Petroleum
Nuclear
Renewable & Alternative
Energy

LITIGATION

Accounting
Analysis of Market
Manipulation
Antitrust/Competition
Bankruptcy & Restructuring
Big Data & Document Analytics
Commercial Damages
Environmental Litigation
& Regulation
Intellectual Property
International Arbitration
International Trade
Labor & Employment
Mergers & Acquisitions
Litigation
Product Liability
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Valuation
White Collar Investigations
& Litigation

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Ancillary Service Impact Study to Calculate Solar Integration Services Charge (SISC)

Astrapé Consulting

3/19/2021

Ancillary Service Impact Study

- **Premise of the Study is to maintain the same amount of flexibility violations before and after solar is added**

- Select Study Year – Use 2024 consistent with recent Resource Adequacy Study
- Simulated different penetration levels of solar across the DEC/DEP Systems

	DEC	DEP
Tranche 1 MW	967	2,908
Tranche 2 MW	2,431	4,019
Tranche 3 MW	3,931	5,519

- Step 1: Run Base Case:
 - Simulate with reasonable operating reserves to determine flexibility violations without solar
- Step 2: Add Solar:
 - As solar is added flexibility violations increase due to the increase in net load volatility
- Step 3: Add Solar and Add ancillary services:
 - Add additional ancillary services in the form of load following to get back to the original number of flexibility violations
- Step 4: Calculate the ancillary service cost impact:
 - Calculate the cost increase of the additional ancillary services between Step 2 and Step 3. Then divide by the incremental solar generation to calculate the ancillary service cost impact

SERVM Framework

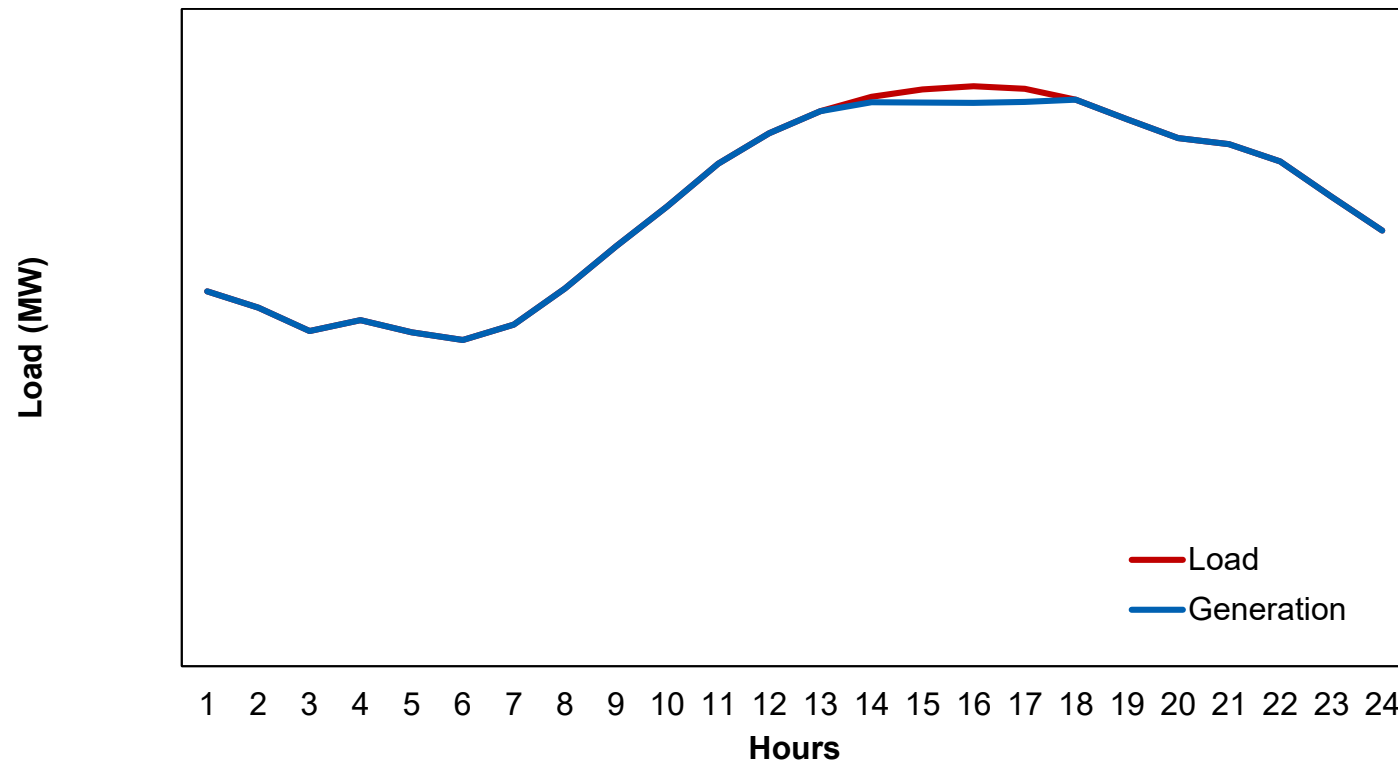
- **Base Case Study Year (2024) – Begin with 2020 Resource Adequacy Study**
 - Weather (39 years of weather history)
 - Impact on Load
 - Impact on Intermittent Resources
 - Economic Load Forecast Error (distribution of 5 points)
 - Unit Outage Modeling (thousands of iterations)
 - Multi-State Monte Carlo
 - Frequency and Duration
 - Model DEC and DEP as individual BAs with traditional capacity added to get to 0.1 LOLE Cap

- Base Case Total Scenario Breakdown: 39 weather years x 5 LFE points = 195 scenarios
- Base Case Total Iteration Breakdown: 195 scenarios * 20 unit outage iterations = 3,900
 - Exact iterations to be determined

- Simulations @ 5-minute increments

LOLE_{CAP} – Example Only

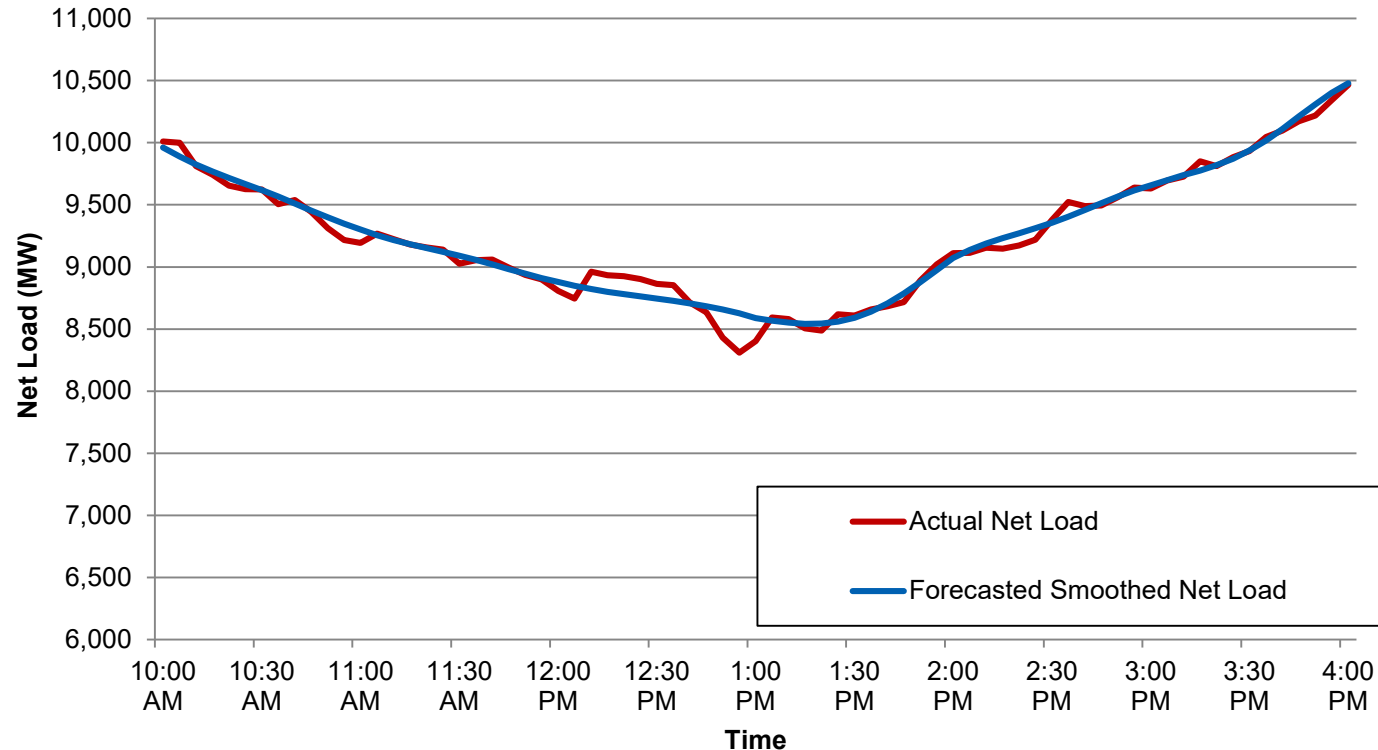
- LOLE_{CAP}:
 - Traditional LOLE; number of loss of load events due to capacity shortages, calculated in events per year.
 - Used for Reserve Margin Planning and Capacity Value of Resources



Flexibility Violation – Example Only

Flexibility Violations:

- Number of events where generators modeled in SERVIM could not meet the next 5-minute net load. There was enough capacity installed but not enough flexibility to meet the net load ramps
- Resolved by adding online ramping capability to meet the volatility of additional solar



Resource Commitment and Dispatch

- **8760 Hourly Chronological Commitment and Dispatch Model**
- **Simulates 1 year allowing for thousands of scenarios to be simulated which vary weather, load, unit performance**
- **Simulated at 5-minute increments**
- **Respects all unit constraints**
 - Capacity maximums and minimums
 - Heat rates
 - Startup times and costs
 - Variable O&M
 - Emissions
 - Minimum up times, minimum down times
 - Must run designations
 - Ramp rates
- **Load and solar volatility modeled which removes perfect foresight**

Ancillary Service Impact Study

- **Ancillary services are input into SERVVM**
 - Regulation Up/Down Requirement – served by units designated with AGC capability
 - Spinning Reserves Requirement – served by units who have minimum load less than maximum load
 - Load Following Up/Down Reserves – identical to spinning reserves; served by units who have minimum load less than maximum load
 - Quick Start Reserves – served by units who are offline and have quick start capability
- **SERVVM commits resources to serve load and ancillary service requirements entered by user**

Potential Improvements in 2021 Study

- Move away from targeting a base number of flexibility violations (i.e. 0.1 events per year) for the Base Case;
 - Instead include reasonable level of operating reserves and allow the model to calculate the baseline flexibility violation. Then target the same number of flexibility violations after solar is added
- Update solar volatility based on most recent data
 - Include diversity benefit at higher solar tranches; Extrapolated from historical data.
- Add operating reserves in a more targeted manner (i.e. during hours when violations are occurring, during solar hours)
- Explore day ahead/multi hour ahead forecast error

Appendix

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2018 Ancillary Service Study Results

- **Average Ancillary Service Cost Impact of Existing Plus Transition**
 - Initial Study represents a conservative approach versus using incremental costs
 - DEC - \$1.10/MWh – 840 MW of solar
 - DEP - \$2.39/MWh – 2,950 MW of solar

Previous DEC Results

	Solar Scenario				
	DEC No Solar	DEC Existing Plus Transition	DEC Tranche 1	DEC Add 1,500 MW 75%	DEC Add 1,500 MW
Incremental Solar MW	0	840	680	1,500	1,500
Total Solar MW	0	840	1,520	3,020	3,020
LOLE Flex Events Per Year	0.10	0.10	0.10	0.10	0.10
Average Ancillary Service Cost Impact \$/MWh	0	1.10	1.37	2.90	9.75
Incremental Ancillary Service Cost Impact \$/MWh	0	1.10	1.67	4.38	17.78
Total Load Following Addition MW	0	26	67	243	634
Additional Renewable Curtailment MWh	0	3,268	16,238	114,657	229,475
Renewable Generation MWh	0	1,556,350	2,949,446	6,022,045	6,022,045
% of Renewable Curtailed %	0	0.2%	0.6%	1.9%	3.8%
Solar Volatility Assumption	Base	Base	Base	75% Assumption	Base

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Previous DEP Results

	Solar Scenario				
	DEP No Solar	DEP Existing Plus Transition	DEP Tranche 1	DEP Add 1,500 MW 75%	DEP Add 1,500 MW
Incremental Solar MW	0	2,950	160	1,500	1,500
Total Solar MW	0	2,950	3,110	4,610	4,610
LOLE Flex Events Per Year	0.10	0.10	0.10	0.10	0.10
Average Ancillary Service Cost Impact \$/MWh	0	2.39	2.64	9.72	14.91
Incremental Ancillary Service Cost Impact \$/MWh	0	2.39	6.80	23.24	38.34
Total Load Following Addition MW	0	166	192	589	832
Additional Renewable Curtailment MWh	0	188,827	246,582	1,428,797	1,921,068
Renewable Generation MWh	0	5,614,112	5,945,439	9,059,760	9,059,760
% of Renewable Curtailed %	0	3.36%	4.15%	15.77%	21.2%
Solar Volatility Assumption	Base	Base	Base	75% Assumption	Base

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DEC Solar Volatility – last study's assumptions

		Normalized Output (%)												
		0	10	20	30	40	50	60	70	80	90			
Normalized Divergence (%)	-13					0.0			0.0					
	-12				0.0	0.0	0.1							
	-11			0.0	0.0	0.0	0.1	0.1			0.0			
	-10			0.0	0.0	0.2	0.2	0.1	0.0	0.0				
	-9			0.0	0.1	0.3	0.2	0.2	0.2	0.0				
	-8		0.0	0.1	0.2	0.4	0.3	0.3	0.3	0.0				
	-7		0.0	0.2	0.3	0.5	0.8	0.5	0.5	0.1				
	-6		0.1	0.3	0.6	0.7	1.3	1.0	1.0	0.3	0.1			
	-5		0.3	0.5	1.4	1.3	2.0	1.8	2.1	0.6	0.2			
	-4		0.7	1.5	2.0	2.6	3.5	2.7	3.6	1.6	0.3			
	-3	0.1	2.5	3.8	4.2	5.0	5.3	5.5	5.9	3.7	1.5			
	-2	0.5	9.2	12.2	13.7	10.9	11.3	9.8	11.4	10.3	6.4			
	-1	16.0	39.6	29.5	27.2	25.8	24.4	28.1	26.6	35.6	42.0			
	0	82.8	35.9	31.7	28.2	28.3	25.5	28.8	25.1	32.5	41.2			
1	0.5	8.9	13.7	12.5	13.2	11.3	10.2	9.6	7.6	5.2				
2	0.1	2.3	3.8	5.2	5.2	5.8	4.6	5.2	3.8	2.0				
3		0.4	1.7	2.0	2.4	3.4	3.0	3.2	1.8	0.7				
4		0.0	0.6	1.4	1.3	1.5	1.3	2.0	1.1	0.2				
5			0.2	0.4	0.9	1.0	1.0	1.4	0.4	0.1				
6			0.0	0.3	0.3	1.1	0.5	0.9	0.3	0.0				
7				0.1	0.3	0.5	0.4	0.4	0.1					
8				0.0	0.2	0.3	0.1	0.3	0.1					
9				0.1	0.1	0.1	0.1	0.1	0.0					
10				0.0	0.1	0.1	0.1	0.1	0.0					
11				0.0	0.0	0.0	0.0	0.1						
12								0.0	0.0					
13				0.0				0.0	0.0				0.0	

Normalized Divergence (%)	Probability (%)
-13	0.000
-12	0.002
-11	0.001
-10	0.008
-9	0.015
-8	0.032
-7	0.097
-6	0.181
-5	0.343
-4	0.803
-3	1.827
-2	5.071
-1	21.689
0	61.506
1	5.085
2	1.845
3	0.772
4	0.352
5	0.210
6	0.082
7	0.045
8	0.018
9	0.010
10	0.004
11	0.001
12	0.002
13	0.000
14	0.000

13

- Normalized divergence represents the divergence of solar on a 5 minute from basis from its expected/smooth shape

DEP Solar Volatility – last study's assumptions

		Normalized Output (%)													
		0	10	20	30	40	50	60	70	80	90				
Normalized Divergence (%)	-13														
	-12				0.0										
	-11						0.0								
	-10			0.0		0.1	0.1	0.0	0.0						
	-9			0.0	0.0	0.1	0.2	0.1	0.0						
	-8			0.1	0.0	0.1	0.2	0.2	0.1	0.1					
	-7		0.0	0.1	0.2	0.5	0.6	0.5	0.3	0.0					
	-6		0.1	0.2	0.7	0.5	1.1	0.9	0.8	0.1					
	-5		0.2	0.6	0.8	1.4	1.6	1.5	1.5	0.4	0.1				
	-4		0.6	1.2	2.3	2.4	3.5	3.1	3.8	1.2	0.4				
	-3	0.0	2.5	4.9	4.9	5.3	6.5	5.4	6.7	3.9	0.7				
	-2	0.5	10.2	14.3	15.0	13.4	12.5	11.8	12.8	11.9	6.1				
	-1	16.0	35.2	26.5	26.9	25.7	24.1	27.1	25.5	33.8	44.3				
	0	82.9	36.4	30.1	23.7	25.9	22.9	26.5	24.3	32.9	40.9				
1	0.6	13.4	15.4	15.2	13.3	12.6	10.9	11.2	9.2	5.3					
2	0.0	1.4	4.9	5.9	6.3	6.8	5.8	6.0	3.7	1.7					
3		0.1	1.2	2.6	3.1	3.1	2.8	3.2	1.6	0.3					
4			0.3	0.8	1.0	1.9	1.7	1.9	0.4	0.1					
5			0.0	0.4	0.5	1.4	1.0	1.0	0.6	0.0					
6			0.1	0.1	0.3	0.5	0.4	0.3	0.1						
7				0.1	0.1	0.2	0.2	0.3	0.1						
8				0.0	0.1	0.1	0.1	0.1							
9						0.0	0.0	0.1	0.0						
10				0.0					0.1						
11								0.0							
12								0.0							
13										0.0					

Normalized Divergence (%)	Probability (%)
-13	0.000
-12	0.001
-11	0.002
-10	0.004
-9	0.009
-8	0.024
-7	0.063
-6	0.124
-5	0.278
-4	0.625
-3	1.427
-2	4.046
-1	18.396
0	68.435
1	4.003
2	1.427
3	0.598
4	0.257
5	0.142
6	0.076
7	0.035
8	0.017
9	0.007
10	0.002
11	0.002
12	0.003
13	0.000
14	0.000

14

- Normalized divergence represents the divergence of solar on a 5 minute from basis from its expected/smooth shape

Load Intra Hour Volatility – last study' assumptions

DEC

Normalized Divergence (%)	Probability (%)
-2.2	0.000
-2	0.007
-1.8	0.007
-1.6	0.007
-1.4	0.016
-1.2	0.058
-1	0.205
-0.8	0.624
-0.6	1.578
-0.4	6.886
-0.2	42.055
0	39.243
0.2	6.500
0.4	1.590
0.6	0.591
0.8	0.361
1	0.170
1.2	0.066
1.4	0.009
1.6	0.003
1.8	0.001
2	0.024
2.2	0.000

DEP East

Normalized Divergence (%)	Probability (%)
-2.2	0.000
-2	0.016
-1.8	0.001
-1.6	0.004
-1.4	0.010
-1.2	0.033
-1	0.200
-0.8	0.709
-0.6	2.504
-0.4	12.605
-0.2	38.955
0	26.894
0.2	12.606
0.4	3.896
0.6	0.977
0.8	0.346
1	0.158
1.2	0.046
1.4	0.017
1.6	0.003
1.8	0.003
2	0.019
2.2	0.000

- Normalized divergence represents the divergence of solar on a 5 minute from basis from its expected/smooth shape