Informing the **Transmission Discussion**

A Look at Renewables Integration and Resilience Issues for Power Transmission in Selected Regions of the United States

January 2020

scottmadden MANAGEMENT CONSULTANTS

WIRES®

Regional Discussion

SOUTHEAST

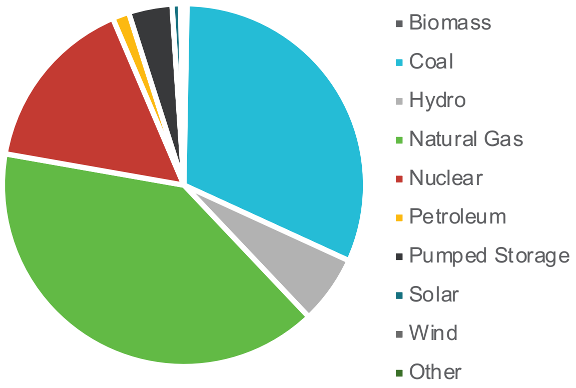
Contents

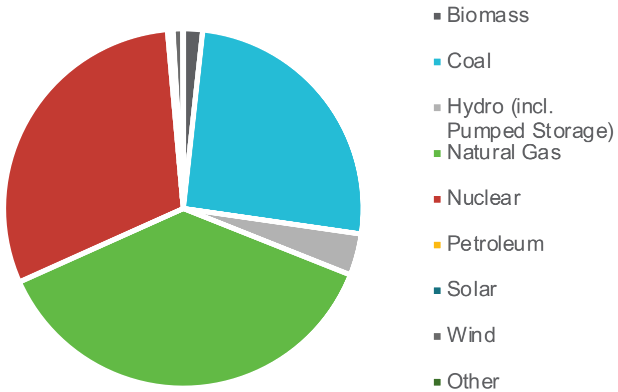
Overview

Description of Region

- The Southeast is principally comprised of vertically integrated investor-owned utilities, a large federal utility, and a number of cooperative and municipal and state utilities.
- SERC, the reliability assessment area covering the Southeast region, is a summer-peaking assessment area, although winter peak exceeded summer in 2018. SERC is divided into three assessment areas: SERC-E, SERC-N, and SERC-SE.
- Reserve margins for the region are expected to remain above 20% through 2027(compared with a 15% target margin level).

Key Regional Statistics	
States Covered	NC, SC, TN, KY, GA, AL, MS, MO
Square Mi. Covered	~308,900
No. of Utilities	14 co-ops; 3 federal/state systems; 10 munis; 12 investor-owned utilities
No. of Customers/Pop. Served	39.4MM population
Installed Capacity	164,037 MWs
Transmission Line Miles	71,564 miles
Peak Hour Demand (2018)†	127,116 MWs summer (136,112 MWs winter)
Net Energy for Load	670,218 GWhs
Forecast Growth (Annual)	0.27%–0.82% peak load growth 0.1%–0.8% demand (usage) growth





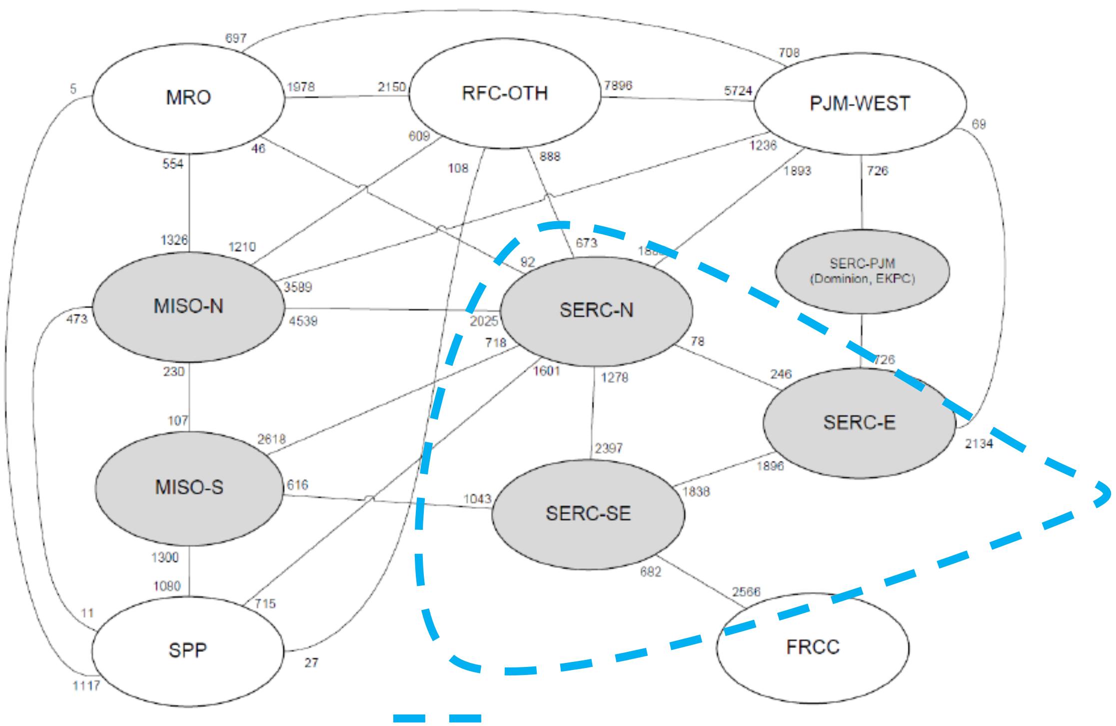
Sources: NERC 2018 LTRA

Notes: SERC recently reorganized into its current three assessment areas. It had traditionally covered some areas of PJM (in VA) as well as MISO-Central (IL, MO) and MISO-South (AR, MS, LA, TX). For some statistics noted here, those legacy areas may be included because the most recent information from SERC includes them (e.g., 2018 SERC Reliability Review Committee Annual Assessment). Those are noted herein with an *.

† Note: Not necessarily coincident; constitutes a sum of subregional peak hour demand for SERC-E, SERC-N, and SERC-SE; net internal demand is net of demand response.

Transmission Topography and Investment

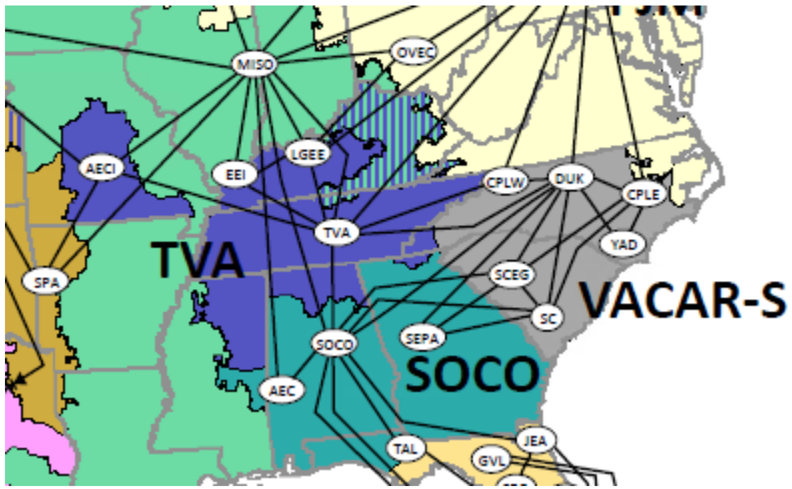
System Transfer Limits (MWs) (Estimated Summer 2020)



Source: 2018 SERC Probabilistic Assessment, Fig. 2

- The Southeast includes 11 balancing authorities as shown in the map below (SOCO, VACAR-S, and TVA). By comparison, PJM and MISO each serve as a single-balancing authority for their respective regions.
- A few large utility systems—Duke Energy, Southern Company, and Tennessee Valley Authority—comprise much of the region. However, a number of other smaller investor-owned utilities and electric cooperatives serve load in the region.
- Georgia has an integrated transmission system, a majority of which is jointly owned by Georgia Power Company (Southern Co. subsidiary), Georgia Transmission Corporation (GTC), the Municipal Electric Authority of Georgia (MEAG), and the City of Dalton.

Southeastern Balancing Authorities as of Oct. 2015 (excl. FL)



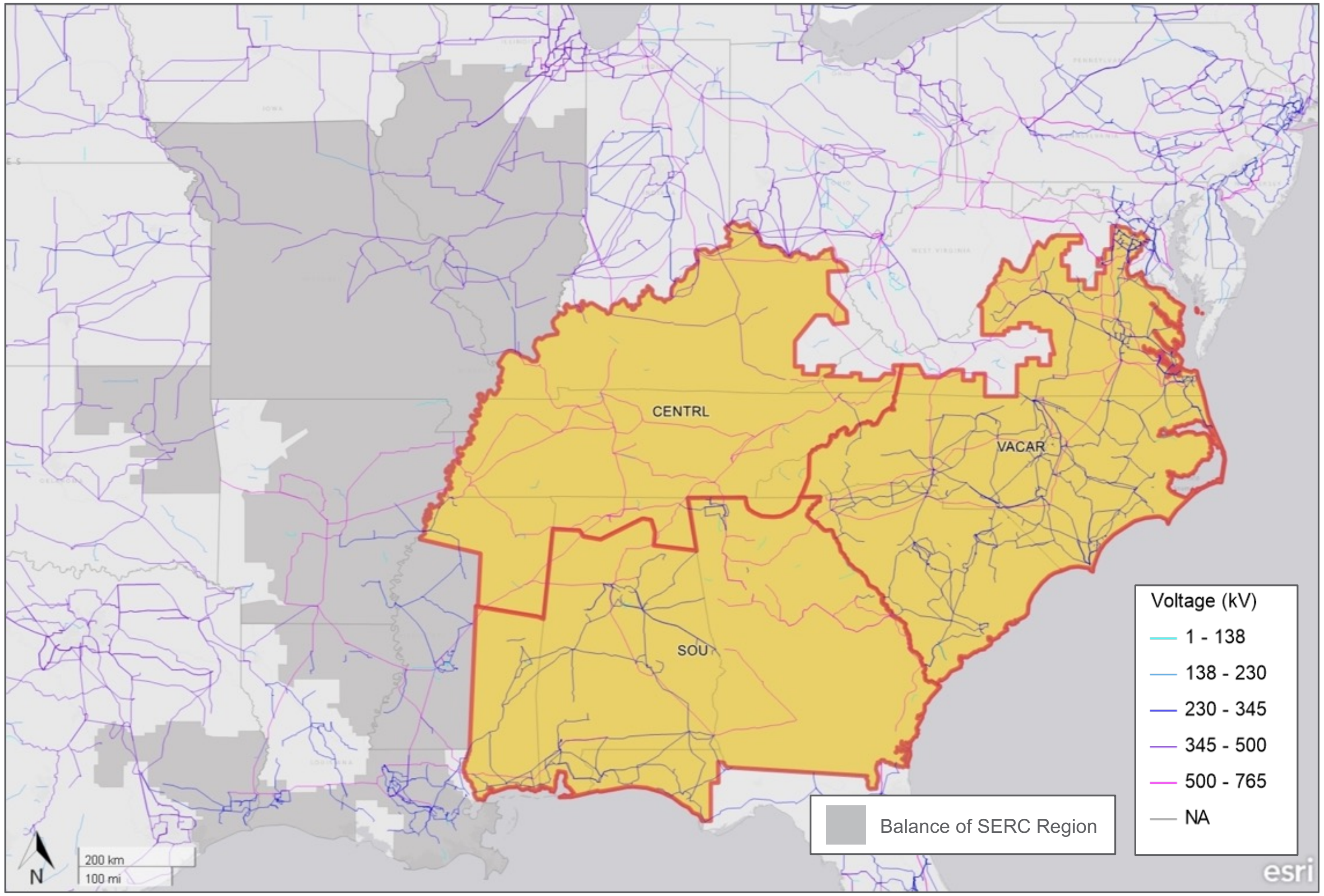
VACAR-S	
CPLW	Duke Energy Progress West*
CPLE	Duke Energy Progress East*
DUK	Duke Energy Carolinas*
YAD	Alcoa Power Gen. – Yadkin Div.
SCEG	South Carolina Electric & Gas
SC	South Carolina Public Serv. Auth.
SOCO	
SEPA	Southeastern Power Admin.
SOCO	Southern Company
AEC	PowerSouth Energy Cooperative
TVA	
TVA	Tennessee Valley Authority
LGEE	Louisville Gas & Electric
EEI	Electric Energy, Inc.
AECI	Associated Elec. Cooperative

*Note: Per NERC, Duke affiliates shown are treated as a single-balancing authority.

Sources: SERC; NERC

Transmission Topography and Investment (Cont'd)

Selected SERC Subregions (VACAR, Southeastern, and Central) Operating Transmission Lines



Source: S&P Global Market Intelligence

- There is significant internal transfer capability, which allows for transfers between subregions. In addition, SERC's subregions are interconnected with PJM, MISO, the Southwest Power Pool, and Florida.
- According to NERC, approximately 721 miles of new transmission lines are either in the planning stages or under construction as of late 2018 (see table below). All but one project was primarily driven by reliability; one large project was driven by nuclear integration with new reactors at Southern Company's Vogtle nuclear station.

Proposed Transmission Projects (Line Length in Circuit Miles) in SERC-E, -N, and –SE (as of Dec. 2018)

Operating Voltage Class (kV)	Conceptual	Planned	Under Construction
100-120		130.6	31.7
151-199	17	75.12	79.96
200-299	47	170	98
300-399		12.35	
400-599		60	
Grand Total	64	448.07	209.66

Source: NERC 2018 Electricity Supply & Demand

Sources: NERC 2018 LTRA; NERC ES&D: SERC 2018 Annual Assessment; S&P Global Market Intelligence

Transmission Topography and Investment (Cont'd)

- Utilities in the Southeast collaborate and coordinate in transmission planning through the Southeastern Regional Transmission Planning (SERTP) process, which provides an open and transparent transmission planning forum for transmission providers to engage with stakeholders regarding transmission plans in the region.
  - SERTP was originally developed to provide an open and transparent regional transmission planning process and to otherwise comply with the Federal Energy Regulatory Commission's (FERC) Order 890 issued in February 2007.
  - SERTP has expanded several times, both in the scope and size of the region, since its initial voluntary formation and now includes the following sponsors: Southern Company (SCS), Dalton Utilities, GTC, MEAG, PowerSouth, Louisville Gas & Electric Company and Kentucky Utilities Company (LG&E/KU), Associated Electric Cooperative Inc. (AECI), the Tennessee Valley Authority (TVA), and Duke Energy (Duke Energy Carolinas, LLC and Duke Energy Progress, LLC).
  - SERTP's region is one of the largest regional transmission planning processes in the United States.
- Regional planners are looking at impacts of high south-to-north and north-to-south transfers due to market conditions. In 2018, they performed economic studies of potential enhancements (1,000 MWs) to improve flows from Georgia into downstate South Carolina and from downstate South Carolina into North Carolina (and in the reverse).
- In 2019, SERTP is planning on analyzing five scenarios in economic planning transmission studies:

Source BAA*	Sink	Load Level	Transfer Capability (MWs)	Year
Southern Company	Santee Cooper	Summer Peak	500	2020
Duke Energy Carolinas	Santee Cooper	Summer Peak	500	2020
Southern Company	Santee Cooper	Summer Peak	800	2020
Duke Energy Carolinas	Santee Cooper	Winter Peak	500	2024
Southern Company	Santee Cooper	Winter Peak	1,000	2024

*Balancing Authority Area

Source: SERTP 2019 Economic Planning Studies Scope Document

Sources: SERTP website, at http://www.southeasternrtp.com/home.cshtml; NERC 2018 LTRA; NERC ES&D; 2018 Annual Assessment

Resilience Issues

Resilience Risks

- The greater Southeast is a broad area with a variety of industries. As a frame of reference for the potential economic impact of a resilience event, its 2018 annual GDP for those states in the SERC-N, -E, and -SE footprint was $2.6 trillion.*
- Historically, the Southeast has been vulnerable to tropical cyclones, winter ice storms, and heat waves that impact both demand and energy infrastructure. Extreme heat also affects thermal generation, as ambient air and water temperatures can cause de-rates. The subregions in their summer reliability assessments use scenario planning that factor in up to 1 to 1.5 GWs in de-rates in each.
- With the addition of behind-the-meter solar facilities, some utilities in the Southeast anticipate becoming winter-peaking systems (as traditional summer peak loads are reduced). In addition to this shift, as utility-scale solar continues to be added to the resource mix, regional grid operators are closely following winter reserve margins.
- SERC has identified key risks – reliability-focused, but with resilience implications below (see table). Extreme weather risk, ranked second, is a risk factor, particularly with effects on fuel availability.

Reported Electric Disturbance Events Affecting Selected Southeastern States (2017- Apr. 2019)

Cause	2017	2018	2019 YTD
Generation Inadequacy	2		
Severe Weather	24	26	5
Vandalism	8	3	
Actual Physical Attack	2		
Suspicious Activity			1
Transmission Interruption		1	1
System Operations	1	10	1

Note: For multiple causes, classified under one only. Includes states of NC, SC, TN, KY, GA, AL, MS, MO.
Sources: DOE OE-417; ScottMadden analysis

2017 Ranked Regional Risk Elements

Engineering Risks	Operational Risks	Critical Infrastructure Protection (CIP) Risks
Resource uncertainty or changing mix, along with generation retirements	Parallel/loop flow issues	Intentional or non-intentional manipulation or misuse of assets
Fuel diversity/fuel availability	Extreme weather	Extreme physical events (man-made): sabotage
Generator governor frequency response	Loss of major application (EMS/SCADA)**	Unauthorized electronic access – lose or deny functionality, visibility, or control of assets

Source: 2018 Annual Assessment, Table 3

Notes: *Figure applies to states of NC, SC, TN, KY, GA, AL, MS, MO.
**EMS is energy management system; SCADA is supervisory control and data acquisition.
Sources: NERC 2018 Summer Reliability Assessment; Bureau of Economic Analysis; NERC 2018 LTRA; 2018 Annual Assessment

Resilience Issues (Cont'd)

Selected Recent Major Bulk Power Events Affecting the Southeast	
Event	**Description**
Total Solar Eclipse (Aug. 21, 2017)	▪ On August 21, 2017, parts of the United States experienced the effects a total or near-total eclipse of the sun. NERC and other reliability coordinators planned for this event and its potential reliability implications, focusing on areas where there was the most solar photovoltaic energy resources, particularly where those were coincident with peak load. A number of states, including North Carolina, were subject to special examination because of their higher amounts of solar resources and expected high-obscuration levels. ▪ NERC projected an increase in load due to lower distributed PV output, although not extreme. It recommended that advanced coordination to mitigate ramping and balancing issues may be needed and recommended that utilities in North Carolina perform detailed studies and retain necessary resources to meet the increased and varying load. The event did not produce any reliability issues because of advanced planning, which extended to neighboring regions such as PJM.
Hurricane Florence (Sept. 2018)	▪ Hurricane Florence made landfall as a NOAA-Category 1 storm on September 14, 2018, near Wrightsville Beach, NC. The hurricane had 2,300 MWs in forced outages/de-rates for the worst part of the storm, as it tracked along portions of the North and South Carolina coasts. The total number of customer outages approached 1.4 million. As many as 50 bulk power system transmission assets sustained damage/outage, and flooding threatened several generation sites in the path of the storm. Generation capacity was sufficient for recovery, but damage and disruption to transmission assets posed a continued problem during the restoration period.
Hurricane Michael (Oct. 2018)	▪ Hurricane Michael made landfall as a NOAA-Category 5 storm on October 10, 2018. The hurricane had 575 MWs in forced generation outages and wavered between 210 and 500 MWs in restricted operation for one nuclear plant. The total number of customer outages was approximately 1.1 million, far exceeding the originally estimated 540,000 distribution customers. ▪ The storm's path was from Florida to Virginia, including Georgia and the Carolinas. The majority of the storm's damage to the electricity system was on the distribution side; however, the transmission system sustained outages to numerous 230 kV and 115 kV lines. Generation damage was limited mainly to renewable solar plants.

Sources: NERC, 2018 and 2019 State of Reliability reports; NERC Eclipse White Paper

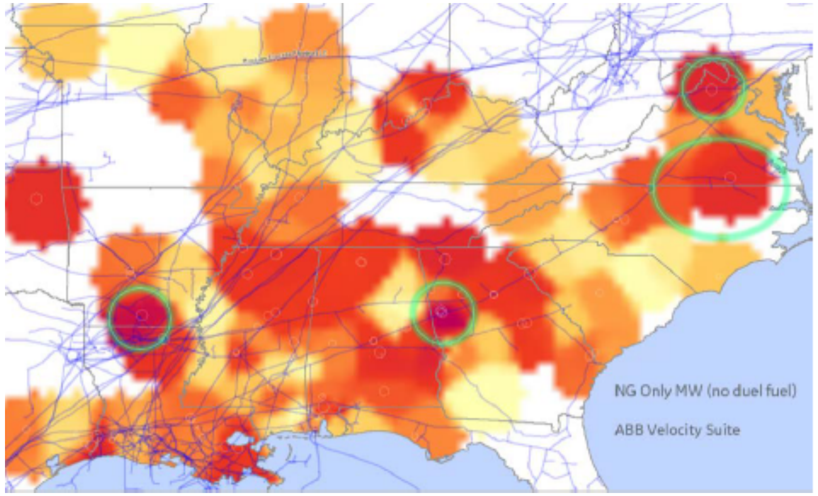
Resilience Issues (Cont'd)

- Finally, the significant influx of gas-fired generation in the region has increased interest on the potential impact of disruptions of key natural gas facilities, including interstate pipelines, branch lines, and storage facilities. Of particular interest are clusters of single-sourced generators (i.e., not dual fuel) (see map at top right).

GE 2018 Probabilistic Assessment

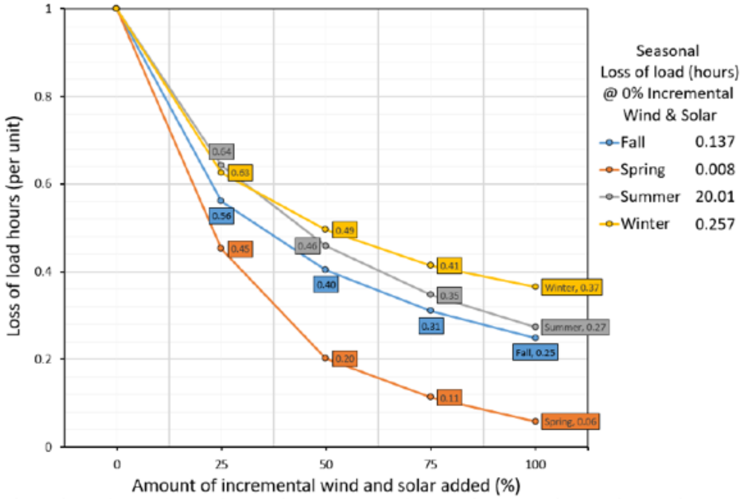
- In 2018, SERC commissioned GE Energy Consulting to conduct a probabilistic assessment of reliability of the region, particularly loss of load and expected "unserved energy," based upon a few key assumptions:
  - Changes in planning reserve margin levels as a result of thermal generation retirements and replacement with variable energy resources
  - Impacts of potential natural gas single points of disruption impacts
- The assessment found the following:
  - Lower reserve margins across the area (2/3 of initial reserve margins) entailed few loss of load events (mostly in SERC-SE and SERC-E); at 1/3 of initial reserve margins showed significant loss of load in SERC-SE, SERC-E, and SERC-N
  - Addition of wind and solar improves reliability metrics, but not proportional to capacity. Riskiest hours are pushed to later in the day, where incremental solar is less effective. But this varies by season: most reliability improvement is in the spring, least is in winter (see graph at lower right).
  - Single point of disruption sensitivities for summer (August) and winter (January) looked at gas supply outages: only two scenarios (of 40 modeled) produced "meaningful" loss of load. Risk is largely confined to SERC-SE and the summer season.

Clusters of Single-Sourced Natural Gas Generators



Source: SERC

Seasonal Reliability Improvements (Modeled) with Increased Renewable Penetration

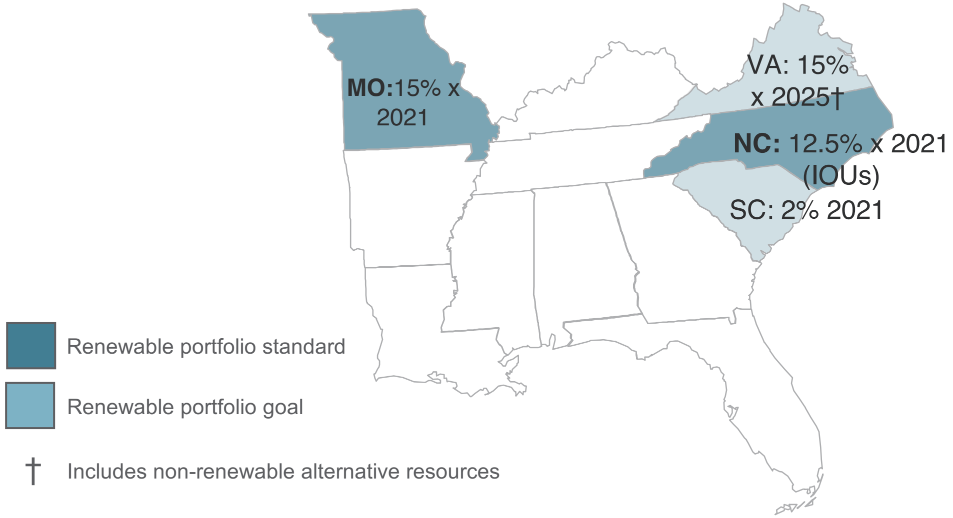


Source: GE/SERC

Sources: NERC 2018 Summer Reliability Assessment; SERC 2018 RRS Annual Assessment; 2018 Probabilistic Assessment

Renewables Integration

Southeastern U.S. Renewable Portfolio Standards and Goals (as of June 2019)



Source: DSIRE

Demand-Side Considerations

- Overall demand growth in the region is generally less than 1% annually, although metro areas are experiencing higher growth than rural areas.
  - Some utilities report demand reduction because of behind-the-meter distributed generation and appliance standards and expect these trends to continue into the future. Most distributed energy resources (DERs) are solar, and the queued amount connected to the sub-transmission system is about 2.1 GWs (roof-top solar, electric vehicles, etc.).
  - Demand response programs in the region are minimal (about 7.3 GWs) in comparison with peak load.
- The Southeast has few renewable or clean energy standards. Only North Carolina and Missouri have renewable portfolio standards. South Carolina and Virginia each have renewable energy goals (see map at left). For states in the SERC-N, -E, and –SE subregions, relevant portfolio goals/standards are targeted for compliance by 2021.
- A few large utilities in the region have announced carbon reduction initiatives:
  - Southern Company has announced that it is targeting a 50% reduction in CO_2 emissions by 2030, with a further reduction to low or no carbon resources by 2050.
  - TVA has pledged to reduce its rate of CO_2 emissions by 60% by 2020. It also targets 55% carbon-free power supply by 2020.
  - Duke Energy's subsidiaries in North Carolina file annual integrated resource plans (IRP) regarding compliance with the state's renewable energy and efficiency requirements. Those IRPs call for reducing CO_2 emissions by at least 40% from 2005 levels by 2030 with approximately 60% of its electricity coming from carbon-free clean energy sources.
  - In September 2019, Duke Energy announced that it will reduce carbon emissions by at least 50% or more (from 2005 levels) by 2030, an increase from a previous target of 40%. It also announced a new goal of net-zero carbon emissions from electric generation by 2050. Duke will adjust resource plans to reflect these goals. It has stated a goal of doubling its renewable portfolio by 2025.

Sources: NERC 2018 LTRA; DSIRE; SEPA

Renewables Integration (Cont'd)

Supply-Side Considerations

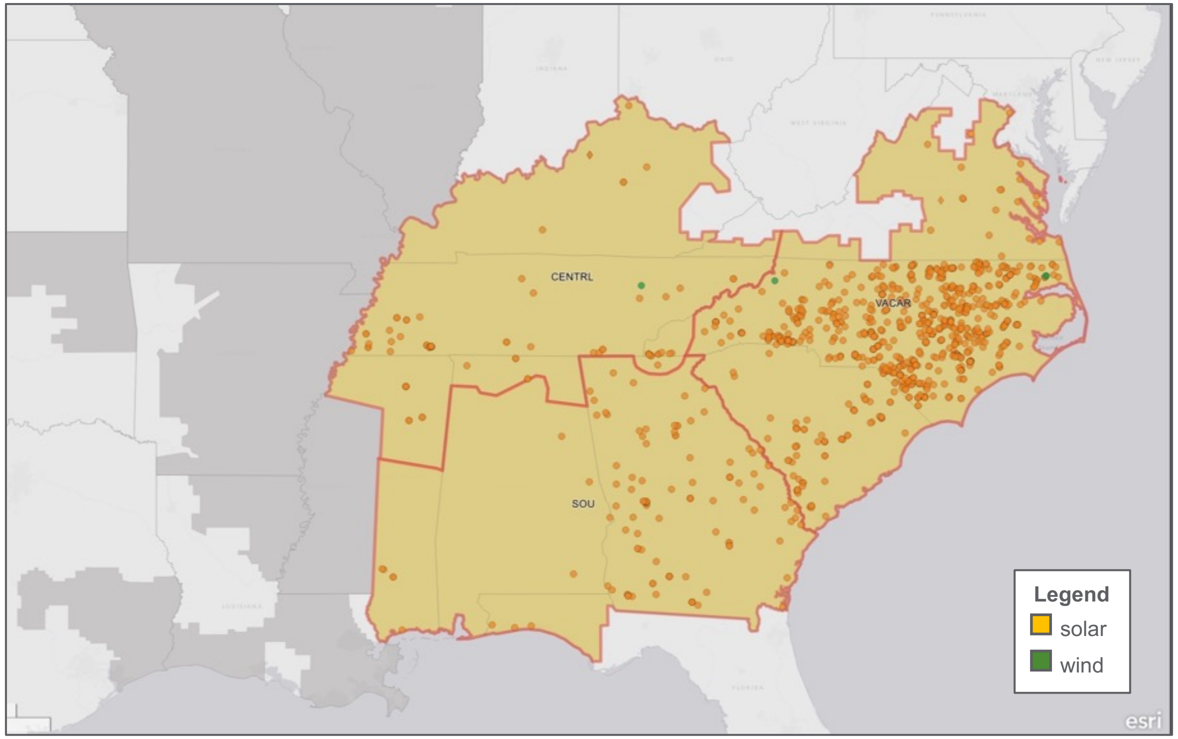
- The Southeast has been adding renewable resources, largely solar, over the past decade. Since 2010, the legacy Central, Southeast, and VACAR subregions have added 6.5 GWs of solar and nearly 1.9 GWs of wind generation. But solar and wind each remain less than 1% of the capacity mix in each of SERC-E, -SE, and -N.
- SERC expects that 21 GWs of utility-scale solar will be in the interconnection queue over the next five years, largely for development in the SERC-E subregion (the Carolinas). Interestingly, SERC's reliability projections do not project significant wind or solar additions, but identified 3.7 GWs of new natural gas-fired generation in SERC-E and 2.2 GWs of new nuclear in SERC-SE.
- IRPs tell a slightly different story. Major utilities Duke Energy (its North and South Carolina operating companies), Georgia Power, and the Tennessee Valley Authority, all project meaningful renewable additions over the next decade (see table below).

Selected Integrated Resource Plan Projected Renewable Capacity Additions

	2019	2033	Change (GWs)
Duke Energy Progress†	2.7	4.2	1.5
Duke Energy Carolinas†	1.2	3.4	2.2
Tennessee Valley Authority††	0.3*	3.4	3.1
Georgia Power Company			0.95**

†Solar only (other figures not meaningful). ††All renewables (excl. hydro).
*2018 figure. **Reflects RFPs for utility-scale renewable capacity with 2022 and 2024 commercial operation dates.

Selected SERC Subregions (VACAR, Southeastern, and Central) Operating and Planned Solar and Wind Capacity (as of Oct. 2019)



Source: S&P Global Market Intelligence

Sources: NERC 2018 LTRA; S&P Global Market Intelligence; Duke Energy, Georgia Power, TVA IRPs; Southeastern Wind Coalition

Renewables Integration (Cont’d)

Potential Onshore Wind Capacity in Southeast States (MW)

State	80 m Hub Height	110 m Hub Height	140 m Hub Height
Alabama	25	16,814	193,376
Arkansas	2,126	180,978	185,713
Florida	0	11,164	153,485
Georgia	35	6,786	188,657
Kentucky	0	76,606	128,123
Louisiana	0	92,823	165,431
Mississippi	0	43,578	188,275
North Carolina	2,201	7,174	102,730
South Carolina	557	10,299	98,638
Tennessee	99	60,329	110,717
Virginia	2,273	9,539	72,112

Source: Department of Energy, Office of Energy Efficiency & Renewable Energy's WINDExchange

Potential Offshore Wind Capacity in Southeast States (MW)

State	0 to 3 Nautical Miles	3 to 12 Nautical Miles	12 to 50 Nautical Miles
Georgia	426	2,648	38,248
Louisiana	776	8,123	75,163
North Carolina	35,136	44,923	288,219
South Carolina	3,083	23,316	122,961
Virginia	23,794	15,233	89,923

Source: Department of Energy, Office of Energy Efficiency & Renewable Energy's WINDExchange

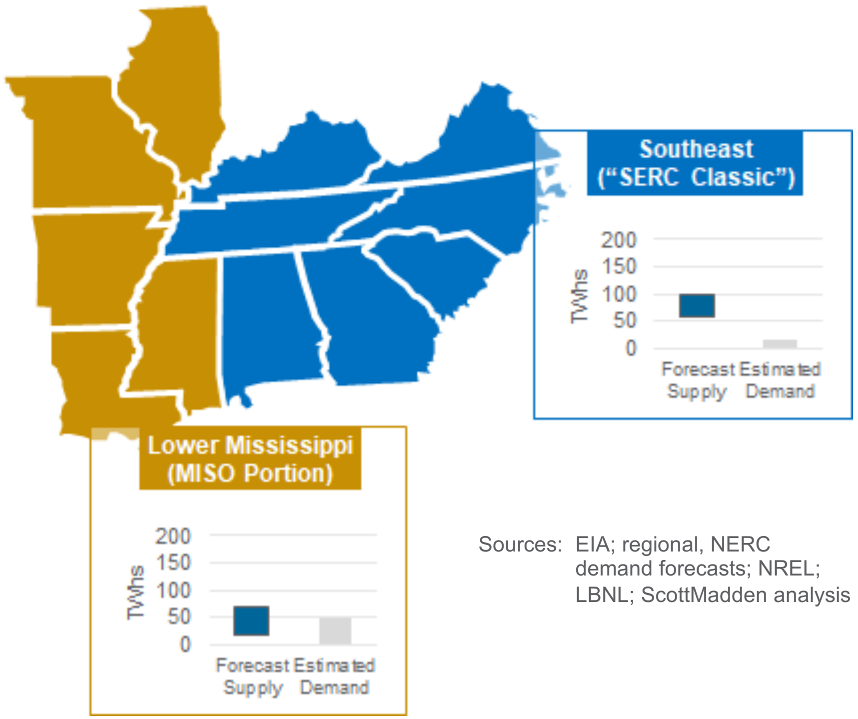
Supply-Side Considerations (Cont’d)

- Wind development in the Southeast has been limited to date.
  - Wind advocates, the U.S. Department of Energy and the Bureau of Ocean Energy Management, are looking at the potential for development across the Eastern Seaboard, including the Southeast.
  - According to the National Renewable Energy Lab, Virginia, North Carolina, South Carolina, and Georgia have 82% of the East Coast’s resource in shallow water and more than 12 miles offshore (enabling locating facilities further offshore) and 45% of the total East Coast’s offshore wind resource (see Appendix).
- A key concern among policymakers has been the potential hazards posed by turbines for military aviation as well as effects on agriculture. In North Carolina, the state legislature has discussed a potential compromise on onshore and offshore wind that would lift an existing ban on those facilities.
- In Virginia (not within the Southeast footprint but nearby), construction work on an offshore wind project (Coastal Virginia Offshore Wind)—the first in the Mid-Atlantic—began in summer 2019. The project consists of two 6-megawatt turbines, expected to be in operation by late 2020.
- In 2017, the U.S. Bureau of Ocean Energy Management held a lease auction for the 122,405-acre Wind Energy Area (WEA) 24-nautical miles off the coast of Kitty Hawk, NC (see Appendix), which was awarded to Avangrid Renewables. Avangrid has been granted an extension of the preliminary term of this lease through November 2019. According to the Southeastern Wind Coalition, the lease area has the potential to generate 2,500 MWs and could begin construction as early as 2024.

Sources: Southeastern Wind Coalition, at http://www.sewind.org/what-we-do/offshore-wind; Dominion Energy; 2017 SEWC White Paper; Bureau of Ocean Energy Management

Renewables Integration (Cont'd)

Southeastern U.S. Potential Policy-Driven Renewable Energy Demand and Forecast Supply (2030) (as of June 2019)



Sources: EIA; regional, NERC demand forecasts; NREL; LBNL; ScottMadden analysis

Integration Challenges

- As can be seen at left, the Southeast and adjacent Lower Mississippi (parts of which are in certain SERC subregions), have more projected supply of renewable generation than expected demand (at least at this time, based upon renewable portfolio standards).
- In the current and last planning cycle, SERTP did not receive any input or proposals for possible transmission needs driven by public policy requirements, such as renewable requirements.
- In its latest final transmission plan (2018), SERTP's members incorporated the following projections of utility-scale renewable additions through 2028 (excluding uprates of hydro and pumped storage facilities):
  - Southern Company: 879 MWs solar; 116 MWs biomass
  - Georgia Transmission Corp.: 199 MWs solar
  - Tennessee Valley Authority: 742 MWs solar
- SERC is studying the potential impacts of increasing inverter-based resources, both utility and distributed. It has identified and is monitoring issues, particularly harmonic distortion. SERC's Dynamics Working Group is looking at the potential impact of renewables on frequency response of SERC (as an electric island) and/or the Eastern Interconnection. As stated by SERC, "Other than the effect on frequency response and wide area power flows, the impact of renewables [is] believed to be more of a local area issue than a SERC-wide area issue."

Sources: SERTP; 2018 SERTP Annual Assumption Planning Summit; 2018 Annual Assessment, at p. 43; LBNL 2019 RPS Analysis; AWEA 2019 RPS Analysis; EIA; regional, NERC demand forecasts; NREL Standard Scenarios; LBNL; ScottMadden analysis

Implications for Transmission

	Resilience	Integration of Renewables	Other Factors	Transmission Opportunities
Southeast	▪ Severe weather greatest cause of electric disturbances: tropical cyclones and tornadoes primary resilience risks; distribution systems also being affected by ice storms ▪ Deeper push of Arctic cold snaps and shift to winter peaks (increased heating load) pose risks to resource availability during low-frequency extreme cold conditions ▪ Baseload-heavy, but increasing amount of gas-fired resources and possible exposure of single source generators to pipeline interruptions; about 3.6 GWs of affected capacity in GA, SC	▪ Projections of renewables additions vary – SERC expects 21 GWs in next 5 years – Duke Energy and Tennessee Valley Authority plan on nearly 7 GWs by 2033 ▪ Solar is primary technology; limited onshore wind development ▪ Investigation of offshore wind opportunity of up to 2.5 GWs, but development is in early stages ▪ Minimal renewables integration issues; managed generation portfolios ▪ Large, well-distributed baseload and load-following resources provide adequate ramping frequency response capability	▪ Relatively modest policy drivers in region if any; limited RPS or clean energy standards but some utility-driven goals advancing (e.g., net zero-carbon emissions by 2050, 50% reduction by 2030) ▪ Some larger integrated utilities are undertaking carbon reduction or clean energy initiatives ▪ SERC studying potential issues with increased non-synchronous inverter-based resources (e.g., voltage, telecommunication interference, thermal heating on transformers and rotating machinery, and mis-operation of protective relays and user equipment) ▪ Vertically integrated, rate-of-return regulated environment: resilience and integration issues addressed through IRP, equipment-sharing programs	▪ Limited needs for interregional transmission for renewables integration—significantly more regional supply than policy demand ▪ With increased renewables over a 10-year time horizon, potential upgrades needed ▪ Integrated utilities are studying resilience issues, including impacts of thermal generator retirements, increase in variable energy resources (esp. for winter resources adequacy ▪ Long-term potential for integration of offshore wind

Sources

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- 2019 Georgia Power Company Integrated Resource Plan, Docket No. 42310 (filed Jan. 31, 2019)
- 2019 Tennessee Valley Authority Integrated Resource Plan (June 28, 2019)
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- FERC Staff Report, Energy Primer: A Handbook of Energy Market Basics (Nov. 2015)
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- SERTP, 2019 Economic Planning Studies Scope Document (May 14, 2019)

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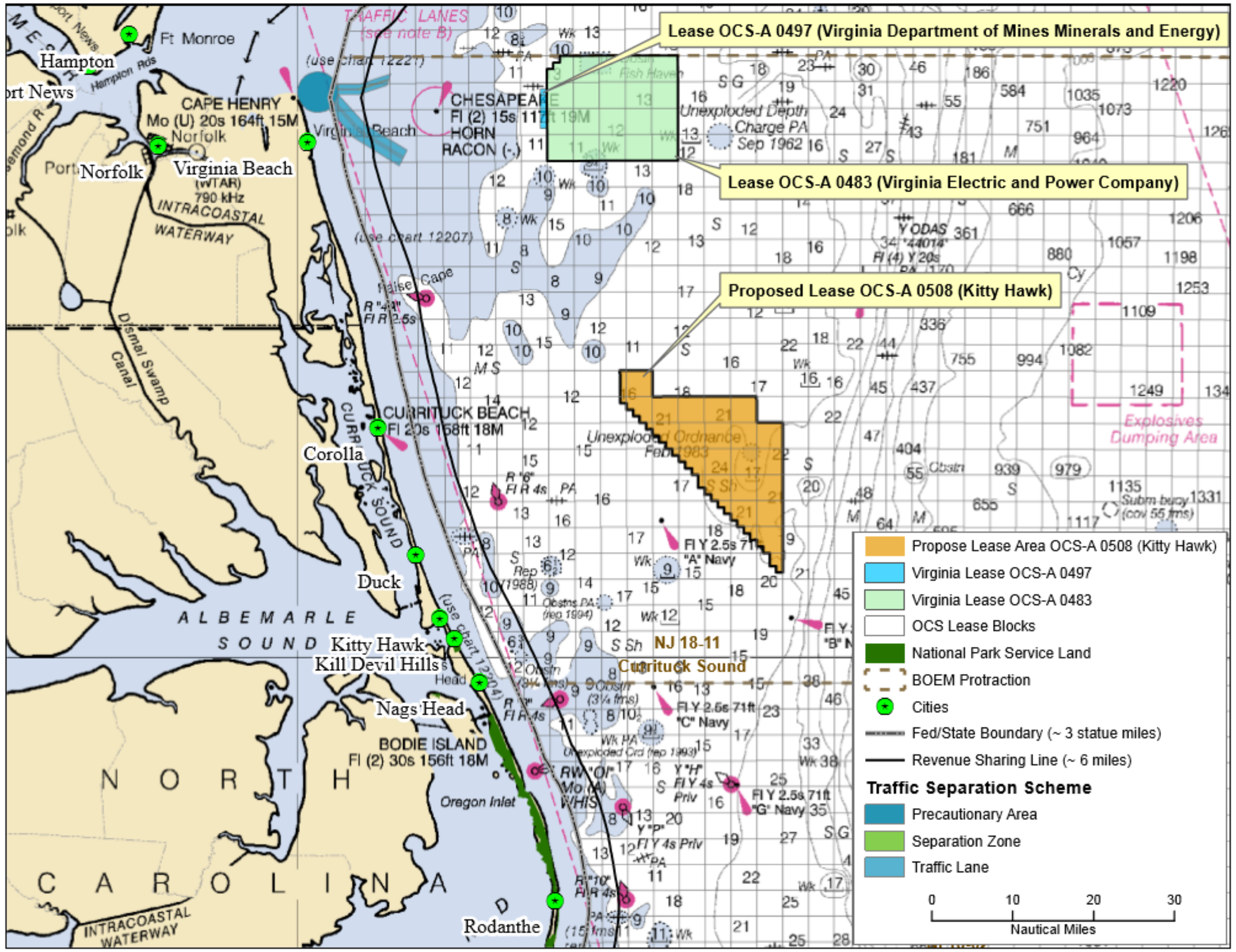
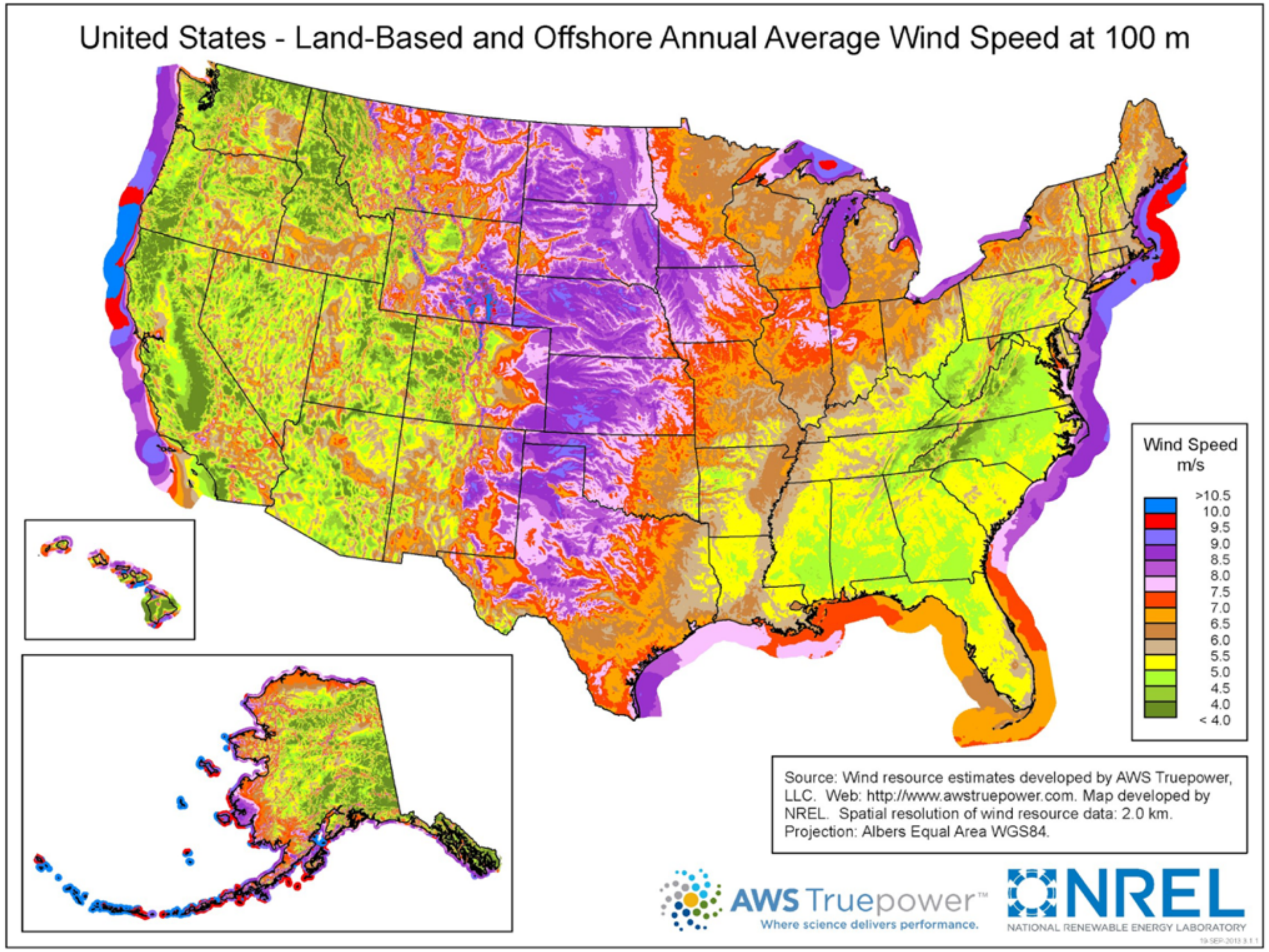
- Southeastern Wind Coalition, at www.sewind.org
- Southeastern Wind Coalition-ScottMadden, "Understanding Wind Energy Potential in the Southeast" (Sept. 2017) (2017 SEWC White Paper)
- U.S. Bureau of Ocean Energy Management, Commercial Wind Leasing Offshore North Carolina, https://www.boem.gov/Commercial-Wind-Leasing-Offshore-North-Carolina/
- U.S. Dept. of Energy, Office of Energy Efficiency and Renewable Energy, WINDExchange, at https://windexchange.energy.gov/
- Regional, state, NERC demand growth forecasts
- S&P Global Market Intelligence

Appendix: BOEM Lease Areas – NC and VA



Source: BOEM Commercial Wind Leasing Offshore North Carolina

Appendix: Wind Average Speed



Source: BOEM website and DOE EERE WINDExchange