Technical Review Committee Report for Duke's Solar Integration Service Charge (SISC)

PRESENTED BY

Hannes Pfeifenberger

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On behalf of the

SISC Technical Review Committee

SEPTEMBER 2, 2021

Brattle

Agenda

- **Review of TRC Process**
- **Summary of Issues Considered and Recommendations made by the TRC**
- **TRC Overview of Preliminary Astrapé Results**
- **Questions and Comments**

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 SERVM simulation tool, and collaborations with national labs.

Hannes Pfeifenberger
Principal, Boston

John Tsoukalis
Principal, Washington DC

Stephanie Ross
Associate, Boston

TRC Members

In addition to the Brattle team, three technical leads from the National Labs with relevant experience and expertise are serving on the TRC:

- Nader Samaan – Chief Engineer and Team Lead (Grid Analytics), Electricity Security Group at Pacific Northwest National Laboratory (PNNL)
- Gregory Brinkman – Researcher V-Model Engineering and Member, Grid Systems Group in the Strategic Energy Analysis Center at National Renewable Energy Laboratory (NREL)
- Andrew Mills – Staff Scientist, Electricity Markets and Policy Group at Lawrence Berkeley National Lab (LBNL)

Regulatory Observers Participating in TRC Meetings

- 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.

Overview of Work Conducted by the TRC

The TRC met twice a month with Astrapé to conduct an independent review of the methodology and assumptions used to develop the SISC

- Input was provided by the regulatory observers, and where appropriate, by Duke subject-matter experts
  - For example, Duke staff assisted in the review of system operations under the joint dispatch agreement, the operating characteristics of Duke's generation, and solar curtailment rules under PURPA contracts
- The TRC requested sensitivities and additional analyses from Astrapé to inform their review of the estimated SISC
- The TRC made recommendations to Astrapé to modify their methodology and assumptions
  - For example, the TRC requested modeling of the Joint Dispatch Agreement (JDA) between DEC and DEP
- The TRC reviewed stakeholder comments and made recommendations based on their review
  - The only set of comments received were provided by the Southern Environmental Law Center (SELC)
- The Brattle team prepared the TRC report with input from the technical experts, and considering comments by stakeholders and regulatory observers during the TRC meetings

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1. The Joint Dispatch Agreement (JDA)

The TRC recommended Astrapé model the JDA, and believes this better represents system operation and the cost of integrating solar resources

- The JDA allows Duke to conducted joint unit commitment and dispatch for all generation resources in DEC and DEP (while retaining individual BAA obligations for DEC and DEP)
- The TRC discussed the operation of the JDA with Duke subject matter experts
  - Based on those conversations, the TRC recommended Astrapé model the JDA in a combined DEC-DEP sensitivity
  - The TRC understands that Duke is required to hold operating and load following reserves independently for the DEC and DEP BAAs, and the Astrapé modeling reflects that constraint
  - The JDA nevertheless allows for lower cost provision of load following reserves than islanded operation
- The TRC finds that modeling the JDA is an improvement on the original study methodology, and recommends that the Commissions refer to Astrapé JDA case results in setting the SISC

2. The Proposed Southeast Energy Exchange Market (SEEM)

The TRC did not recommend that the SEEM be modeled in this estimate of the SISC, but should be included in future estimates

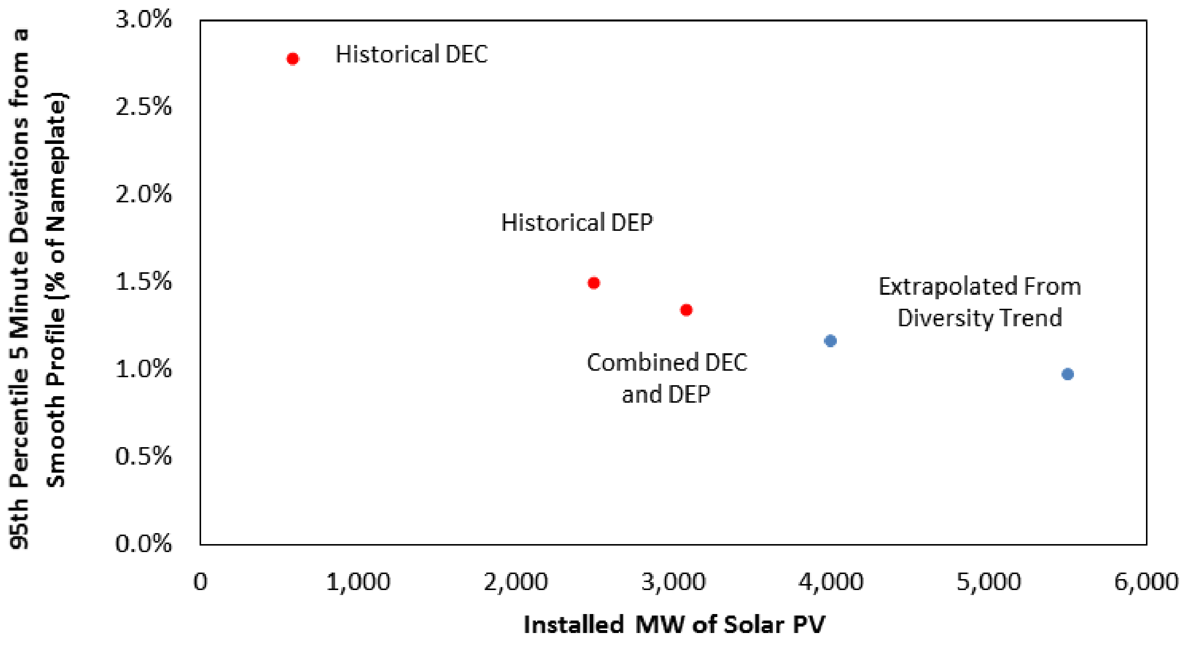
- The proposed SEEM will allow for 15 minute trading of energy between Duke and its neighbors
  - The TRC discussed the proposed market design with Duke subject matter experts.
  - The TRC understands that trades will need to be locked in 5-10 minutes prior to the 15 minute trading period, implying that the SEEM could respond on a 20-25 minute basis to help balance solar volatility.
    - The TRC debated, but did not ask Astrapé to analyze, whether the SEEM would actually reduce the cost of integrating solar due to the 20-25 minute time lag between locking in trades and real-time
- The proposed market rules for the SEEM have yet to be approved by FERC, which leaves uncertainty regarding the market design.
- Based on this uncertainty, the TRC does <u>not</u> recommend that the SEEM be modeled at this time
  - Once SEEM market rules are finalized and there is an operational history with the SEEM, it should be included in simulations to derive SCIC estimates

3. Solar Volatility and the Benefit of Geographic Diversity

The TRC found Astrapé appropriately accounts for the geographic diversity of new solar and the declining per MW volatility as installed solar MW increase

- Astrapé plotted the declining relationship between solar volatility and installed capacity based on the recent historical volatility of Duke's solar resources
  - Observed three data points: DEC, DEP, and combined
- The extrapolated trend from historical data is used to model solar volatility at higher levels of installed solar capacity
- The TRC finds that this approach is a significant improvement over the 2018 study and includes the benefit of declining per-unit volatility as new solar resources come online

Solar Capacity vs. Volatility from Astrapé Study



4. Solar Curtailments

The TRC finds not including an penalty for solar curtailments aligns with system operation and is conservative with respect to the SISC

- The TRC observed that simulated solar curtailments in the model are significant (14% in DEP under Tranche 2 in the Island Case)
  - The JDA Case only saw solar curtailments of 3% under Tranche 2 in the combined DEC-DEP system
  - Note: only a small portion of the curtailments are due to intra-hour load following constraints
- The TRC asked Astrapé to conduct a sensitivity with an economic penalty for solar curtailments
  - The economic penalty did not reduce curtailments significantly and resulted in a slightly higher SISC, indicating that solar curtailments provide relatively low-cost supply of load following reserves
  - Higher curtailments are likely to result in higher overall system costs, even though they lower the SISC
- The regulatory observers and Duke subject matter experts indicated that Astrapé's approach (no penalty for curtailments) is more consistent with PURPA contracts in the Carolinas
- Based on the results of the sensitivity, the TRC did not recommend any change to Astrapé's approach

5. The Operational Flexibility of Duke Generation Resources

The TRC investigated the modeling assumptions related to resource flexibility and concluded that they accurately reflect actual operating constraints

- The TRC observed that the modeled operating characteristics for some of Duke's CTs and their pumped storage resources seems relatively inflexible compared to similar resources owned by other utilities
  - DEC pumped storage resources (Jocassee and Bad Creek) must have all units operating in the same direction (e.g., pumping or generating), the units all have a single pumping capacity (i.e., no flexibility when pumping), and limited difference between min and max generation when generating:
    - Bad Creek units 1-4 can generate between 320 and 420 MW
    - Jocassee units 1-4 can generate between 170 and 195 MW
  - DEC Lincoln and Mill Creek CTs are completely block-loaded (i.e., operate only at max gen)
- The TRC met with subject matter experts at Duke to discuss the operational capabilities of these resources and found that the modeling assumptions accurately reflect unit constraints
  - Investments to upgrade the pumped storage resources would be necessary to increase their flexibility
  - The CTs are relatively small, allowing for some flexibility by committing them individually within the hour

6. The Addition of Flexible Generation Resources to Duke's Fleet

The TRC found that the load following needed (under Tranche 2) for integration likely cannot be provided at a lower cost with new flexible resources

- For Tranche 2, Astrapé estimates solar integration costs in the JDA Case of **$24.3 million/year**
  - The *average* additional load following reserves needed for integration are 204 MW
  - The *maximum* load following needed is more likely to be around 470 MW
- Industry studies suggest new 1-hour battery storage can be added for $55-$87/kW-year
  - Therefore, building or contracting 470 MW of 1-hour batteries would cost **$26.9 to $41.1 million/year**
- At higher levels of solar penetration, new flexible resources may be more cost effective than using Duke's convention resources to provide the needed load following
- New battery resources would provide other benefits to Duke customers; if taken together all the benefits may justify the cost of new batteries
- The TRC concluded that the Commissions can decide to analyze adding additional flexible resources through Duke's resource planning processes

7. Methodology for Modeling Addition of Load Following Reserves

Astrapé improved the methodology for adding load following reserves by adding varying levels of reserves and only in hours with solar production

- In the 2018 study, the model added fixed blocks of reserves in all hours to eliminate flexibility violations
  - This resulted in more reserves than needed (especially in non-solar hours), causing higher estimated solar integration costs
- The current methodology adds load following reserves only in solar production hours and only in amounts necessary until flexibility violations return to the level observed in the no solar case
- The TRC finds that the new approach represents a significant improvement over the previous approach, and is consistent with how other system operators hold the additional load following needed to integrate solar

8. Benchmarking the Estimated Cost of Reserves

The TRC found that the estimated cost of load following reserves is reasonable based on the characteristics of Duke's system

- The TRC benchmarked the estimated cost of load following reserves against reserve prices in PJM
  - The estimated cost of intra-hour load following from the Astrapé model in the JDA Case is $17.25/MWh (Tranche 1) and $20.45/MWh (Tranche 2)
  - The cost of 5-minute regulation reserves in PJM was $13.55/MWh in 2020 and $16.27/MWh in 2019
    - The comparison to 5-minute regulation in PJM is not a perfect comparison, as the load following reserve in the model is a 10-minute product.
- The higher cost of load following for the Duke system is expected given the smaller size of the footprint and the relative low flexibility of some of Duke's generation fleet
- The TRC concluded that the estimated cost of load following reserves was reasonable compared to the neighboring market region (PJM).

9. Suggestions from the SELC

The TRC reviewed and discussed all the conceptual suggestions submitted by SELC; some aligned with the TRC's view and were implemented

- Many of SELC's suggestions aligned with the TRC's view and were implemented by Astrapé:
  - **Account for the JDA:** The TRC recommended this change and it was implemented by Astrapé
    - The JDA Case modeled by Astrapé produces a lower estimated SISC charge for DEC and DEP
  - **Allow Non-Spin Reserves to Provide Load Following:** This was already reflected in the Astrapé approach
  - **Account for Aggregation Benefits at Higher Solar Levels:** Astrapé made several adjustments since the 2018 study that account for the benefit of reduced volatility due to the diversity of a larger solar portfolio
  - **Address the High Cost of Conventional Generator Inflexibility:** The TRC reviewed assumptions on conventional resources and concluded that they are accurate, though some of Duke's resources are less flexible than expected
    - The TRC observed that the estimated integration costs may be large enough to support investment in new flexible resources at higher future levels of solar penetration (e.g., Tranche 3)
    - The SELC recommended that inflexible conventional resource pay an inflexibility charge; the TRC found that this would not be a common approach and is a topic for the Commissions to address

9. Suggestions from the SELC (cont'd)

- Some of SELC's suggestions were not implemented in the study:
  - **Model NERC Standards:** The TRC did not recommend Astrapé model the NERC standards, for several reasons:
    - The approach used by Astrapé is a significant improvement over the 2018 study, and is likely conservative given the perfect 5-minute foresight used in the model (actual solar ramps would be larger than modeled)
    - Modeling the NERC standards would require a model of the entire Eastern Interconnection; given the limitations of this study scope the TRC did not recommend implementing this change
    - The TRC questioned if it is appropriate to model NERC standards if Duke's historical operation was more conservative (i.e., provided higher reliability than required). Modeling lower reliability than historically achieved (even if complying with NERC standards) would shift benefits from customers (who benefit from higher reliability) to solar resources
  - **Account for the Proposed SEEM:** The TRC did not recommend Astrapé model the SEEM
    - The TRC recommends that the SEEM be modeled in future estimates of the SISC, once the market design in approved and there is some operational history in the SEEM
  - **Validate the Results Against Historical Reserve Levels:** The TRC discussed this as a potential benchmark, but found that comparing against historical reserve levels held by Duke may not be informative
    - Historical data would be based on lower solar penetration and different system conditions than represented in the model (e.g., fuel costs, coal retirements, water conditions, etc.)

10. Interpretation of Tranches Modeled by Astrapé

The TRC recommends that the Commissions not consider the Tranche 3 results when establishing the SISC

- The solar generation levels modeled in Tranche 1 and 2 are consistent with recent resource plans for solar development in DEC and DEP
  - Tranche 3 models significantly more solar penetration than contained by Duke's recent resource plans
  - Tranche 3 is illustrative of potential future integration needs, but is largely speculative at this point
    - Duke's conventional resource mix will likely change before reaching the solar penetration levels modeled in Tranche 3, which will alter the integration cost

	Installed Solar Capacity (MW)	
	DEC	DEP
Tranche 1	967	2,908
Tranche 2	2,431	4,019
(Tranche 3*	3,931	5,519)

** Tranche 3 models solar penetration levels beyond current plans; it is included for illustrative purposes only*

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Overview of Preliminary Astrapé Results

Astrapé's preliminary results show a range of integration charges from $0.63/MWh to $2.41/MWh, depending on the solar penetration and utility

Preliminary Estimated SISC from Astrapé Study ($/MWh)

	Island Case		Combined Case	
	DEC	DEP	DEC	DEP
Tranche 1	$1.00	$2.01	$0.63	$1.68
Tranche 2	$1.43	$2.41	$1.05	$2.26

- The Combined Case illustrates the savings from the JDA between DEC and DEP
- A draft Astrapé report was circulated to participants, which includes details of the modeling approach and a complete set of results
  - A final report will be filed with the Commissions

Overview of Preliminary Astrapé Results:
Summary of Cases

- Astrapé estimated the SISC under three levels of solar penetration (all compared to a *no solar case*)

	Installed Solar Capacity (MW)	
	DEC	DEP
Tranche 1	967	2,908
Tranche 2	2,431	4,019
(Tranche 3*	3,931	5,519)

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- Astrapé simulated two cases:
  - The ***island case*** that conducted unit commitment and dispatch independently for DEC and DEP; and
  - The ***combined case*** that reflects the Joint Dispatch Agreement (JDA), allowing for joint unit commitment and dispatch between two companies
    - Recognizing individual BAA obligations, such as operating reserves

Overview of Preliminary Astrapé Results:
Annual Solar Integration Costs

Total annual integration costs decline (relative to the Island case) when the JDA is considered:

- From **$13.3 million/year** to **$10.7 million/year** under Tranche 1
- From **$27.6 million/year** to **$24.3 million/year** under Tranche 2

Summary of Results from Astrapé Study

		Tranche 1			Tranche 2		
		DEC	DEP	Combined	DEC	DEP	Combined
	Solar Capacity (MW)	967	2,908	3,875	2,431	4,019	6,450
	Solar Generation (MWh)	1,887,513	5,677,206	7,564,719	5,279,071	8,312,634	13,591,705
Island Case	10-min LF Reserves During Solar Hours (Island Case)	12	95	106	46	157	204
Island Case	Island Case Integration Costs ($)	$1,886,777	$11,422,833	$13,309,610	$7,555,552	$20,015,360	$27,570,912
Island Case	Island Case Average SISC ($/MWh)	$1.00	$2.01	$1.76	$1.43	$2.41	$2.03
JDA Case	10-min LF Reserves Cost in JDA Case ($/MWh)	$17.25	$17.25	$17.25	$20.45	$20.45	$20.45
JDA Case	JDA Case Integration Costs ($)	$3,174,863	$7,542,222	$10,717,085	$9,645,181	$14,691,557	$24,336,737
JDA Case	JDA Case Average SISC ($/MWh)	$0.63	$1.68	$1.42	$1.05	$2.26	$1.79
JDA Case	JDA Case Incremental SISC ($/MWh)	n/a	n/a	n/a	$1.29	$3.51	$2.26

Overview of Preliminary Astrapé Results:
SISC Estimates

SISC estimates also decline (relative to the Island case) when the JDA is considered

- From **$1/MWh** to **$0.63/MWh** (for DEC) and **$2.01/MWh** to **$1.68/MWh** (for DEP) under Tranche 1
- From **$1.43/MWh** to **$1.05/MWh** (for DEC) and **$2.41/MWh** to **$2.26/MWh** (for DEP) under Tranche 2

Summary of Results from Astrapé Study

		Tranche 1			Tranche 2		
		DEC	DEP	Combined	DEC	DEP	Combined
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Questions or Comments?

Our Practices and Industries

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- Competition & Market Manipulation
- Distributed Energy Resources
- Electric Transmission
- Electricity Market Modeling & Resource Planning
- Electrification & Growth Opportunities
- Energy Litigation
- 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
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- Bankruptcy & Restructuring
- Big Data & Document Analytics
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- Environmental Litigation & Regulation
- Intellectual Property
- International Arbitration
- International Trade
- Labor & Employment
- Mergers & Acquisitions Litigation
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