TAG Meeting
October 15, 2019

Webinar

TAG Meeting Agenda

1. Administrative Items – Rich Wodyka
2. 2019 Study Activities Update – Orvane Piper and Mark Byrd
3. Regional Studies Update – Bob Pierce
4. 2019 TAG Work Plan – Rich Wodyka
5. TAG Open Forum – Rich Wodyka

2019 Study Activities Update

Orvane Piper - Duke Energy Carolinas

Mark Byrd - Duke Energy Progress

Study Process Steps

Completed

1. Assumptions Selected
2. Study Criteria Established
3. Study Methodologies Selected
4. Models and Cases Developed
5. Technical Analysis Performed
6. Problems Identified and Solutions Developed
7. Collaborative Plan Projects Selected
8. Study Report Prepared

Problems Identified and Solutions Developed

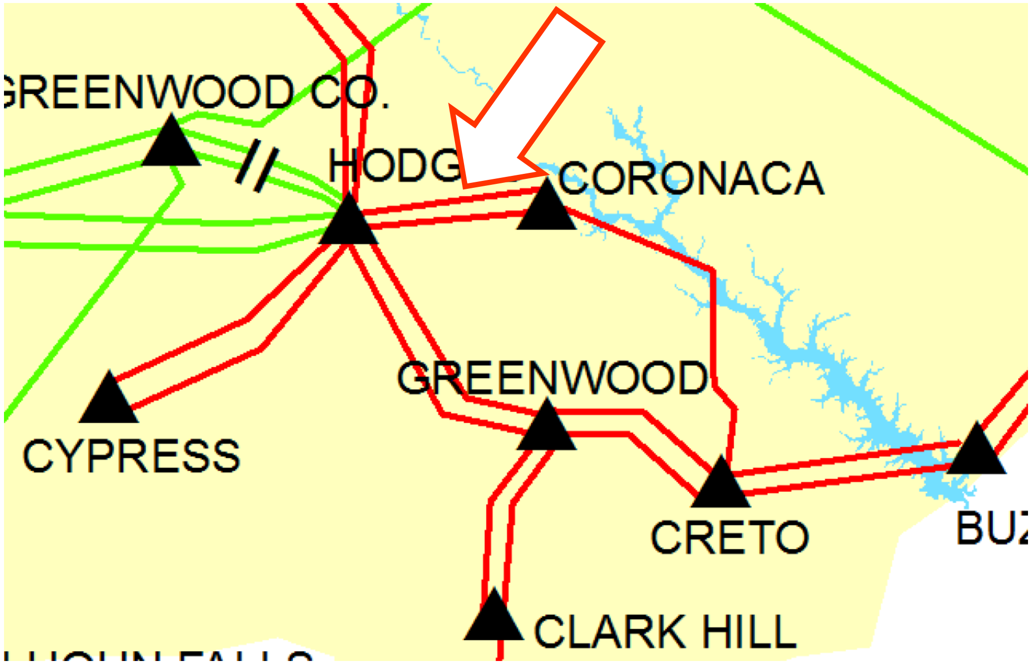
- Identify limitations and develop potential alternative solutions for further testing and evaluation
- Estimate project costs and schedule

Annual Reliability Studies

- 2024 Summer
- 2024/2025 Winter
- 2029 Summer

New Projects in 2019 Plan

Reliability Project	TO	I/S Date
Upgrade Cokesbury 100 kV Line	DEC	6/1/24



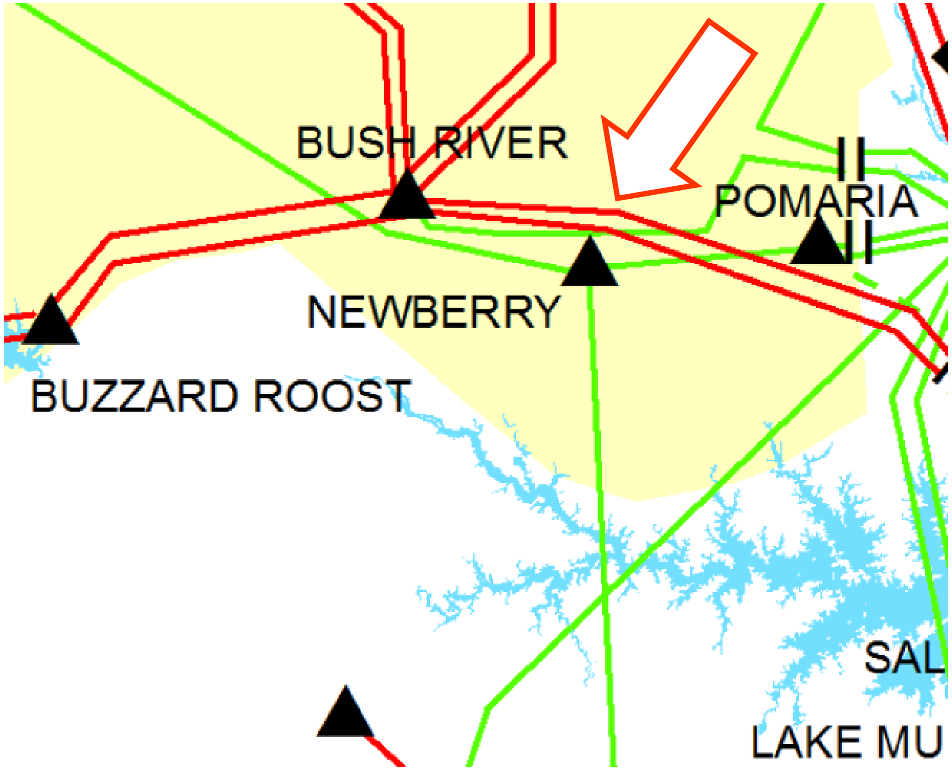
Local Economic Studies Hypothetical Transfers

Resource From	Sink	Test Level (MW)
PJM	DUK[1]	1,000
SOCO	DUK	1,000
CPLE[2]	DUK	1,000
TVA[3]	DUK	1,000
PJM	CPLE	1,000
DUK	CPLE	1,000
DUK	SOCO	1,000
PJM	DUK/CPLE	1,000/1,000
DUK/CPLE	PJM	1,000/1,000
CPLE	PJM	1,000
DUK	PJM	1,000
SOCO[4]	CPLE	1,000
DUK[5]	TVA	1,000
PJM[6]	SCEG	1,000

1 – DUK is the Balancing Authority Area for DEC
2 – CPLE is the eastern Balancing Authority Area for DEP
3 – This hypothetical transfer is intended to evaluate the impact of a 1,000 MW TVA transaction through the SOCO transmission system into DUK
4 – This hypothetical transfer is intended to evaluate the impact of a 1,000 MW Southern Co transaction through the DEC transmission system into CPLE
5 – This hypothetical transfer is intended to evaluate the impact of a 1,000 MW DUK transaction through the SOCO transmission system into TVA
6 – This hypothetical transfer is intended to evaluate the impact of a 1,000 MW PJM transaction through the CPLE transmission system into SCEG

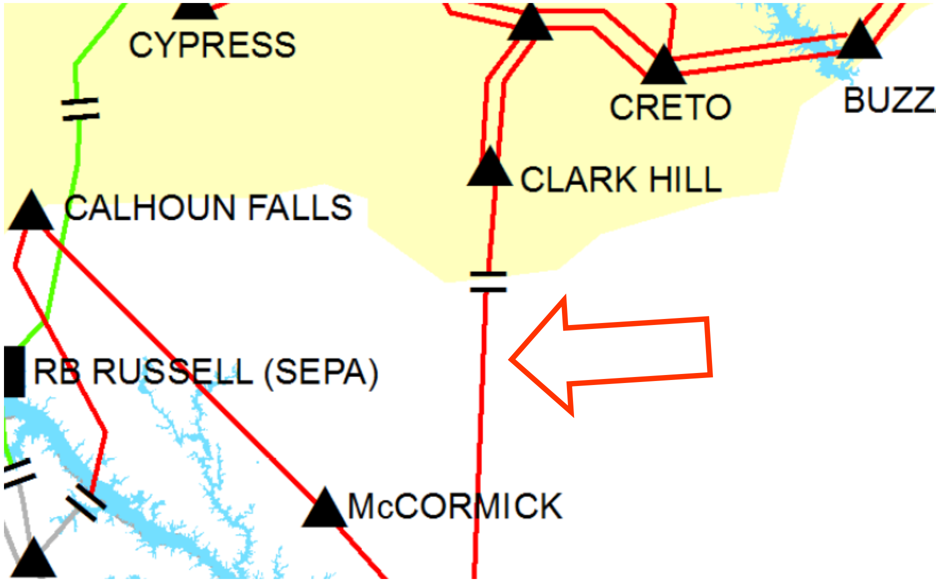
Local Economic Studies
Hypothetical Transfers (cont.)

- **Upgrade Newberry 115 kV lines ($17 MM)**
  - **PJM-SCEG**



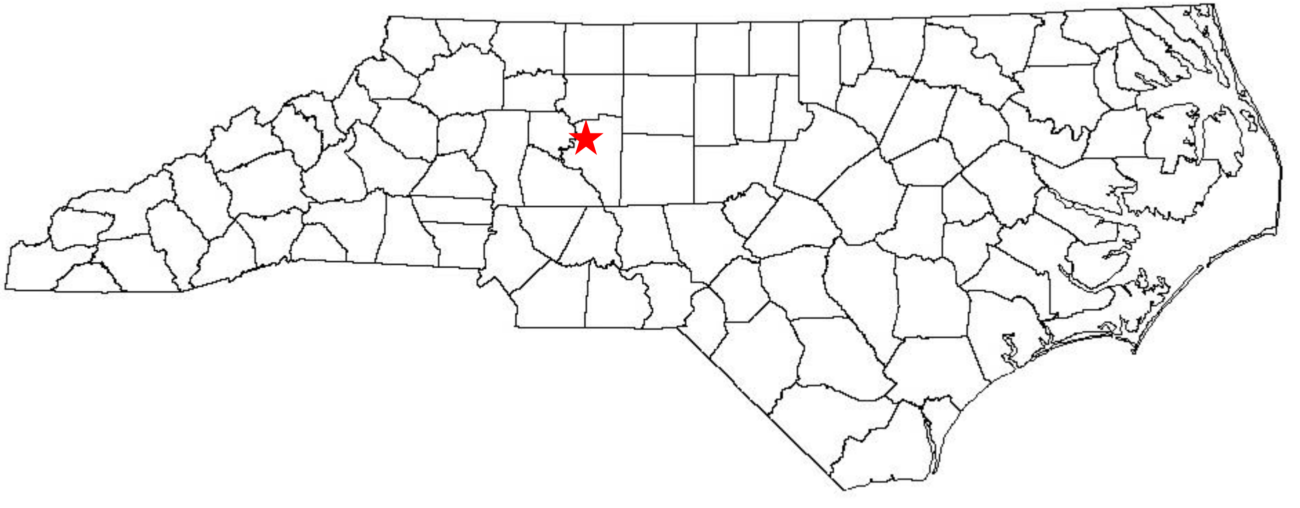
Local Economic Studies
Hypothetical Transfers (cont.)

- **Upgrade Clark Hill 115 kV line ($66 MM)**
  - **CPLE-DUK**
  - **PJM-DUK**
  - **PJM-DUK/CPLE**
  - **SOCO-CPLE**
  - **SOCO-DUK**
  - **TVA-DUK**



Local Economic Studies
Hypothetical Generation

- 2,200 MW Combined Cycle Plant in Davidson County, NC
- 20 MW Solar + Storage Facility in Davidson County, NC



Local Economic Studies
Hypothetical Generation (cont.)
2,200 MW Combined Cycle Plant

- Interconnect via switching station on 230 kV lines
- Construct double circuit 230 kV lines (Buck CC-Site-Beckerdite)
- Upgrade Batte 100 kV lines (Winecoff-Concord City)
- Upgrade Collins 100 kV (Buck Steam-Industrial Customer Tap)
- Upgrade Linden St 100 kV lines (Beckerdite-HP City 4)
- Upgrade Oval 100 kV lines (Buck Steam-Buck Tie)
- Upgrade Salisbury 100 kV lines (Buck Steam-Salisbury)
- Upgrade Tyro 230 kV lines (Buck-Beckerdite)
- Replace (2) 230/100 kV transformers at Beckerdite
- Replace (1) 230/100 kV transformer at Buck

- $184 MM

Local Economic Studies
Hypothetical Generation (cont.)
20 MW Solar + Storage Facility

- **No additional projects identified beyond what was identified in base reliability results for 2024 Summer and 2024/2025 Winter**
- **Interconnect via tap to 100 kV line**

- **$3 MM**

TAG Input Request

- **TAG is requested to provide any feedback and/or propose alternative solutions to the OSC on the 2019 Preliminary Study Results.**
- **Provide input by October 29th to**

  Rich Wodyka (rawodyka@aol.com)

Collaborative Plan Projects Selected

- **Compare all alternatives and select preferred solutions**

Study Report Prepared

- **Prepare draft report and distribute to TAG for review and comment**

North Carolina Transmission Planning Collaborative

Questions ?

Regional Studies Reports

Bob Pierce
Duke Energy Carolinas

SERC Long Term Working Group Update

SERC Long Term Working Group

- Completed work on 2019 series MMWG cases
- Completing study of 2024S and preparing report

SERTP

SERTP

- 3rd Quarter Meeting held on September 26th
- 4th Quarter Meeting will be December 12th in Atlanta
- 2019 Economic Planning Studies results

Economic Planning Studies

- **Southern BAA to Santee Cooper Border**
  - 500 MW (2020 Summer Peak)
- **Duke Energy Carolinas to Santee Cooper Border**
  - 500 MW (2020 Summer Peak)
- **Southern BAA to Santee Cooper Border**
  - 800 MW (2020 Summer Peak)
- **Duke Energy Carolinas to Santee Cooper Border**
  - 500 MW (2024 Winter Peak)
- **Southern BAA to Santee Cooper Border**
  - 1000 MW (2024 Winter Peak)

Power Flow Cases Utilized

- **Study Years:**
  - 2020 and 2024

- **Load Flow Cases:**
  - 2019 Series Version 2 SERTP Regional Models
  - Summer Peak and Winter Peak

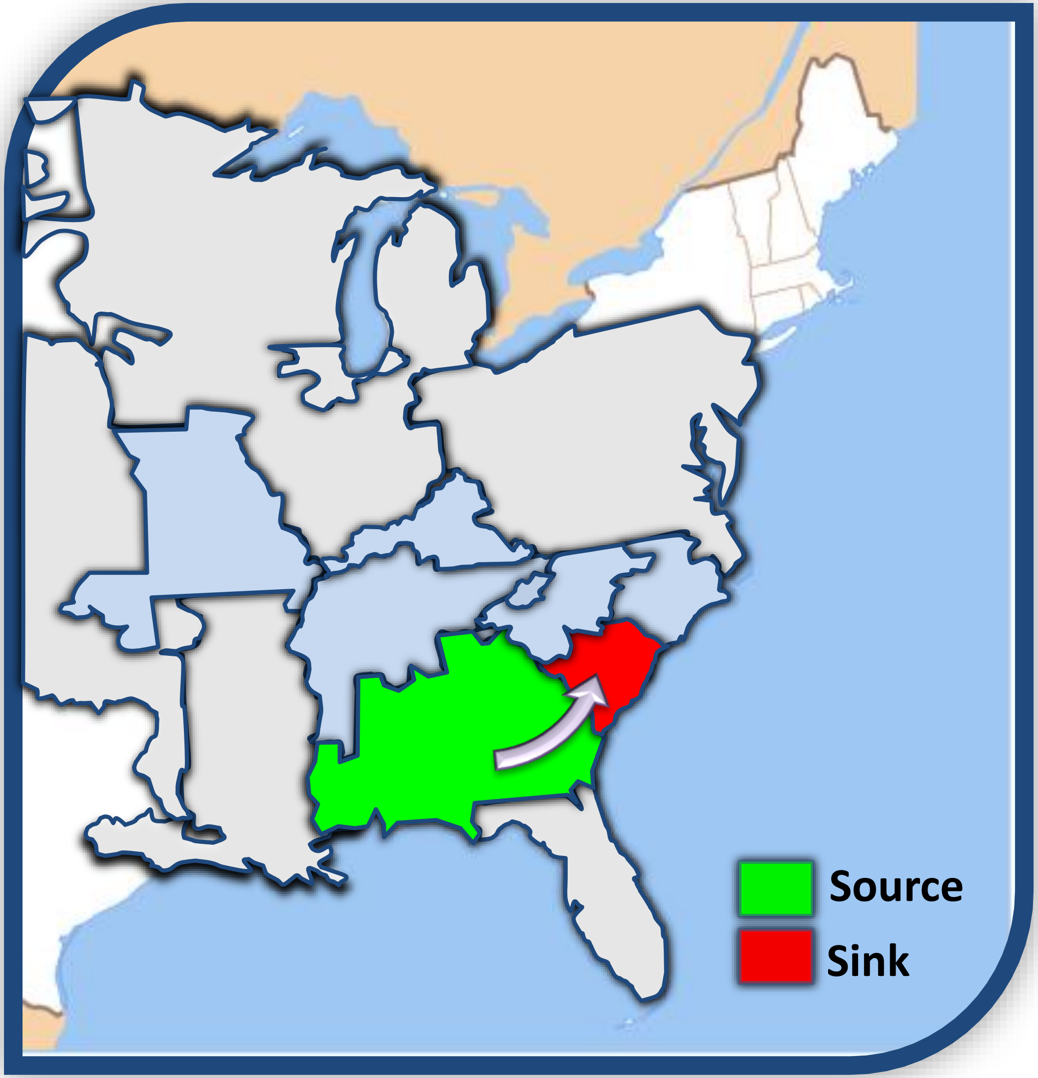
Economic Planning Studies – Preliminary Results

Southern BAA to Santee Cooper Border 500 MW

Southern BAA to Santee Cooper – 500 MW

Study Assumptions

- **<u>Source</u>:** Generation within Southern BAA
- **<u>Sink</u>:** Uniform generation scale within Santee Cooper
- **<u>Transfer Type</u>:** Generation to Generation
- **<u>Year</u>:** 2020
- **<u>Load Level</u>:** Summer Peak



Southern BAA to Santee Cooper – 500 MW

Transmission System Impacts

- **Transmission System Impacts Identified:**
  - Significant constraints were identified in the following SERTP Balancing Authority Areas:
    - DEC
- **Potential Transmission Enhancements Identified:**
  - (DEC) Two (2) 100kV Transmission Line Upgrades

SERTP TOTAL ($2019) = $11,000,000

Southeastern Regional TRANSMISSION PLANNING

Southern BAA to Santee Cooper – 500 MW

Significant Constraints Identified – *DEC*

Table 1: Significant Constraints - DEC

Potential Enhancement	Limiting Element	Rating (MVA)	Thermal Loadings (%) Without Request	Thermal Loadings (%) With Request
P1	Bush River Tie – Saluda Hydro 100kV T.L.	79	101.5	107.4
P2	Laurens Tie – Bush River Tie 100kV T.L.	65	93.9	100.1

Southeastern Regional TRANSMISSION PLANNING

Southern BAA to Santee Cooper – 500 MW

Potential Enhancements Identified – *DEC*

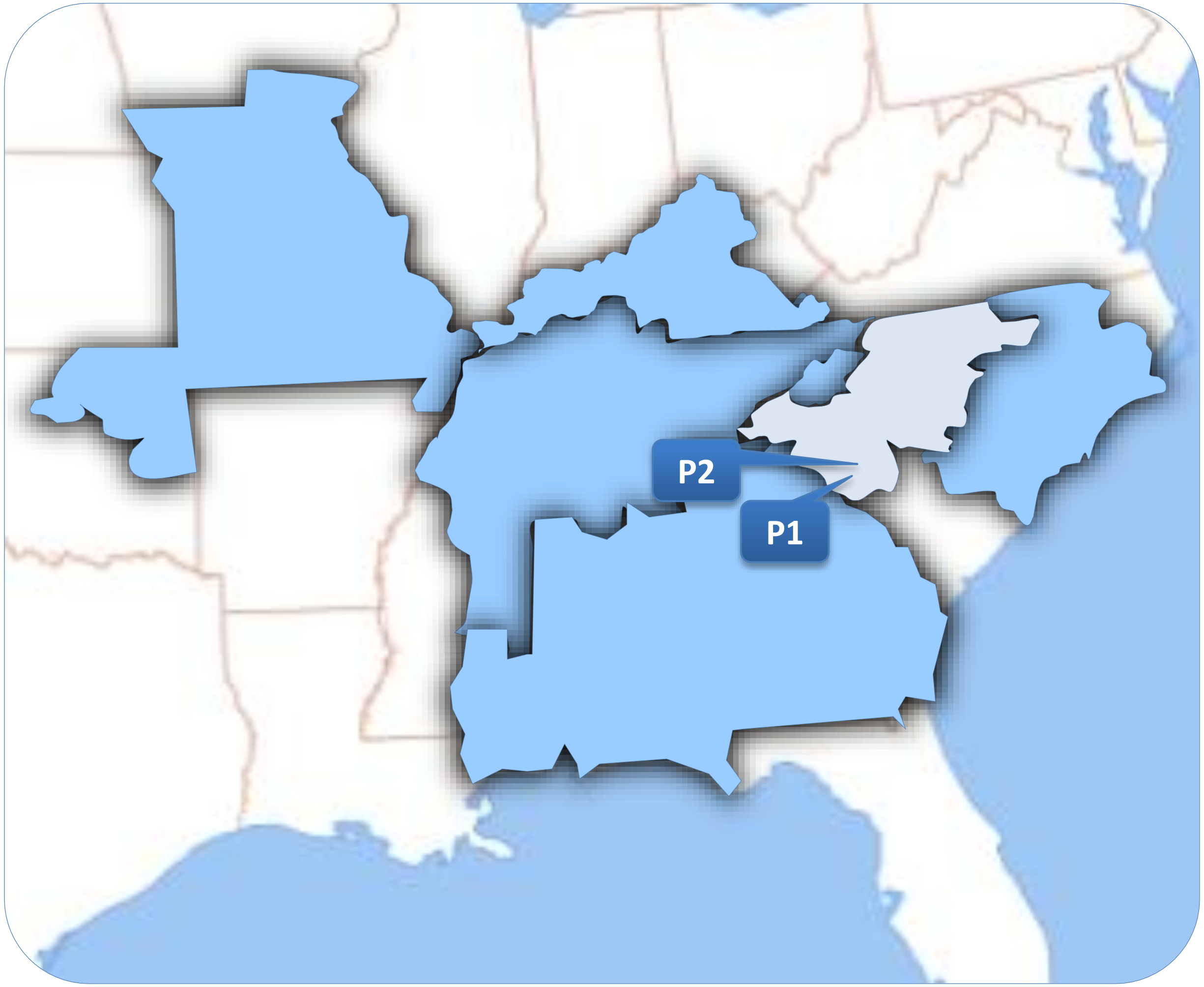
Table 2: Potential Enhancements - DEC

Item	Potential Enhancement	Planning Level Cost Estimate
P1	**Bush River Tie – Saluda Hydro 100kV double circuit** T.L. • Rebuild the 2.7 miles of Bush River Tie – Saluda Hydro 100kV double circuit transmission line with 954 ACSR conductors rated to 120˚C	**$4,900,000**
P2	**Laurens Tie – Bush River Tie 100kV double circuit T.L.** • Rebuild approximately 2.8 miles of Laurens Tie – Bush River Tie 100kV double circuit transmission line with 954 ACSR conductors rated to 120˚C.	**$5,100,000**
	DEC TOTAL ($2019)	**$ 11,000,000**(1)

(1) Total planning level cost estimate does not include the cost of projects that are included in SERTP Sponsors' expansion plans and are scheduled to be completed by June 1st of the study year. The studied transfer depends on these projects being in-service, and the cost to support the study transfer could be greater than the total shown above if any of these projects are delayed or cancelled.

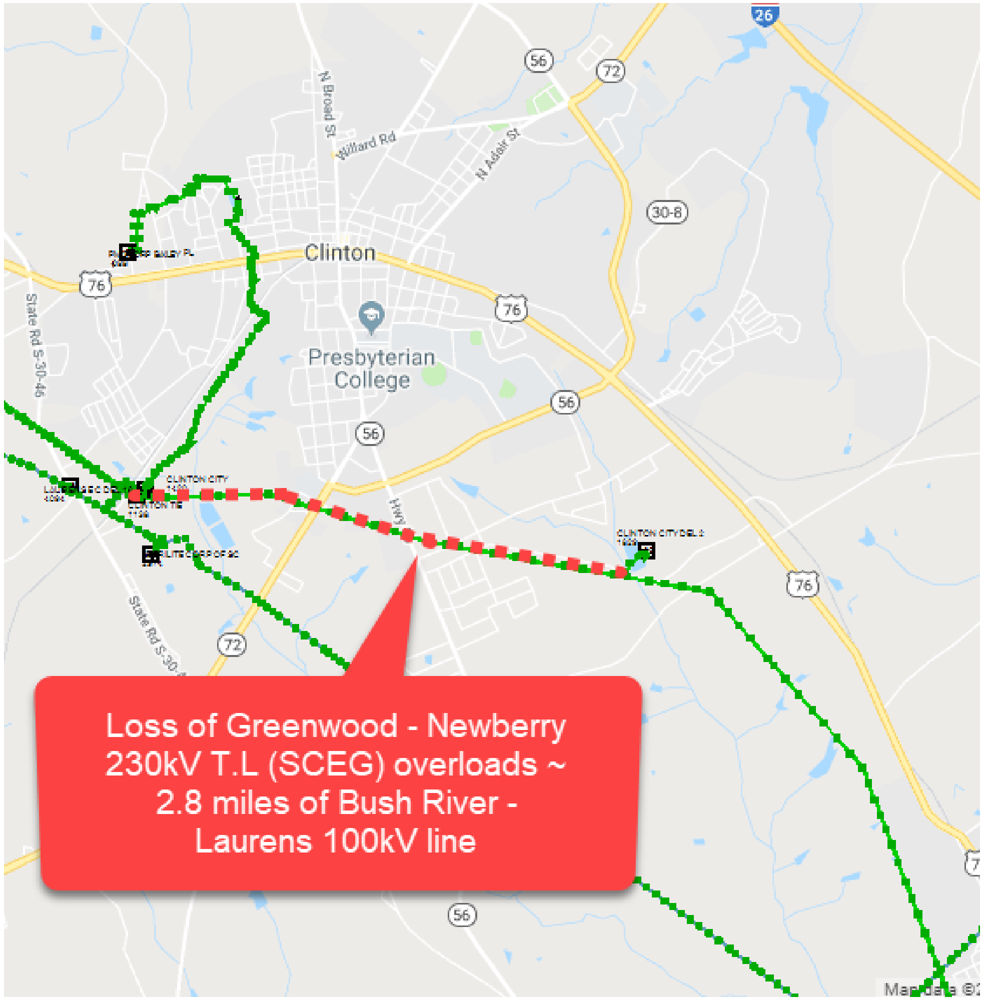
Southern BAA to Santee Cooper – 500 MW

Potential Enhancement Locations – *DEC*



Southern BAA to Santee Cooper – 500 MW

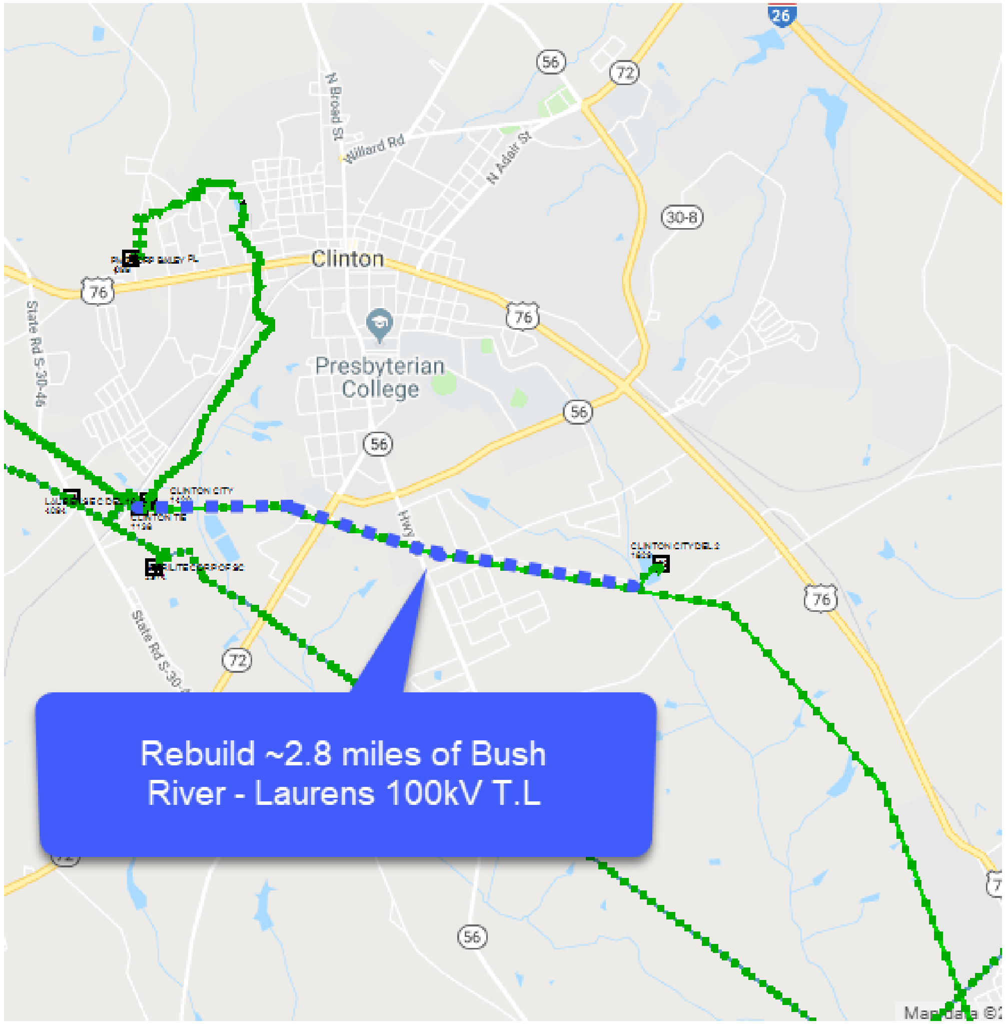
Significant Constraint (P1) – *DEC*



Southeastern Regional TRANSMISSION PLANNING

Southern BAA to Santee Cooper – 500 MW

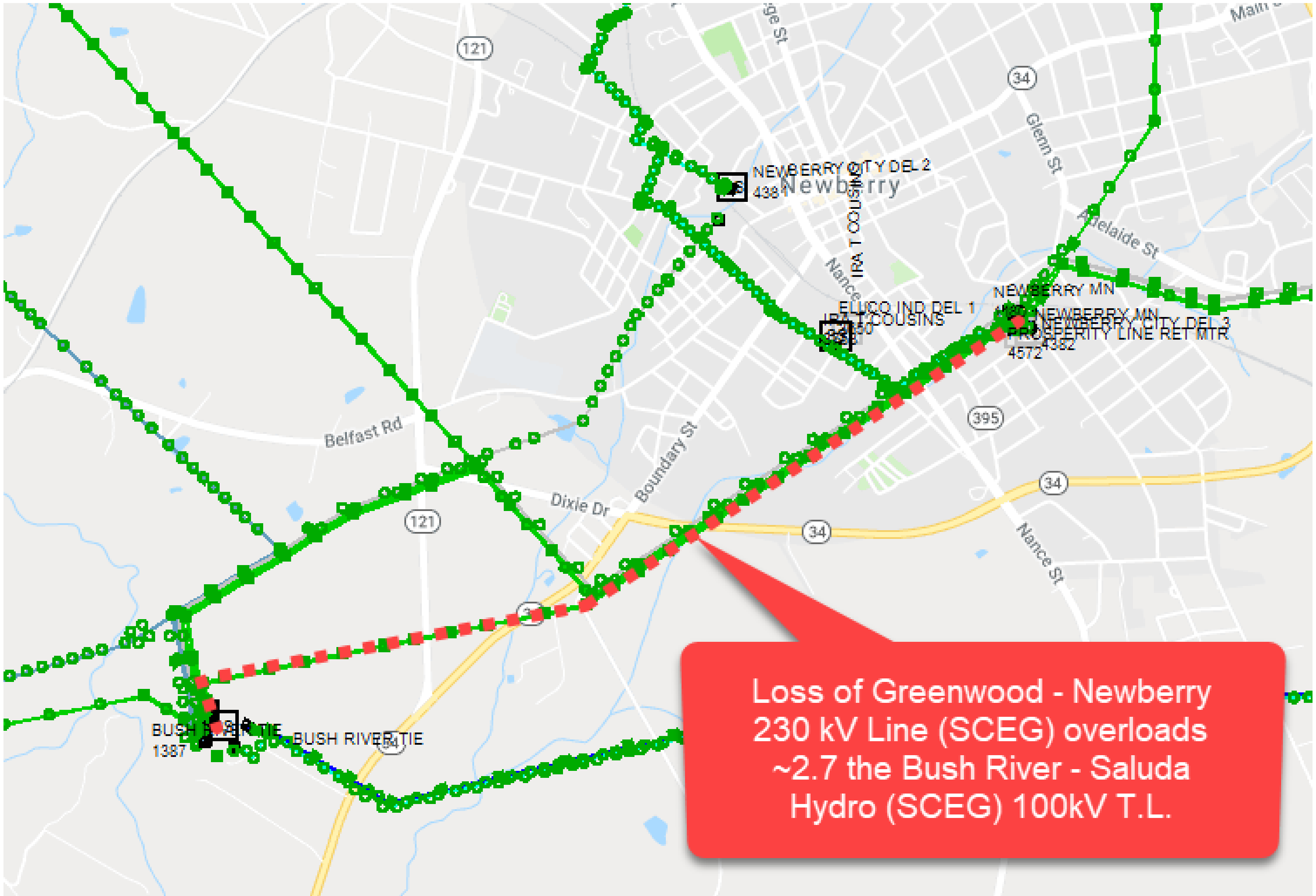
Potential Enhancement (P1) – *DEC*



Southern BAA to Santee Cooper – 500 MW

Southeastern Regional TRANSMISSION PLANNING

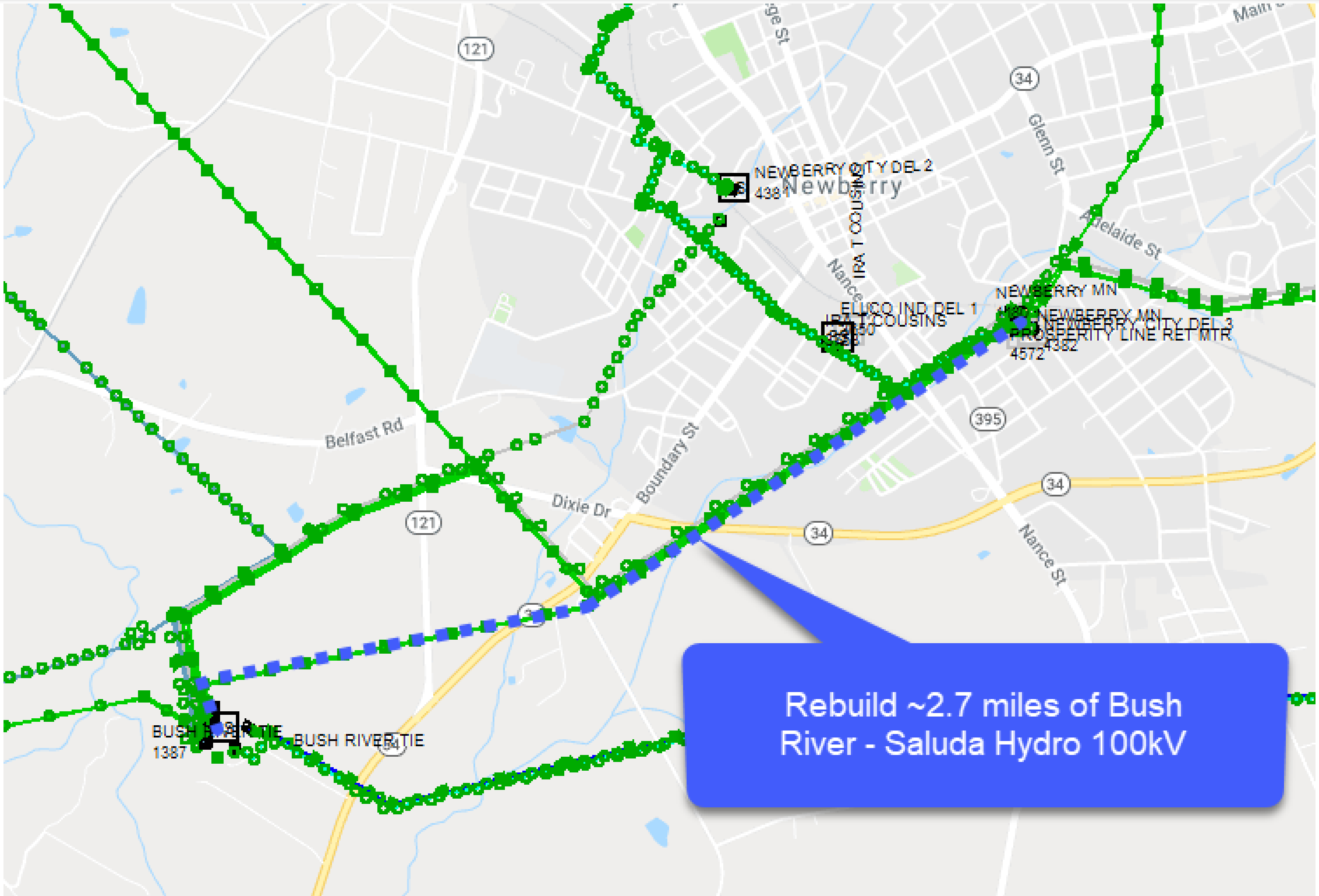
Significant Constraint (P2) – *DEC*



Southeastern Regional TRANSMISSION PLANNING

Southern BAA to Santee Cooper – 500 MW

Potential Enhancement (P2) – *DEC*



Southeastern Regional TRANSMISSION PLANNING

Southern BAA to Santee Cooper – 500 MW

Transmission System Impacts – *SERTP*

Table 3: Transmission System Impacts - SERTP

Balancing Authority	Planning Level Cost Estimate
Associated Electric Cooperative (AECI)	$0
Duke Carolinas (DEC)	$11,000,000
Duke Progress East (DEPE)	$0
Duke Progress West (DEPW)	$0
Louisville Gas & Electric and Kentucky Utilities (LG&E/KU)	$0
PowerSouth (PS)	$0
Southern (SBAA)	$0
Tennessee Valley Authority (TVA)	$0
SERTP TOTAL ($2019)	**$11,000,000**

Economic Planning Studies

Economic Planning Studies – Preliminary Results

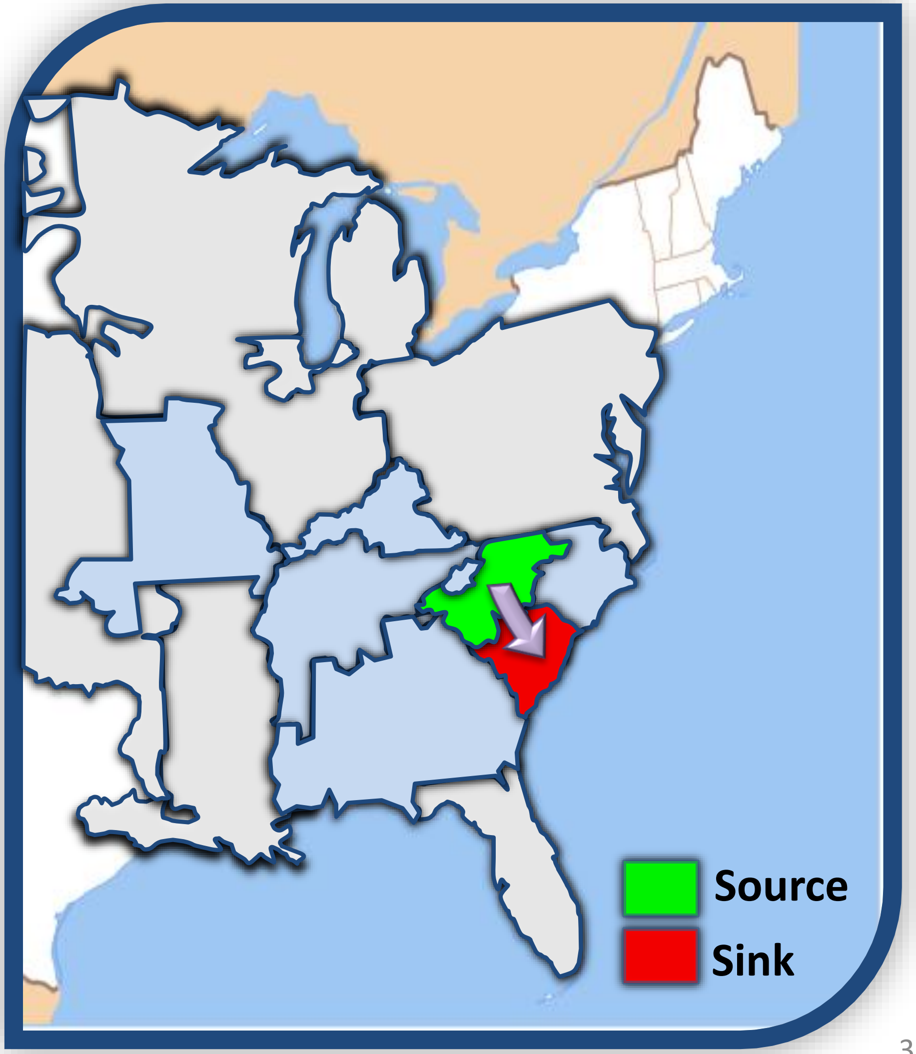
Duke Energy Carolinas to Santee Cooper Border
500 MW

Southeastern Regional TRANSMISSION PLANNING

Duke Energy to Santee Cooper – 500 MW

Study Assumptions

- **Source**: Generation within Duke Energy Carolinas
- **Sink**: Uniform generation scale within Santee Cooper
- **Transfer Type**: Generation to Generation
- **Year**: 2020
- **Load Level**: Summer Peak



Duke Energy to Santee Cooper – 500 MW

Transmission System Impacts – *SERTP*

- **Transmission System Impacts Identified:**
  - Significant constraints were identified in the following SERTP Balancing Authority Areas:
    - ***DEC***

- **Potential Transmission Enhancements Identified:**
  - (DEC) Two (2) 100kV Transmission Line Upgrades

SERTP Total ($2019) = $11,000,000

Southeastern Regional TRANSMISSION PLANNING

Duke Energy to Santee Cooper – 500 MW

Significant Constraints Identified – *DEC*

Table 4: Significant Constraints - DEC

			Thermal Loadings (%)	
Potential Enhancement	**Limiting Element**	**Rating (MVA)**	**Without Request**	**With Request**
P1	Bush River Tie – Saluda Hydro 100kV T.L.	79	101.5	108
P2	Laurens Tie – Bush River Tie 100kV T.L.	65	93.9	100.2

Potential Enhancements Identified – *DEC*

Table 5: Potential Enhancements - DEC

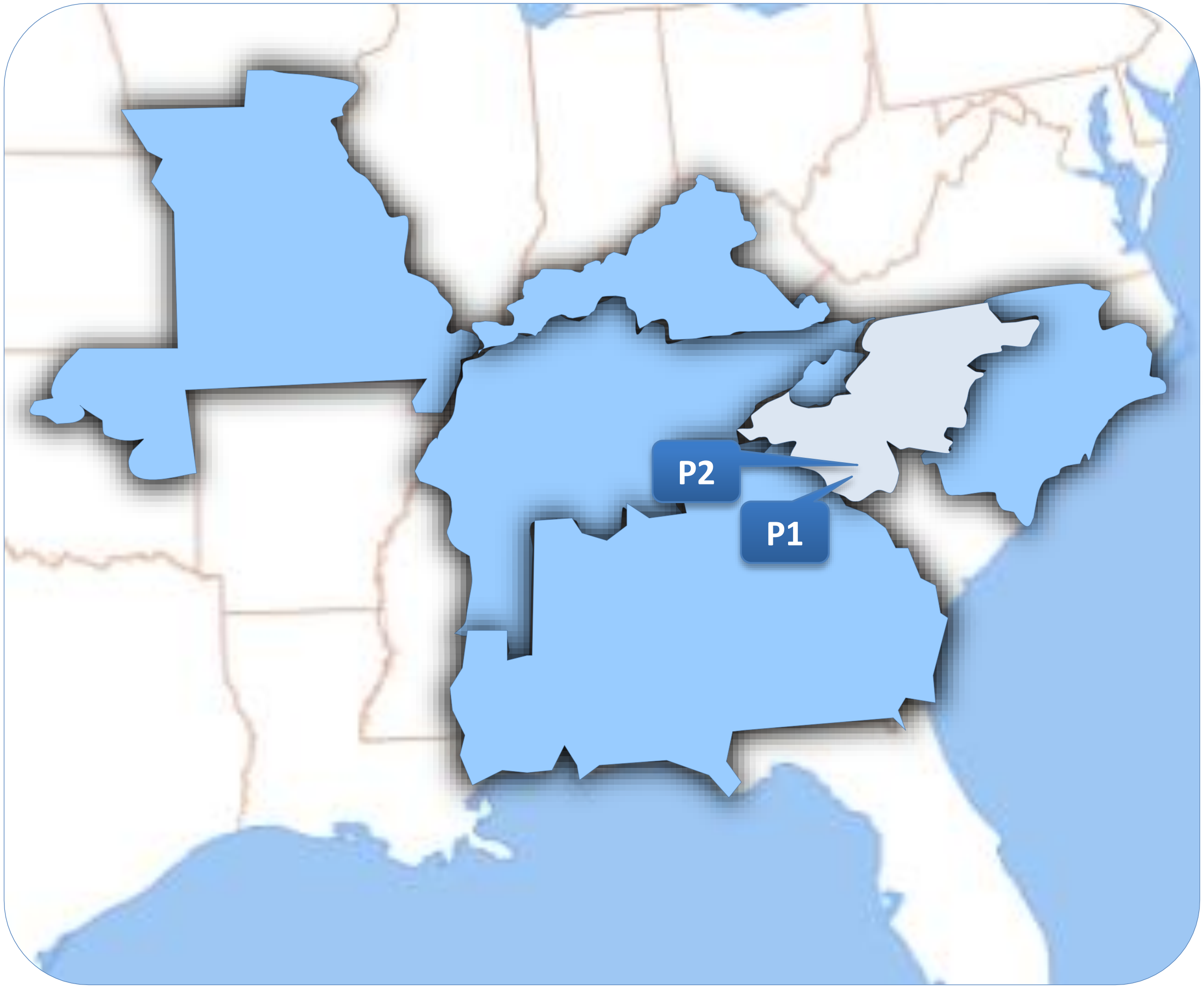
Item	Potential Enhancement	Planning Level Cost Estimate
P1	**Bush River Tie – Saluda Hydro 100kV double circuit** T.L. • Rebuild the 2.7 miles of Bush River Tie – Saluda Hydro 100kV double circuit transmission line with 954 ACSR conductors rated to 120˚C	**$4,900,000**
P2	**Laurens Tie – Bush River Tie 100kV double circuit T.L.** • Rebuild approximately 2.8 miles of Laurens Tie – Bush River Tie 100kV double circuit transmission line with 954 ACSR conductors rated to 120˚C.	**$5,100,000**
	DEC TOTAL ($2019)	**$ 11,000,000**(1)

(1) Total planning level cost estimate does not include the cost of projects that are included in SERTP Sponsors' expansion plans and are scheduled to be completed by June 1st of the study year. The studied transfer depends on these projects being in-service, and the cost to support the study transfer could be greater than the total shown above if any of these projects are delayed or cancelled.

Southeastern Regional TRANSMISSION PLANNING

Duke Energy to Santee Cooper – 500 MW

Potential Enhancement Locations – *DEC*



Southeastern Regional TRANSMISSION PLANNING

Duke Energy to Santee Cooper – 500 MW

Transmission System Impacts – *SERTP*

Table 6: Transmission System Impacts - SERTP

Balancing Authority	Planning Level Cost Estimate
Associated Electric Cooperative (AECI)	$0
Duke Carolinas (DEC)	$11,000,000
Duke Progress East (DEPE)	$0
Duke Progress West (DEPW)	$0
Louisville Gas & Electric and Kentucky Utilities (LG&E/KU)	$0
PowerSouth (PS)	$0
Southern (SBAA)	$0
Tennessee Valley Authority (TVA)	$0
SERTP TOTAL ($2019)	**$11,000,000**

Economic Planning Studies – Preliminary Results

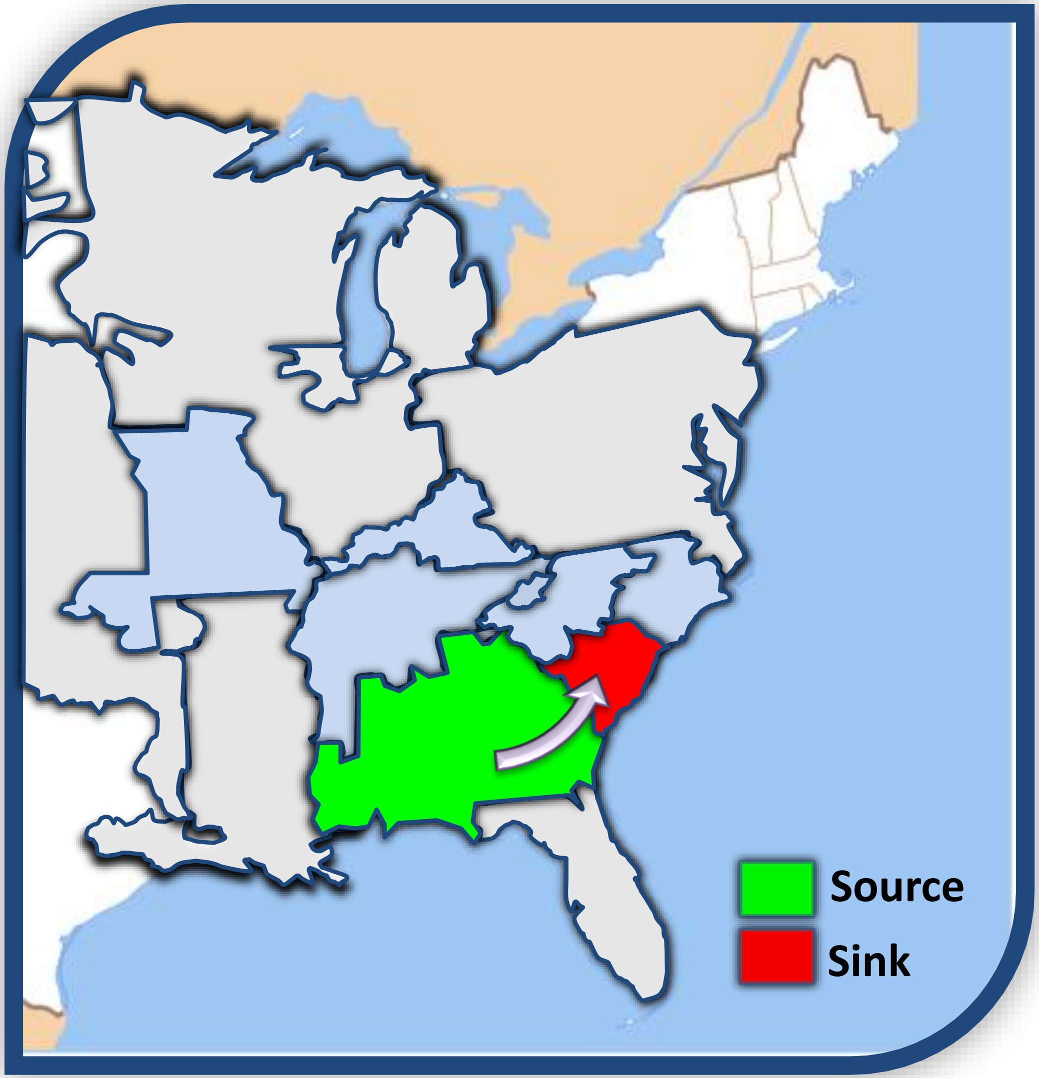
Southern BAA to Santee Cooper Border 800 MW

Southeastern Regional TRANSMISSION PLANNING

Southern BAA to Santee Cooper – 800 MW

Study Assumptions

- **Source**: Generation within Southern BAA
- **Sink**: Uniform generation scale within Santee Cooper
- **Transfer Type**: Generation to Generation
- **Year**: 2020
- **Load Level**: Summer Peak



Southern BAA to Santee Cooper – 800 MW

Transmission System Impacts – *SERTP*

- **Transmission System Impacts Identified:**
  - Significant constraints were identified in the following SERTP Balancing Authority Areas:
    - ***DEC***
    - ***SBAA***
- **Potential Transmission Enhancements Identified:**
  - (DEC) Two (2) 100kV Transmission Line Upgrades
  - (SBAA) One (1) 115kV Transmission Line Rebuild

SERTP Total ($2019) = $22,000,000

Southeastern Regional TRANSMISSION PLANNING

Southern BAA to Santee Cooper – 800 MW

Significant Constraints Identified – *DEC*

Table 7: Significant Constraints - DEC

Potential Enhancement	Limiting Element	Rating (MVA)	Thermal Loadings (%) Without Request	Thermal Loadings (%) With Request
P1	Bush River Tie – Saluda Hydro 100kV T.L.	79	101.5	110.8
P2	Laurens Tie – Bush River Tie 100kV T.L.	65	93.9	103.1

Potential Enhancements Identified – *DEC*

Table 8: Potential Enhancements - DEC

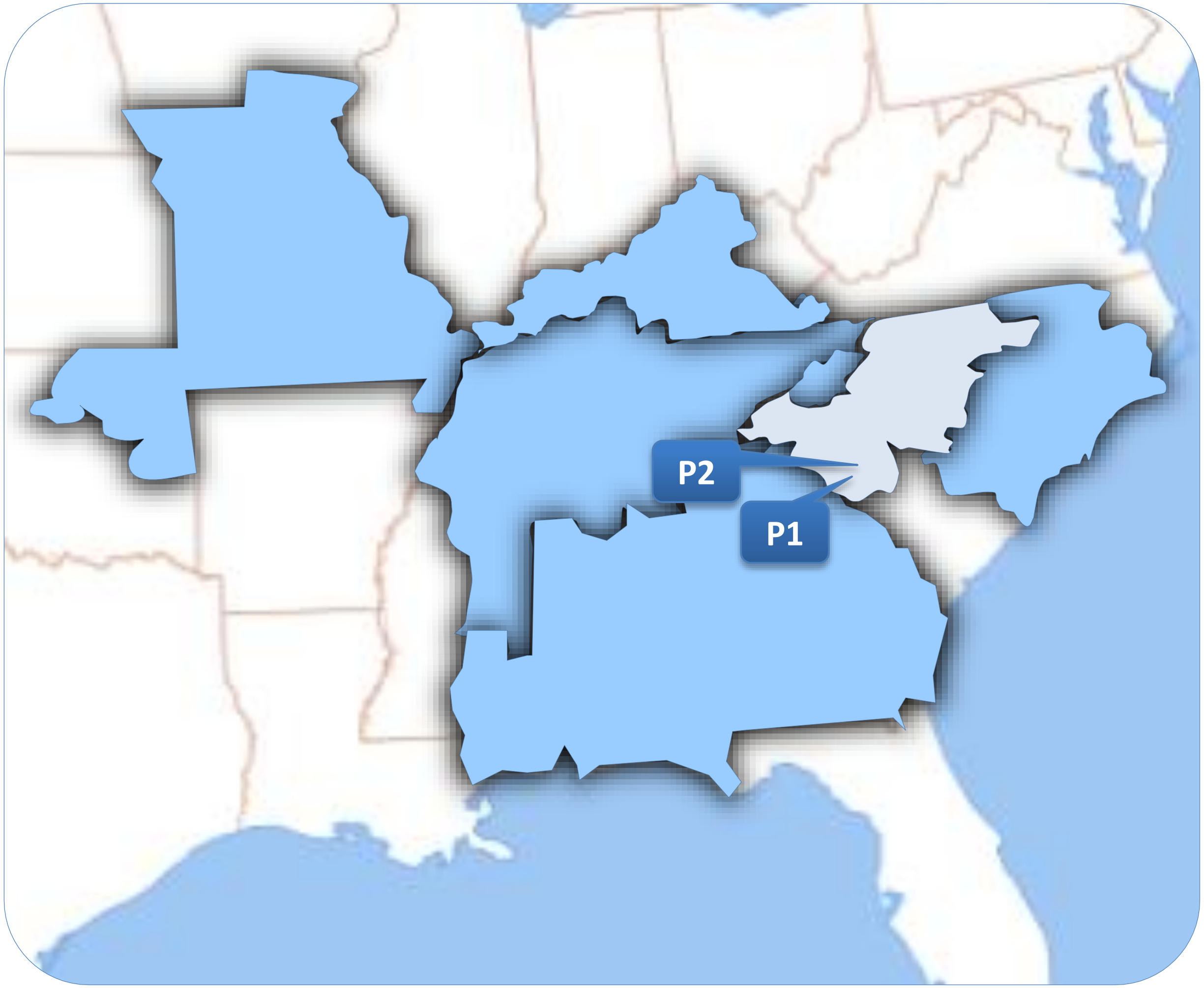
Item	Potential Enhancement	Planning Level Cost Estimate
P1	**Bush River Tie – Saluda Hydro 100kV double circuit** T.L. • Rebuild the 2.7 miles of Bush River Tie – Saluda Hydro 100kV double circuit transmission line with 954 ACSR conductors rated to 120˚C	**$4,900,000**
P2	**Laurens Tie – Bush River Tie 100kV double circuit T.L.** • Rebuild approximately 2.8 miles of Laurens Tie – Bush River Tie 100kV double circuit transmission line with 954 ACSR conductors rated to 120˚C.	**$5,100,000**
	DEC TOTAL ($2019)	**$ 11,000,000**(1)

(1) Total planning level cost estimate does not include the cost of projects that are included in SERTP Sponsors' expansion plans and are scheduled to be completed by June 1st of the study year. The studied transfer depends on these projects being in-service, and the cost to support the study transfer could be greater than the total shown above if any of these projects are delayed or cancelled.

Southeastern Regional TRANSMISSION PLANNING

Southern BAA to Santee Cooper – 800 MW

Potential Enhancement Locations – *DEC*



Transmission System Impacts – *SERTP*

Table 11: Transmission System Impacts - SERTP

Balancing Authority	Planning Level Cost Estimate
Associated Electric Cooperative (AECI)	$0
Duke Carolinas (DEC)	$11,000,000
Duke Progress East (DEPE)	$0
Duke Progress West (DEPW)	$0
Louisville Gas & Electric and Kentucky Utilities (LG&E/KU)	$0
PowerSouth (PS)	$0
Southern (SBAA)	$11,000,000
Tennessee Valley Authority (TVA)	$0
SERTP TOTAL ($2019)	**$22,000,000**

Economic Planning Studies – Preliminary Results

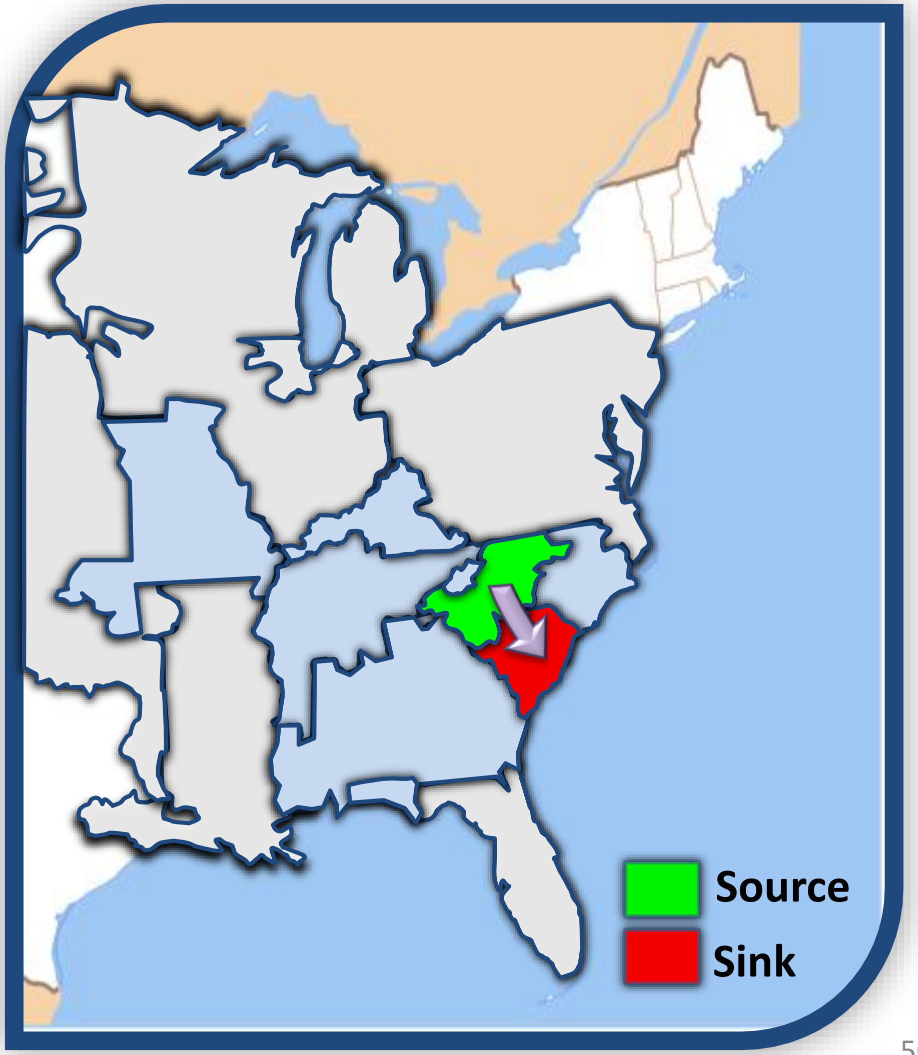
Duke Energy Carolinas to Santee Cooper Border
500 MW

Southeastern Regional TRANSMISSION PLANNING

Duke Energy to Santee Cooper – 500 MW

Study Assumptions

- **Source**: Generation within Duke Energy Carolinas
- **Sink**: Uniform generation scale within Santee Cooper
- **Transfer Type**: Generation to Generation
- **Year**: 2024
- **Load Level**: Winter Peak



Duke Energy to Santee Cooper – 500 MW

Transmission System Impacts – *SERTP*

- **Transmission System Impacts Identified:**
  - Significant constraints were identified in the following SERTP Balancing Authority Areas:
    - ***DEPE***

- **Potential Transmission Enhancements Identified:**
  - (DEPE) One (1) Substation Upgrade

SERTP Total ($2019) = $6,500,000

Southeastern Regional TRANSMISSION PLANNING

Duke Energy to Santee Cooper – 500 MW

Significant Constraints Identified – *DEPE*

Table 12: Significant Constraints - DEPE

Potential Enhancement	Limiting Element	Rating (MVA)	Thermal Loadings (%) Without Request	Thermal Loadings (%) With Request
P1	Wateree 115/100kV Transformers	150	93	103

Potential Enhancements Identified – *DEPE*

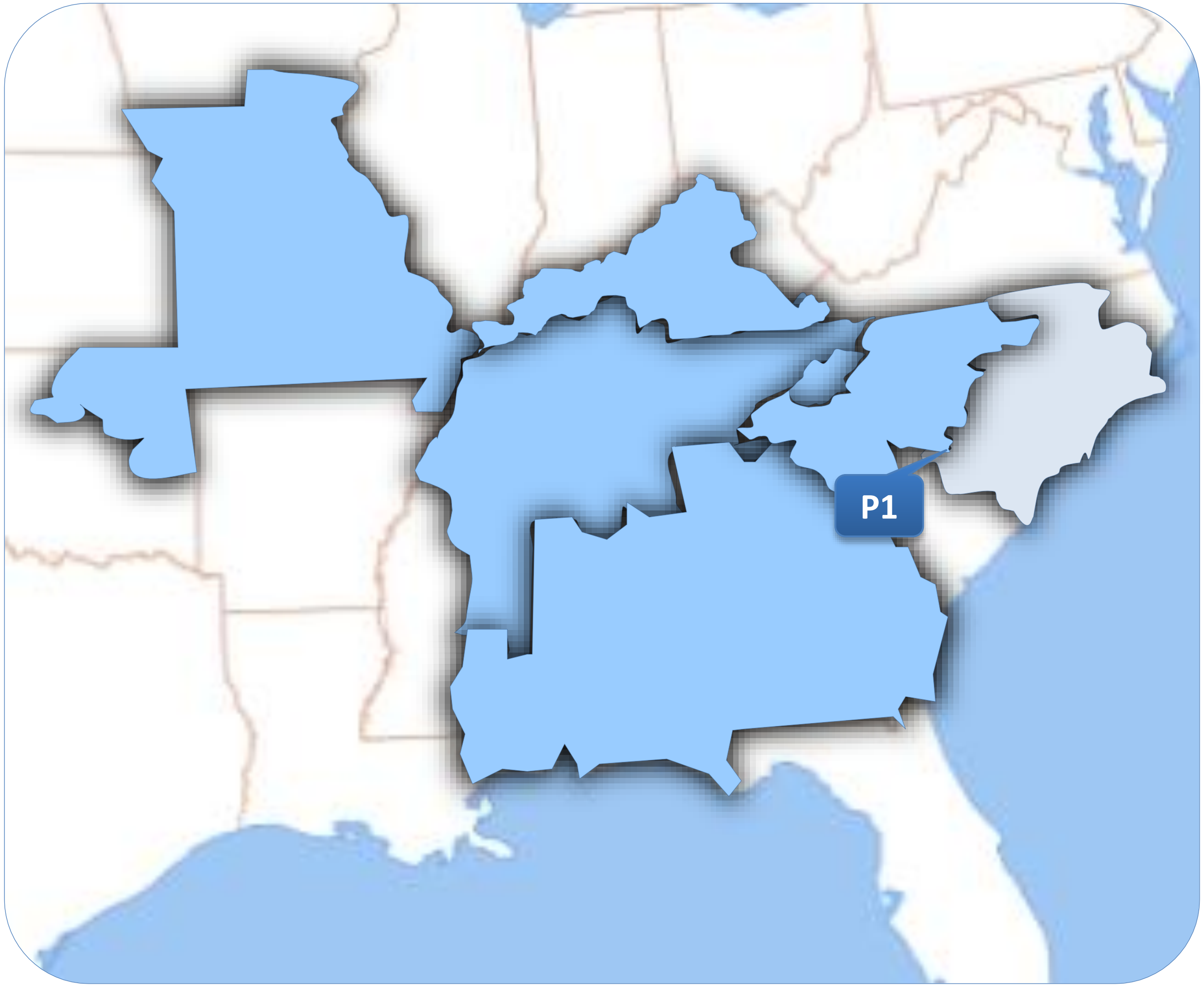
Table 13: Potential Enhancements - DEPE

Item	Potential Enhancement	Planning Level Cost Estimate
P1	**Wateree 115/100kV Transformers** • Replace existing 150 MVA 115/100kV transformer bank with 336 MVA 115/100kV transformer bank	**$6,500,000**
DEPE TOTAL ($2019)		**$6,500,000** (1)

(1) Total planning level cost estimate does not include the cost of projects that are included in SERTP Sponsors' expansion plans and are scheduled to be completed by winter of the study year. The studied transfer depends on these projects being in-service, and the cost to support the study transfer could be greater than the total shown above if any of these projects are delayed or cancelled.

Duke Energy to Santee Cooper – 500 MW

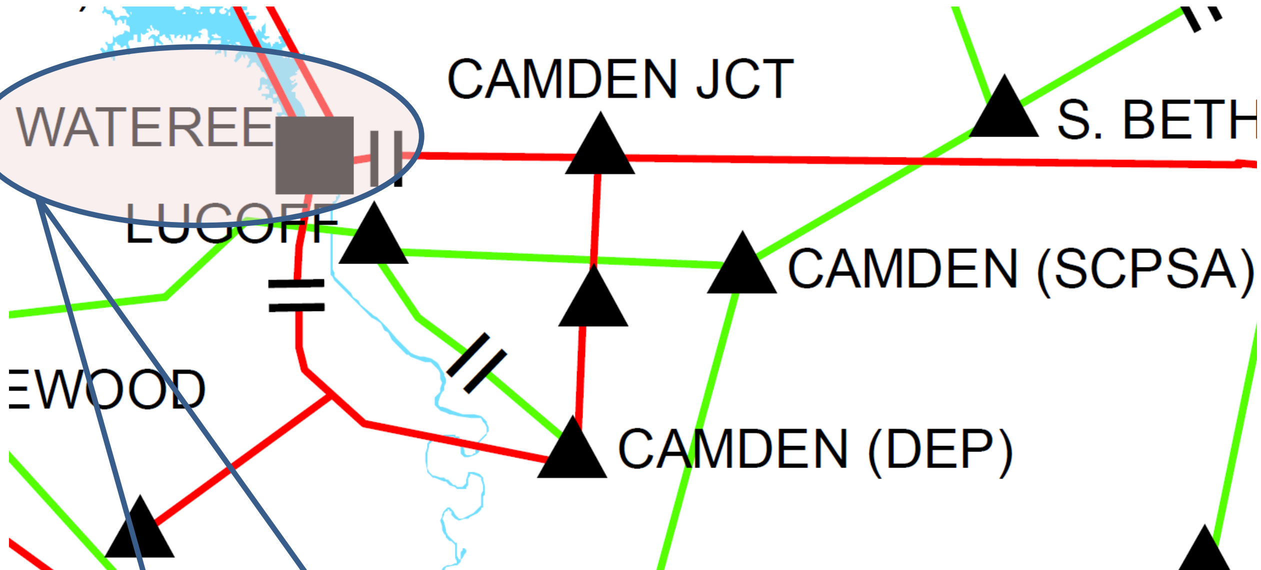
Potential Enhancement Locations – *DEPE*



Southeastern Regional TRANSMISSION PLANNING

Duke Energy to Santee Cooper – 500 MW

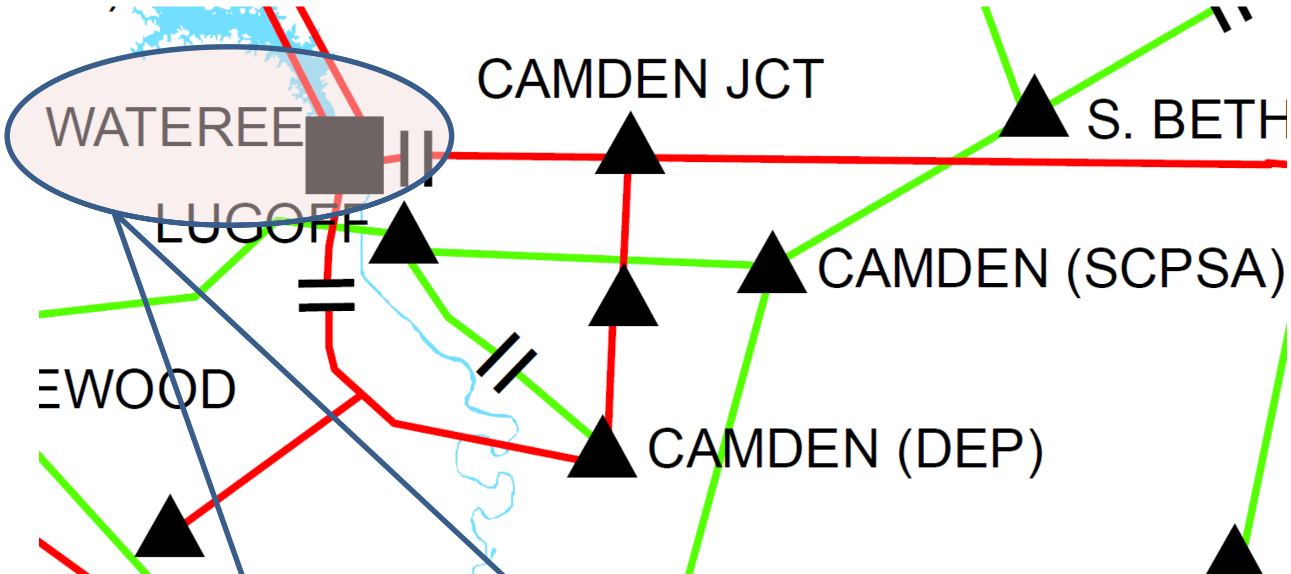
Significant Constraints (P1) – *DEPE*



Overloads existing Wateree 150 MVA 115/100 kV transformers

Duke Energy to Santee Cooper – 500 MW

Potential Enhancement (P1) – *DEPE*



Replace existing Wateree 150 MVA 115/100 kV transformers with 336 MVA 115/100 kV transformers

Duke Energy to Santee Cooper – 500 MW

Transmission System Impacts – *SERTP*

Table 14: Transmission System Impacts - SERTP

Balancing Authority	Planning Level Cost Estimate
Associated Electric Cooperative (AECI)	$0
Duke Carolinas (DEC)	$0
Duke Progress East (DEPE)	$6,500,000
Duke Progress West (DEPW)	$0
Gulf Power (GULF)	$0
Louisville Gas & Electric and Kentucky Utilities (LG&E/KU)	$0
PowerSouth (PS)	$0
Southern (SBAA)	$0
Tennessee Valley Authority (TVA)	$0
SERTP TOTAL ($2019)	**$6,500,000**

Economic Planning Studies – Preliminary Results

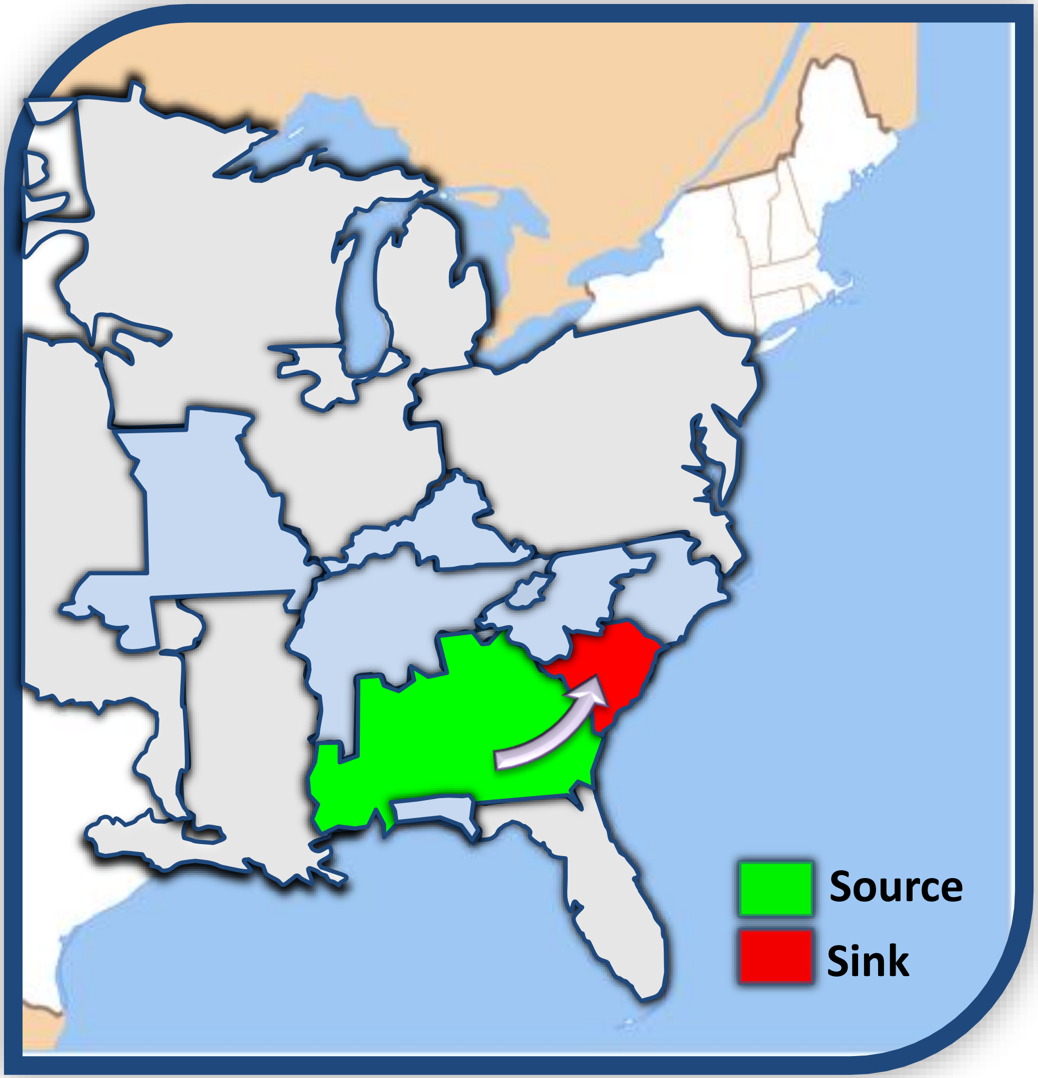
Southern BAA to Santee Cooper Border 1000 MW

Southeastern Regional TRANSMISSION PLANNING

Southern BAA to Santee Cooper – 1000 MW

Study Assumptions

- **Source**: Generation within Southern BAA
- **Sink**: Uniform generation scale within Santee Cooper
- **Transfer Type**: Generation to Generation
- **Year**: 2024
- **Load Level**: Winter Peak



Transmission System Impacts – *SERTP*

- **Transmission System Impacts Identified:**
  – No significant constraints were identified in the SERTP Balancing Authority Areas
- **Potential Transmission Enhancements Identified:**
  – None Required

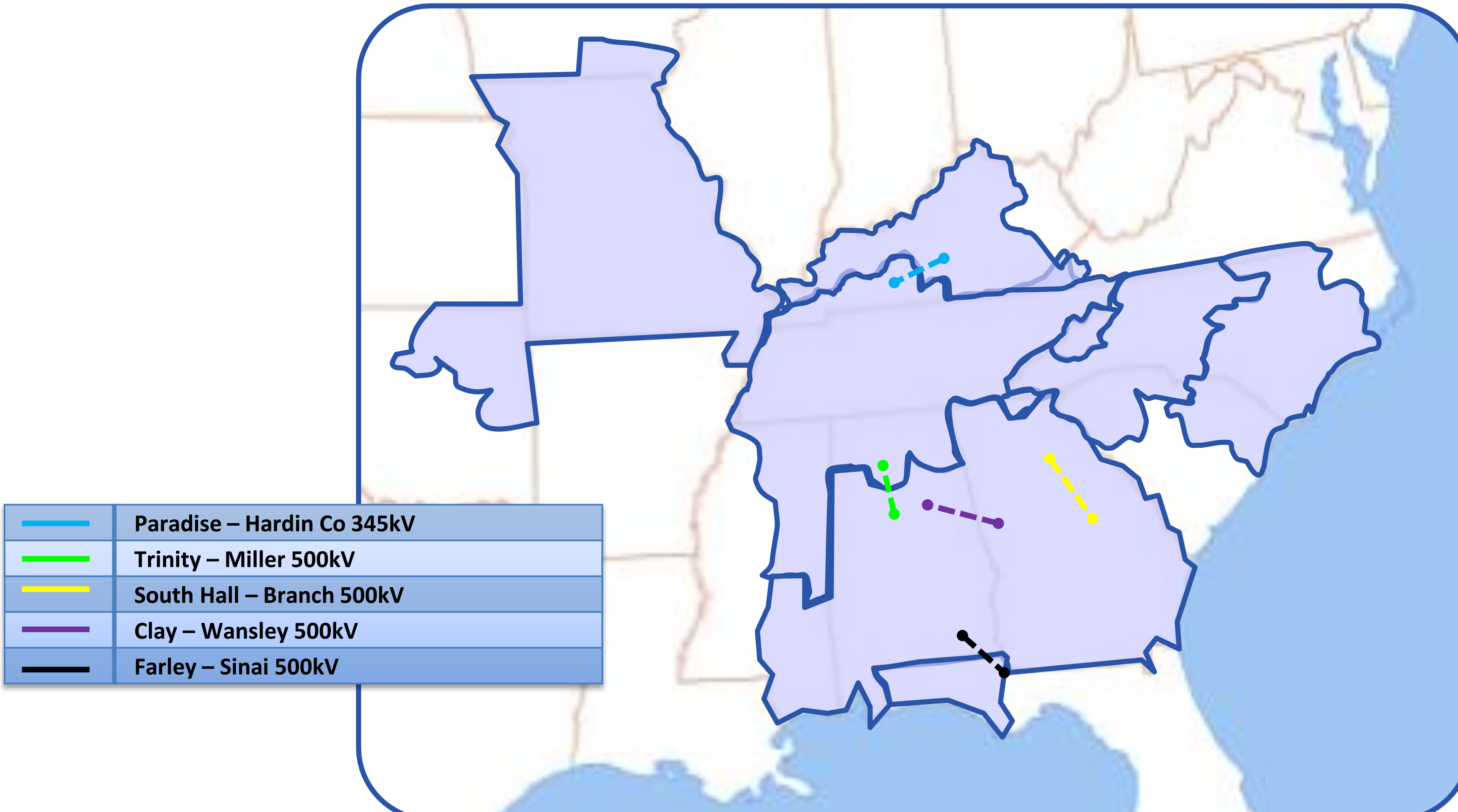
SERTP Total ($2019) = $0

Preliminary List of Alternative Regional Transmission Projects

Alternative Regional Transmission Projects	Miles	From	To
		BAA (State)	BAA (State)
Paradise – Hardin Co 345kV	65	TVA (KY)	LG&E/KU (KY)
Trinity – Miller 500kV	68	TVA (AL)	SBAA (AL)
Clay – Wansley 500kV	90	SBAA (AL)	SBAA (GA)
South Hall – Branch 500kV	78	SBAA (GA)	SBAA (GA)
Farley – Sinai 500kV	50	SBAA (AL)	Gulf (FL)

2019 Regional Transmission Analyses

Preliminary List of Alternative Regional Transmission Projects



http://www.southeasternrtp.com/

UK Blackout
8/9/19

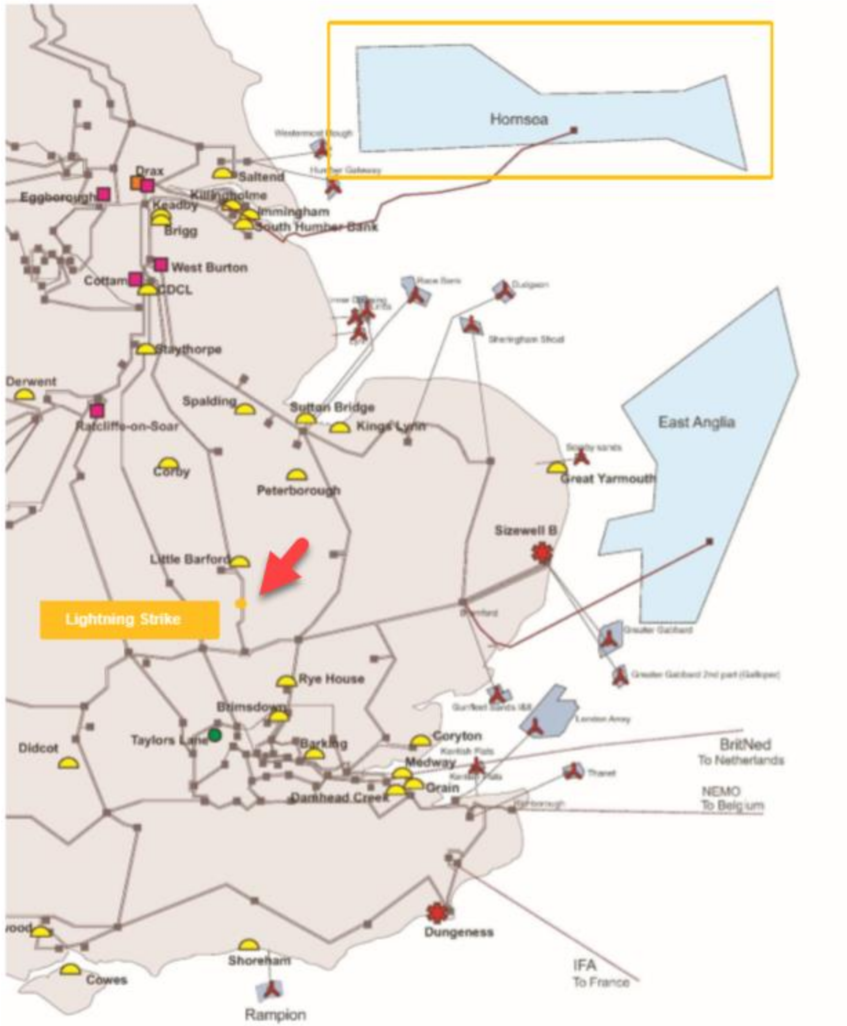
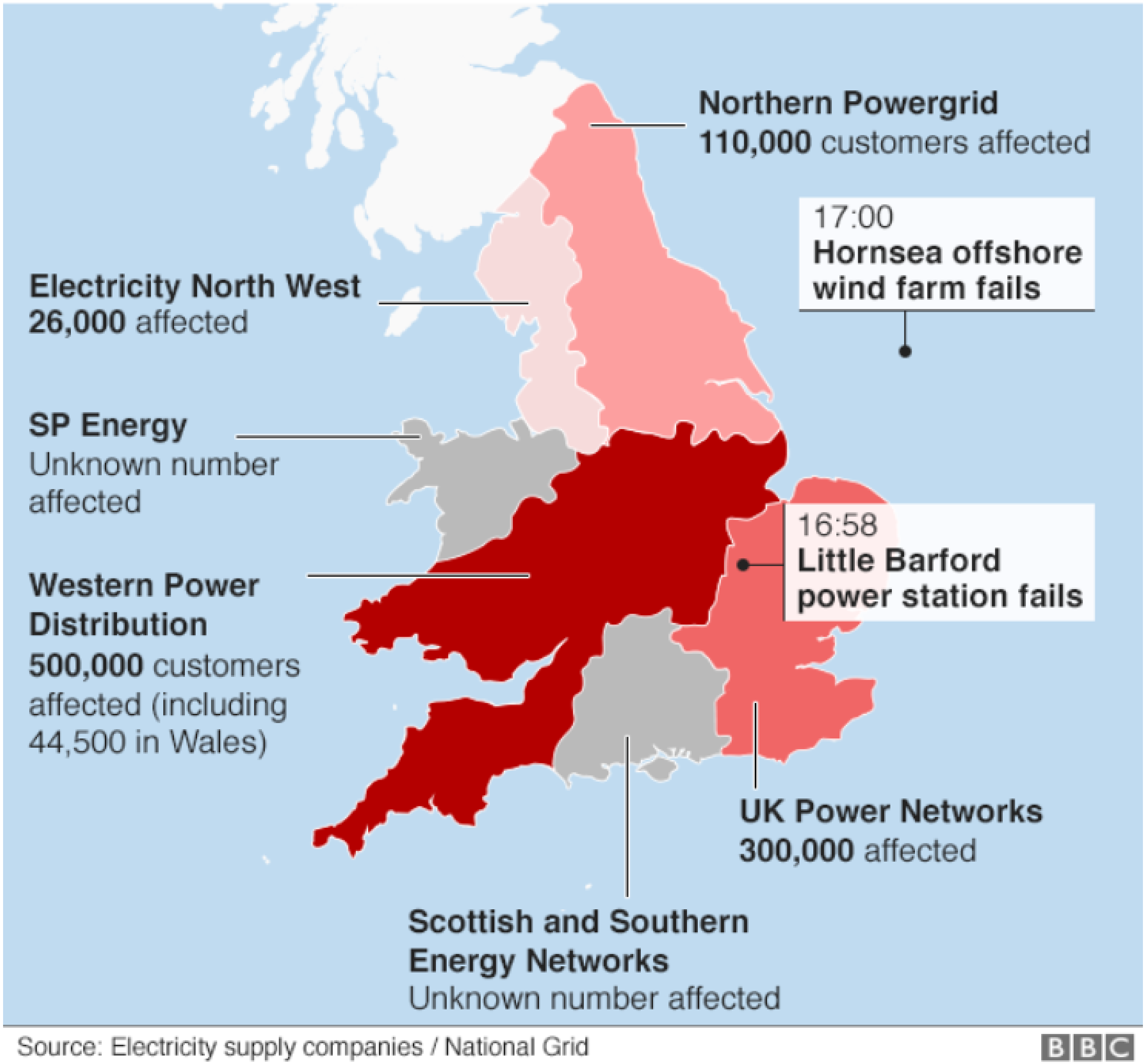


Figure 1 – Map of Hornsea, Little Barford and the Lightning Strike


Northern Powergrid
110,000 customers affected
17:00
Hornsea offshore wind farm fails
Electricity North West
26,000 affected
SP Energy
Unknown number affected
16:58
Little Barford power station fails
Western Power Distribution
500,000 customers affected (including 44,500 in Wales)
UK Power Networks
300,000 affected
Scottish and Southern Energy Networks
Unknown number affected
Source: Electricity supply companies / National Grid
BBC

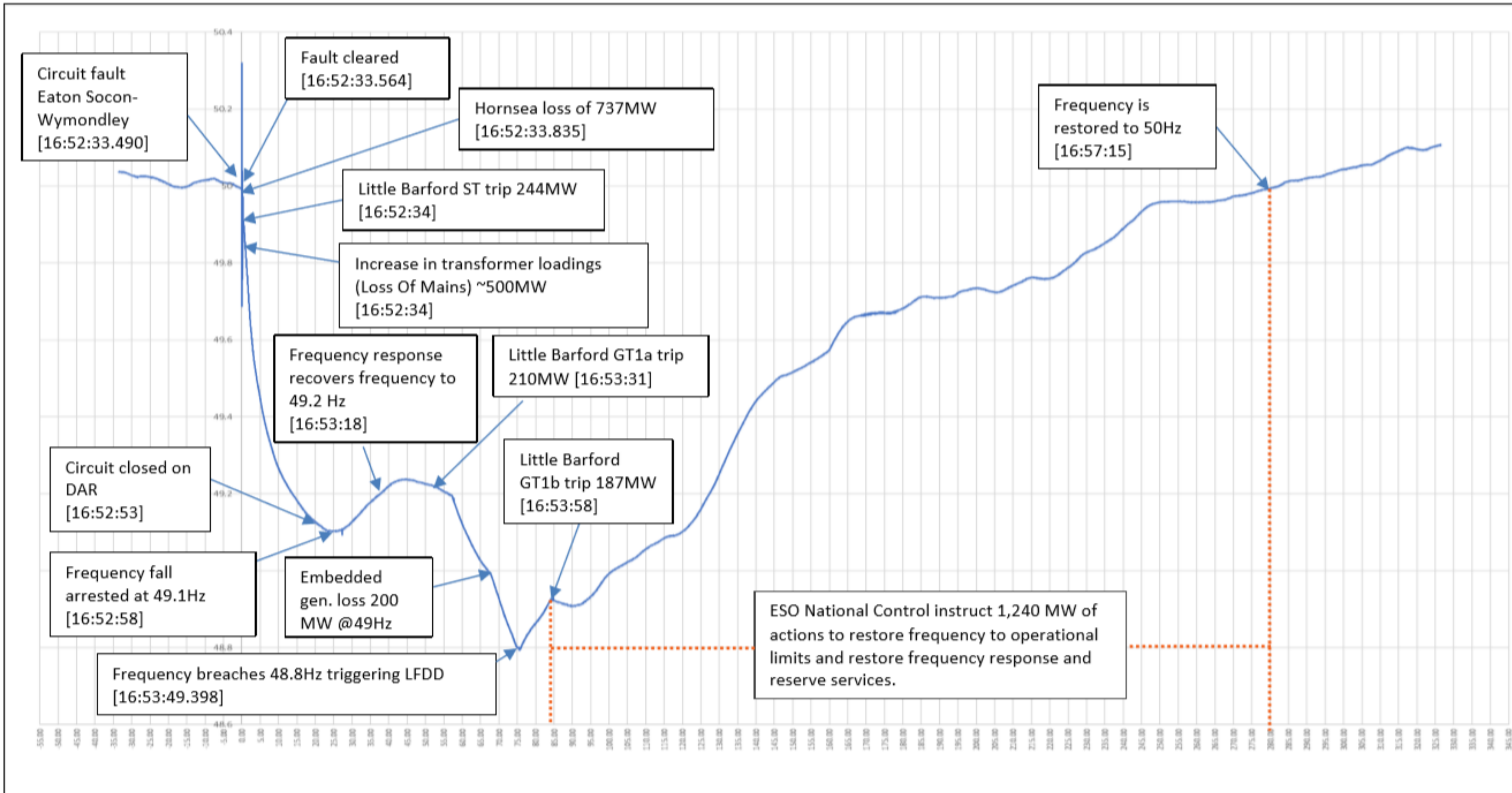
Time	Activity	Source
16:52:26	Frequency at 50.0Hz, ESO securing for a loss of power infeed of 1000MW	ESO
16:52:33	There were three lightning strikes detected in very close proximity to the Eaton Socon – Wymondley circuit.	MeteoGroup
16:52:33.490	A single (blue) Phase to Earth fault on Eaton Socon - Wymondley circuit (fault infeed approximately 21kA (RMS) from Wymondley and 7kA (RMS) from Eaton Socon) with an estimated 50% voltage depression on the blue phase during the fault. This is consistent with a lightning strike on Eaton Socon - Wymondley circuit	NGET
16:52:33	Approximately 150MW of embedded generation trips on vector-shift protection	ESO
16:52:33.531	Hornsea was generating 799MW and absorbing 0.4MVAR	Orsted
16:52:33.560	70ms after fault, Wymondley end opens to clear the fault	NGET
16:52:33.564	74ms after fault, Eaton Socon end opens to clear the fault	NGET
16:52:33.728	Hornsea started deloading	Orsted
16:52:33.835	Hornsea stabilised at 62MW and injecting 21 MVAR	Orsted
16:52:34	Little Barford Steam Turbine trips 244MW instantaneously. Source: RWE [1,131MW of cumulative infeed loss]	RWE
16:52:34	Approximately 350MW of embedded generation trips on RoCoF protection [1,481MW cumulative infeed loss]	ESO
16:52:34	Frequency response initiates.	ESO

16:52:34	Frequency response initiates.	ESO
16:52:44	Frequency Response has delivered at least 650MW of power to stabilise the frequency.	ESO
16:52:53	Eaton Socon - Wymondley circuit energised on DAR	NGET
16:52:58	Frequency drop is arrested at 49.1Hz due to the delivery of frequency response products	ESO
16:52	Contracted response service from Low Frequency Gas Turbines initiated	ESO
16:53:04	Frequency Response has delivered 900MW of power to stabilise the frequency	ESO
Since 16:53	Short Term Operating Reserve (STOR) units were instructed; overall amount 400MW	ESO
16:53:18	Frequency recovers to 49.2Hz, due to the continued delivery of frequency response	ESO

Generation Unit	Infeed Loss	Cumulative Infeed Loss
Little Barford ST1C	244 MW	244 MW
Hornsea Offshore Windfarm	737 MW	981 MW
Estimated, Embedded generation infeed loss due to Vector Shift Loss of Mains Protection	150 MW	1,131 MW
Estimated, Embedded generation infeed loss due to RoCoF Loss of Mains Protection	350 MW	1,481 MW
Little Barford GT1A	210 MW	1,691 MW
Little Barford GT1B	187 MW	1,878 MW

3.4. Impact on Frequency

Figure 2 – Annotated Frequency Trace of the Event



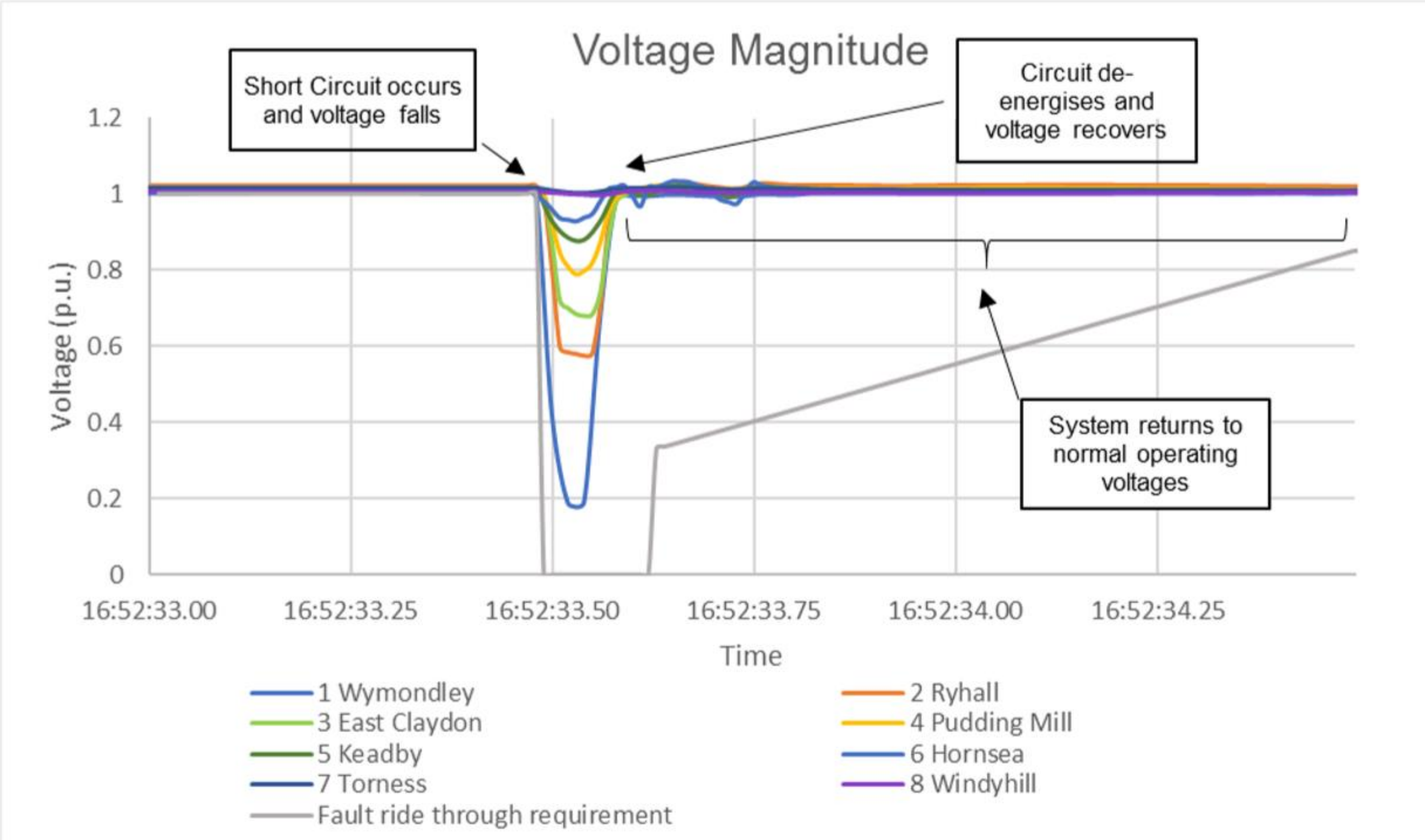


Figure 6 – single phase voltage profile at various locations

Hornsea Response

<u>Orsted's report advises the following:</u>

Initially, Orsted understood that the Dynamic Reactive Compensator (DRC) was responsible for the rapid de-load of Hornsea-1. Orsted have since concluded that the DRC worked as designed and was not the cause of the de-load.

The configuration of the Hornsea network, with one SGT and one offshore transmission system user asset (OTSUA Circuit) on outage, was a contributory factor as it created a weak internal network environment. Subsequently Orsted have reviewed and reconfigured their network.

The wind turbine settings were standard settings from the manufacturer. During the incident, the turbine controllers reacted incorrectly due to an insufficiently damped electrical resonance in the sub-synchronous frequency range, so that the local Hornsea voltage dropped and the turbines shut themselves down.

Orsted have since updated the control system software for the wind turbines and have observed that the behaviour of the turbines now demonstrates a stable control system that will withstand any future events in line with Grid Code and CUSC requirements.

Software change made on 8/10/19

Little Barford Response

The initiation of the trip of Little Barford steam turbine (ST1C) was caused by a discrepancy between the measurements from three speed signals. A review of hardware, software, fault handling and diagnostic coverage for the conditions that the Steam Turbine was subjected to is ongoing.

Normal operation of Little Barford power station following the loss of the steam turbine is for the steam generated from the Gas Turbines to be fed directly into the condenser in a steam bypass mode of operation. RWE have confirmed that for reasons presently unknown, after approximately 1 minute the first gas turbine tripped due to a high-pressure excursion in the steam bypass system. This trip occurred automatically and shut the gas turbine (GT1A) down. The second gas turbine (GT1B) was manually tripped by the RWE operational staff in response to high steam pressures around 30 seconds later. In total this meant a total loss at Little Barford of 641MW.

RWE have confirmed that their Uninterrupted Power Supply (UPS) functioned correctly to enable continuity of supply to plant equipment. RWE do not believe the UPS operation was related to the subsequent turbine trips detailed below. During a forthcoming outage in September 2019, the OEM will undertake resilience testing to reaffirm the functionality of the system.

A physical inspection of the bypass system is now planned during a forthcoming outage in September 2019 to determine the root cause of the pressure excursions.

Embedded Generation Response

Analysis undertaken by ESO has shown that some parts of the system may have experienced a rate of change of frequency of 0.125Hz/s or above and/or a Vector Shift exceeding 6^{O}, which is likely to have led to RoCoF and/or Vector Shift events.

DNOs were asked to indicate the reason for the change of output, for example RoCoF, Vector Shift, Active Network Management (ANM) operation.

All DNOs have responded to this request and indicated a combined total of 462MW of embedded generation was lost during the event. In providing their analysis some DNOs noted challenges in obtaining the data due to the way it is collected or stored and without confirmation from generators, DNOs were unable to determine whether a specific generator tripped due to RoCoF or Vector Shift.

Post-event Power System studies undertaken by the ESO have indicated that, for an event such as this, a loss of embedded generation on Vector Shift protection of approximately 150MW would be expected. Therefore, based on this plus the data provided by the DNO's, it is estimated that approximately 350MW of embedded generation was lost due to RoCoF[2].

A number of embedded generators and demand customers have advised that their protection operated when the frequency reached 49Hz and as such they were disconnected from the system. The net effect of this disconnection has been modelled as a 200MW loss of generation. Protection operating at this frequency was not expected and has not previously been observed.

UFLS

The Grid Code, requires each DNO to make arrangements that will enable automatic disconnection of demand if the frequency on the transmission system drops below 48.8Hz. The amount of demand that is disconnected is in staged “Blocks” (5%, 7.5% and 10%) to increase the amount of demand disconnected if the frequency continues to drop. This scheme is the Lower Frequency Demand Disconnection (LFDD) scheme. The DNO’s have indicated that 931MW (3.2%) of demand was automatically disconnected by the operation of the LFDD scheme.

The LFDD process worked largely as expected. While the process provided slightly lower than 5% of demand this did not materially impact the function of the LFDD in returning the frequency to normal operational parameters.

UFLS

Frequency (Hz)	% of Demand Disconnection
48.8	5
48.75	5
48.7	10
48.6	7.5
48.5	7.5
48.4	7.5
48.2	7.5
48.0	5
47.8	5
Total % Demand	60

LFDD schemes are fitted at 132kV substations and are designed to trip the lower voltage side of the incoming 132kV transformers or some or all of the outgoing feeders. The operating time of an LFDD scheme is as far as reasonably practicable be less than 200mS.

Conclusions

Two almost simultaneous unexpected power losses at Hornsea and Little Barford occurred independently of one another but each coincident with a lightning strike. This caused a significant loss of power from the grid and represented an event beyond the standards to which the system is normally secured.

The scale of generation loss exceeded the normal automatic protection systems and reserve holdings and resulted in automatic disconnection of 1GW of demand in order to preserve the system (and allow supply to continue for the remaining 28GW of demand). These systems worked in line with their design to protect as much electricity demand as possible. However, there was significant knock-on disruption from the event (see conclusion on rail services below) and to other critical infrastructure.

Recommended Action: Review the security standards (SQSS) to determine whether it would be appropriate to provide for higher levels of resilience in the electricity system. This should be done in a structured way to ensure a proper balancing risks and costs.

Full Report Link

https://www.ofgem.gov.uk/system/files/docs/2019/09/eso_technical_report_-_final.pdf

Questions ?

2019 TAG Work Plan

Rich Wodyka

Administrator

2019 NCTPC Overview Schedule

Reliability Planning Process

- Evaluate current reliability problems and transmission upgrade plans
- Perform analysis, identify problems, and develop solutions
- Review Reliability Study Results

Local Economic Planning Process

- Propose and select Local Economic Studies and Public Policy Study scenarios
- Perform analysis, identify problems, and develop solutions
- Review Local Economic Study and Public Policy Results

Coordinated Plan Development

- Combine Reliability and Local Economic Study and Public Policy Results
- OSC publishes DRAFT Plan
- TAG review and comment

TAG Meetings

1st Quarter 2nd Quarter 3rd Quarter 4th Quarter

January - February – March

- **2019 Study – Finalize Study Scope of Work**
  - ✓ **Receive request from OSC to provide input on proposed Local Economic Study scenarios and interfaces for study**
    - – ***TAG provide input to the OSC on proposed Local Economic Study scenarios and interfaces for study – No TAG requests received***
  - ✓ **Receive request from OSC to provide input in identifying any public policies that are driving the need for local transmission**
    - – ***TAG provide input to the OSC in identifying any public policies that are driving the need for local transmission for study - No TAG requests received***
  - ✓ **Receive final 2019 Reliability Study Scope for comment**
    - – ***TAG review and provide comments to the OSC on the final 2019 Study Scope – Sent out on March 18th – No additional comments***

January - February – March

First Quarter TAG Meeting – March 13th

- **2019 Study Update**
  - ✓ **Receive a report on the Local Economic Study scope and any public policy scenarios that are driving the need for local transmission for study**
  - ✓ **Receive a progress report on the Reliability Planning study activities and the final draft of the 2019 Study Scope**

April - May – June

Second Quarter TAG Meeting – June 20th

- 2019 Study Update
  - ✓ Receive a progress report on study activities
  - ✓ Receive update status of the upgrades in the 2018 Collaborative Plan

July - August – September

Third Quarter TAG Meeting – October 15th

➢ **2019 Study Update**

- ✓ **Receive a progress report on the study activities and preliminary results**

- ✓ **TAG is requested to provide feedback to the OSC on the technical analysis performed, the problems identified as well as proposing alternative solutions to the problems identified - Provide feedback by October 29th to Rich Wodyka (rawodyka@aol.com)**

October - November - December

Fourth Quarter TAG Meeting – December 12th

➢ **2019 Selection of Solutions**

- **TAG will receive feedback from the OSC on any alternative solutions that were proposed by TAG members**

➢ **2019 Study Update**

- **Receive and discuss final draft of the 2019 Collaborative Transmission Plan Report**
- **Discuss potential study scope for 2020 studies**

Questions ?

TAG
Open Forum Discussion

Comments or Questions ?