Informing the **Transmission Discussion**

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

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Preface

This report was prepared by ScottMadden, Inc. for WIRES.[1] The study includes a comprehensive overview of the current state of play of the electric industry and conducts a region-by-region examination of the challenges posed by changing energy resources, increasing electrification, and a greater need and preference for location-constrained renewables integration, in addition to addressing growing concerns about and risks to the resilience of the North American electric power system. The study also explores how these issues should be considered from an interregional transmission development perspective.

One of the clear takeaways from the report is that transmission can, and should, play a significant role in addressing the challenges raised by these factors. In particular, as more states, utilities, and other companies are mandating or committing to clean energy targets and agendas, it will not be possible to meet those goals without additional transmission to connect desired resources to load. Similarly, the current transmission system will need further expansion and hardening beyond the traditional focus on meeting reliability needs if the system is to be adequately designed and constructed to withstand and timely recover from disruptive or low probability, high-impact events affecting the resilience of the bulk power system.

To the extent all of these signs point toward a need for more transmission, time is of the essence. In the current environment, transmission is increasingly more difficult to build and operate. With transmission projects taking ten years or longer to be built and put into service, decisions regarding any transmission projects required to meet renewables integration and resilience concerns must be made with sufficient lead time if they are to play a role in meeting needs existing today, much less in the future. WIRES offers this report to facilitate a comprehensive review and discussion by planners, policy makers, regulators, and all those who are interested in the development of a robust transmission grid that is adequate to meet environmental and resilience goals.

WIRES solicits and looks forward to comments and questions regarding the study, which can be submitted to www.wiresgroup.com.[2]

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[1] WIRES is an international non-profit trade association of investor-, member-, and publicly-owned entities dedicated to promoting investment in a strong, well-planned, and environmentally beneficial high voltage electric transmission grid. WIRES members include integrated utilities, regional transmission organizations, renewable energy developers, and engineering, environmental, and economic policy consulting firms. WIRES' principles, its studies, and all public comments are available at www.wiresgroup.com.

[2] WIRES would like to acknowledge and thank the team of experts at ScottMadden, Inc., led by Cristin Lyons and Greg Litra, for their industry knowledge and insightful analysis as reflected in this study. In addition, we express our appreciation to former WIRES Counsel and Advisor James J. Hoecker for his leadership in initiating this study.

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Executive Summary

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Objectives of This Study

- Much has been written discussing the role of and need for transmission for integration of renewables and grid resiliency issues in the wake of heightened cybersecurity awareness (given global geopolitics) and other natural events (e.g., superstorms and hurricanes, bomb cyclones, extreme cold snaps, and wildfires).
- Many examinations of these topics have been conceptual, addressing policy issues with broad recommendations. Other treatments have been more technical, looking at specific physical insufficiencies in infrastructure.
- The challenge of these issues, and previous discussions of them, is the desire for a “universal solvent” that will remedy transmission infrastructure gaps across the nation; however, many of these issues are inherently regional. Each location has its endowment of existing infrastructure (including power generation and transmission), load sinks, renewable resource potential, and potential risks from widespread resilience events. Moreover, states have a meaningful role in siting and permitting electric facilities, mandating renewables procurement, and cost recovery. Indeed, different states are forcing the issue on renewables integration as they announce aggressive clean energy standards.
- This study focuses, region-by-region, on the key issues of renewables integration and resilience challenges. It reviews the current transmission landscape, renewable integration issues, recent resilience concerns, what regional transmission planners have done to address these, and what they believe ought to be done going forward to ensure reliability and resilient accommodation of growing amounts of renewable resources.
- It also examines some of the interregional needs and barriers to transmission development, summarizing key interregional issues in integrating renewables, identifying how regional organizations and others are dealing with these issues, and gleaning any lessons learned.

The goal of this study is to inform policymakers and the public of region-specific needs, issues, and challenges including the integration of location-constrained renewable resources and resilience. This review is done with a view of where and how transmission can and should play a role in addressing these needs.

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Industry Backdrop

The electric industry has undergone a tremendous amount of growth and change over the past two decades, and it continues to evolve as policy and customer preferences, improving technology costs, and increasing focus on reducing greenhouse gas emissions (GHG) drive shifts in energy resources and consumption patterns. This transformation is driven by four key developments:

Changing Energy Mix	Deployment of Distributed Energy Resources (DERs) and Energy Storage	Aspirations for Beneficial Electrification	Strong Interest in Renewable and Greenhouse Gas Emissions-Free Resources
▪ Abundant and inexpensive natural gas making gas-fired power generation attractive ▪ Continued retirement of conventional fossil power plants nearer to load, as well as some nuclear plants ▪ Growing amounts of utility-scale wind and solar generation being proposed, but highly location-specific	▪ Growth in smaller DERs on the distribution system, both behind-the-meter and in larger-scale applications like microgrids, spurred by policy support and declining costs, and subject to favorable benefit-cost analysis ▪ Potential for support of local reliability and resilience ▪ However, lack of visibility and control, and uncertain impacts on demand behavior	▪ Customer, select policy interest in “deep decarbonization” and utility interest in increasing system load ▪ Electric industry and stakeholders looking at beneficial electrification to displace some traditional non-electric applications (e.g., light- and heavy-duty vehicles, space heating) ▪ GHG emissions “exchange” with electrification highly dependent upon power supply fuel mix	▪ Renewable portfolio standards (RPS), in place for years, increasing in scale ▪ States announcing ambitious clean energy (i.e., non-GHG-emitting energy resources) goals ▪ Large corporate buyers looking for renewable energy supply for national and global operations, for value and brand equity ▪ Latest trend: clean energy and net-zero emissions targets announced by some electric utilities

The developments noted above warrant consideration of impacts on the bulk power system and transmission in particular.

Regional Transmission Summary – ISO-New England

ISO-New England

- Ambitious clean energy goals in all six states: Ranging from 25.2% by 2025 in New Hampshire at the low end to 100% by 2050 in Maine at the high end, with demand expected to exceed supply in 2030, opening opportunity for more imports from Canada.
- Large offshore wind development target requires related offshore grid build-out, and onshore wind development in Northern Maine requires capacity to move wind to load
- Retiring nuclear and other thermal generation and significant reliance on natural gas generation creates fuel and energy availability risk.
- Resilience concerns, including extreme cold weather gas constraints for generation fuel, opens possible need for increased capacity at interfaces – “gas by wire” from PJM (via NYISO), hydropower from Canada (Quebec, in particular).

Regional Transmission Summary – New York ISO

- Ambitious clean energy goals: 70% by 2040 and possibly inadequate in-state renewables supply opens opportunity for imports from Canada, west.
- Large offshore wind development target requires related offshore grid build-out.
- Ongoing “de-bottlenecking” of upstate renewables for deliverability to downstate load centers.
- Retiring nuclear and other thermal generation and significant reliance on natural gas generation downstate creates fuel and energy availability risk.
- Resilience concerns, including extreme cold weather gas constraints for generation fuel, opens possible need for increased transmission capacity at interfaces – “gas by wire” from PJM, hydropower from Canada.

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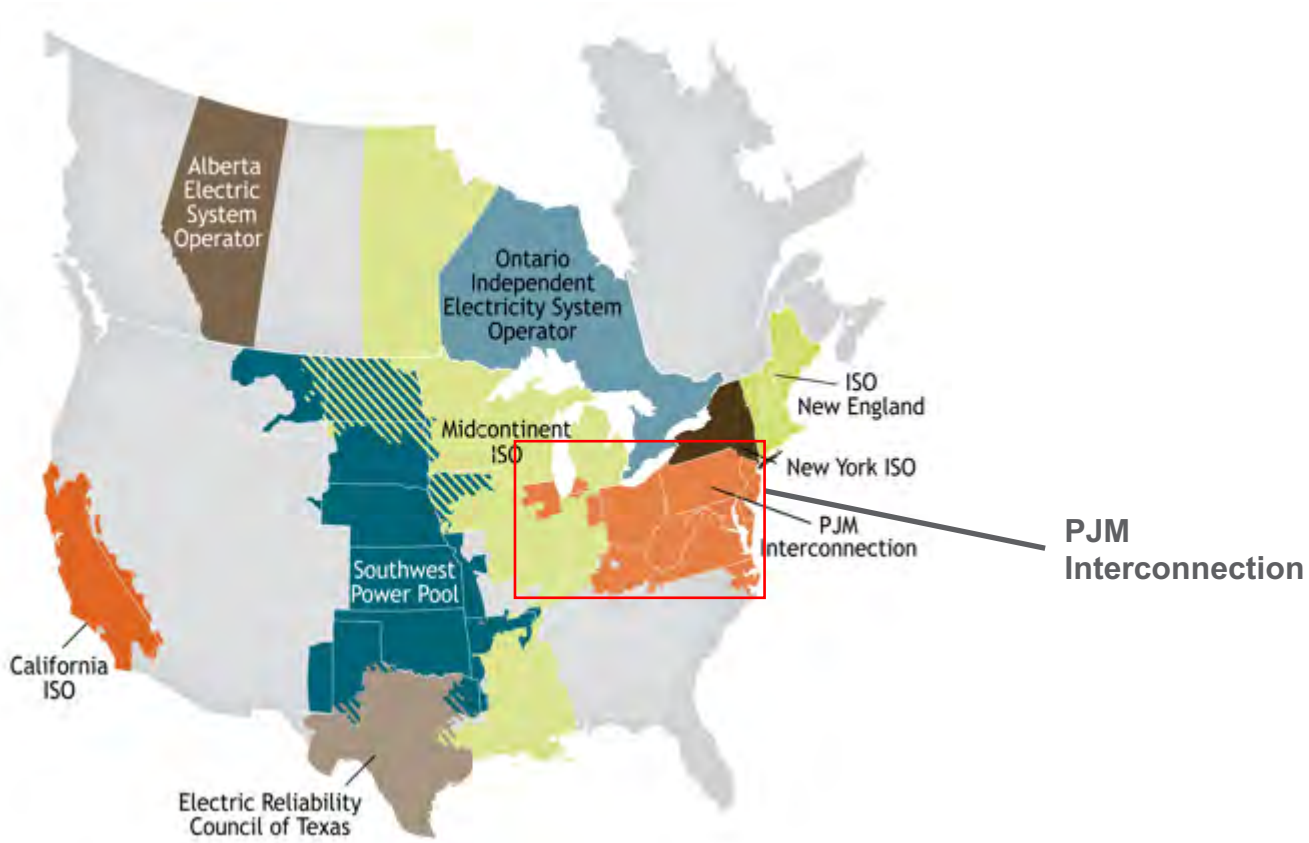
Regional Transmission Summary – PJM Interconnection



- Disparate clean energy goals among the states within the region has led to a contentious capacity market ruling by Federal Energy Regulatory Commission (FERC), issued in December 2019 and likely to generate more debate when PJM makes it compliance filing.
- New wind and gas generation development has driven interconnection needs in recent years, but new solar represents the majority of capacity currently in the queue.
- More renewable resources than policy demand in region, and more gas capacity than needed; opportunity for export.
- Transmission investment has trended toward more local and lower voltage “Supplemental Projects” recently, driven by asset performance, condition, and risk, as congestion in the region has been reduced.
- Retiring nuclear and other thermal generation and significant reliance on natural gas generation creates fuel and energy availability risk.
- Resilience concerns, including extreme cold weather gas constraints for generation fuel, opens possible need for increased capacity at interfaces with MISO and NYISO.
- Complications to expansion in region: Public policy differences among states, low to negative load growth expectation for the planning horizon.

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Regional Transmission Summary – Midcontinent ISO

- Diverse region with three distinct areas: wind-heavy west; thermal baseload-heavy central (with growing retirements); and gas-fired generation-heavy south.
- While wind development, especially in the west northwest of region is a big part of resource development, increasing amount of solar across region, potentially creating some different and more localized transmission needs.
- Significantly more renewable resources than policy demand in region; opportunity for export.
- Potential for targeted transmission needs in Midcontinent ISO (MISO) West as region contemplates potential for long-term “tipping point” of 30% to 40% wind penetration.
- Reducing congestion has been a goal, and multi-value projects completed since 2011 have lowered congestion and allowed for lower marginal cost wind greater market access and has removed need for $300M in baseline reliability upgrades.
- Market-to-market payments indicate potential for east-west interregional enhanced transfer capability with PJM and load centers to the east.
- Resilience challenges different within region, largely seasonal extreme weather; potential for transmission capacity between north and south to diversify resources, energy transfers during times of system stress.
- Potential for expansion of transfer capacity on north-south constraint between MISO North/Central and MISO South – off-peak wind moving south, low cost gas, solar power moving north.
- Complications to expansion in region: 2015 settlement agreement upon addition of MISO South; public policy differences between MISO South states and MISO North/Central states.

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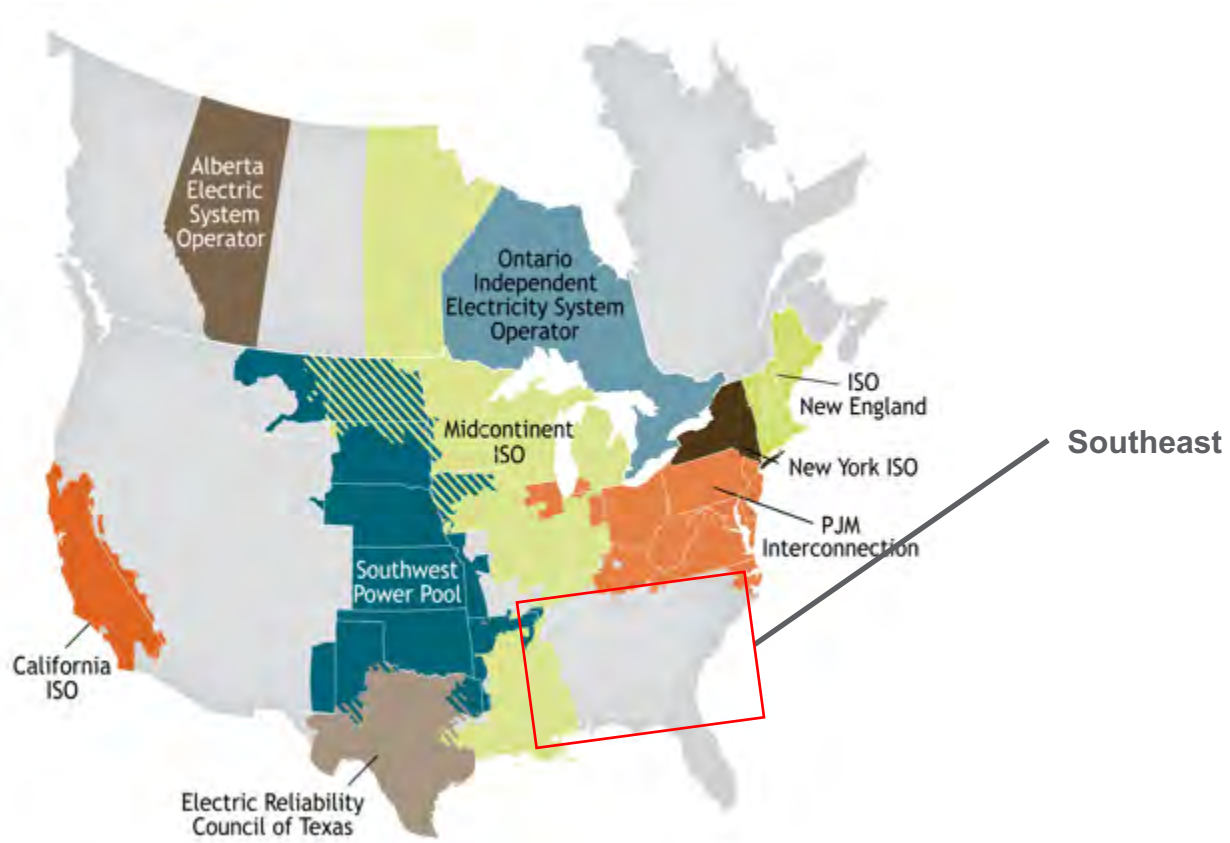
Regional Transmission Summary – Southeast



- Vertically integrated, rate-of-return market area, with generation and transmission considered mostly using traditional integrated resource planning – transmission "built to suit."
- Growing renewable resources in region (especially utility-scale solar), more than policy-generated demand in region, but still small in comparison to thermal resources, including growing gas-fired and new nuclear generation units.
- Long-term potential for offshore wind, but limited activity to date.
- Limited renewable integration issues to date; region is now studying potential impacts, including effect of increased solar in increasingly winter-peaking region.
- Some resilience challenges driven by tropical cyclones and ice storms; opportunity for grid hardening.
- Increasingly winter-peaking with exposure to extreme cold weather (cold snaps); increased gas dependence raises issues around single point of disruption (pipeline interruption or reduced gas availability).

Regional Transmission Summary – Southwest Power Pool

- "Tale of two grids" with high wind penetration in north and west approaching levels that typically cause integration issues, with population centers south and east.
- Large wind potential in region, in north and south, with large (51 GWs) interconnection queue, with growing interest in solar (28+ GWs in queue) in south.
- Significantly more renewable resources than policy demand in region; opportunity for export.
- The region has developed a high-voltage backbone, which has been well-utilized as renewable resources have come online.
- Potential west-to-east transmission for relief of "pinch points" in central Kansas/southwest Missouri to accommodate northeast-to-southwest Southwest Power Pool (SPP) flows.
- Potential for increased integration with Western Interconnection for broader footprint for renewable resource optimization; being tested with SPP's Western Energy Imbalance Service and reliability coordinator role.
- Potential for increased integration with MISO for west-to-east flows of increasing wind and solar resources to load centers, resilience support.

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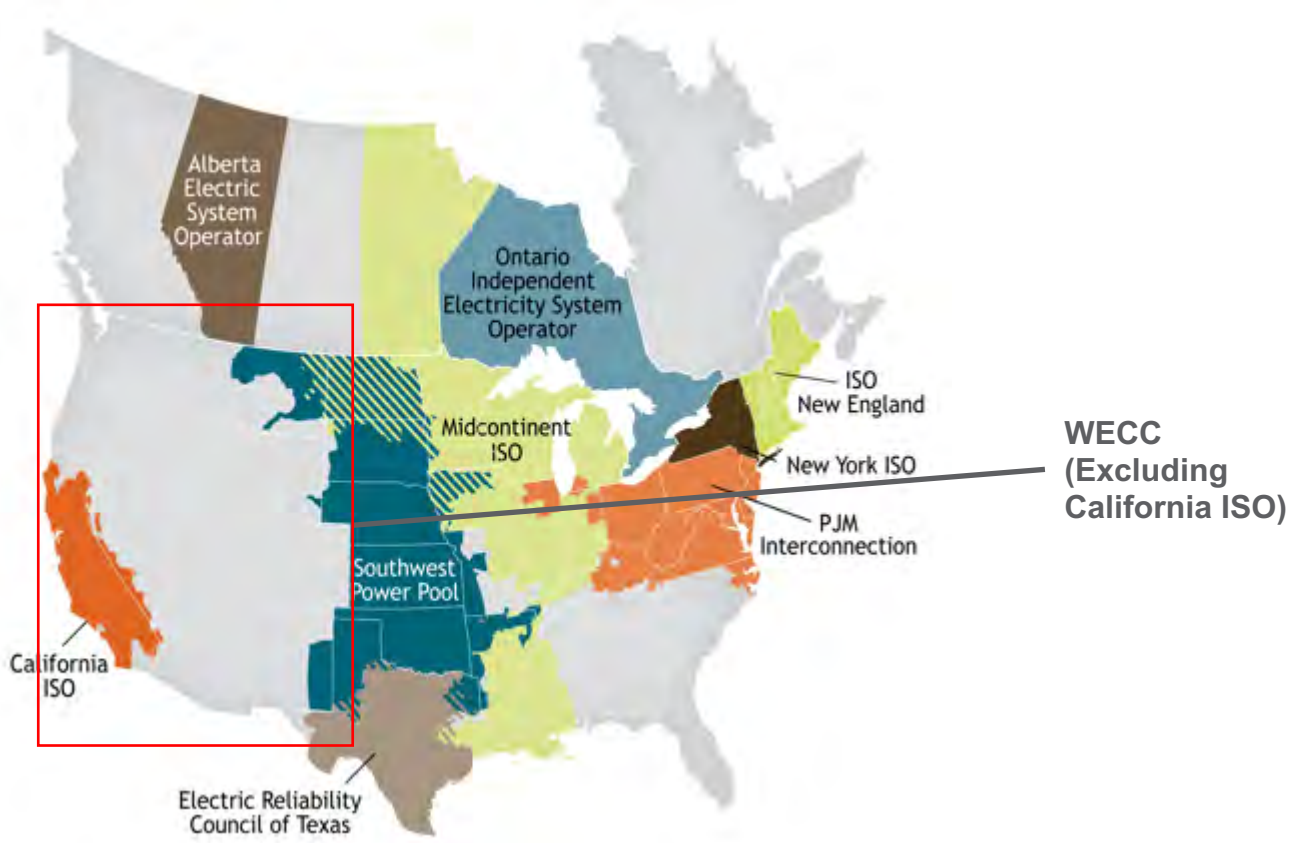
Regional Transmission Summary – Western U.S. (Excl. California ISO)



- Diverse and expansive region with varying climate and weather patterns, including access to some of the richest wind (east central portion) and solar (southern portion) resource areas in the United States; New Mexico and Wyoming are hot spots for wind development due to prevalence of low-cost and temporally uncorrelated wind, and the Southwest is seeing strong buildout of solar, including utility scale and DERs.
- Heterogeneity of state policies related to renewables creates challenges for multi-state backbone projects; Colorado, New Mexico, Nevada, Oregon, and Washington have targets of 50% or higher; Idaho and Wyoming have no standard.
- Abundant hydro resources in the Northwest could play a role in balancing increasing amounts of variable generation across the Western Interconnection if there is sufficient long-haul transmission capacity to other parts of the region.
- Majority of transmission projects in recent years have been executed within the four discrete planning areas in WECC*, though six interregional projects are currently being developed across seams.
- Opportunities to increase transfer capacity across seams with Canada, SPP, ERCOT**, and California ISO for broader footprint for renewable resource optimization, particularly to accommodate growing demand for renewables within California, as well as the need to reduce curtailments at times of excess generation within California.
- Developing long-distance, high-voltage transmission through remotely populated Western areas poses unique challenges: terrain, distance, and impacts on federal, native lands.

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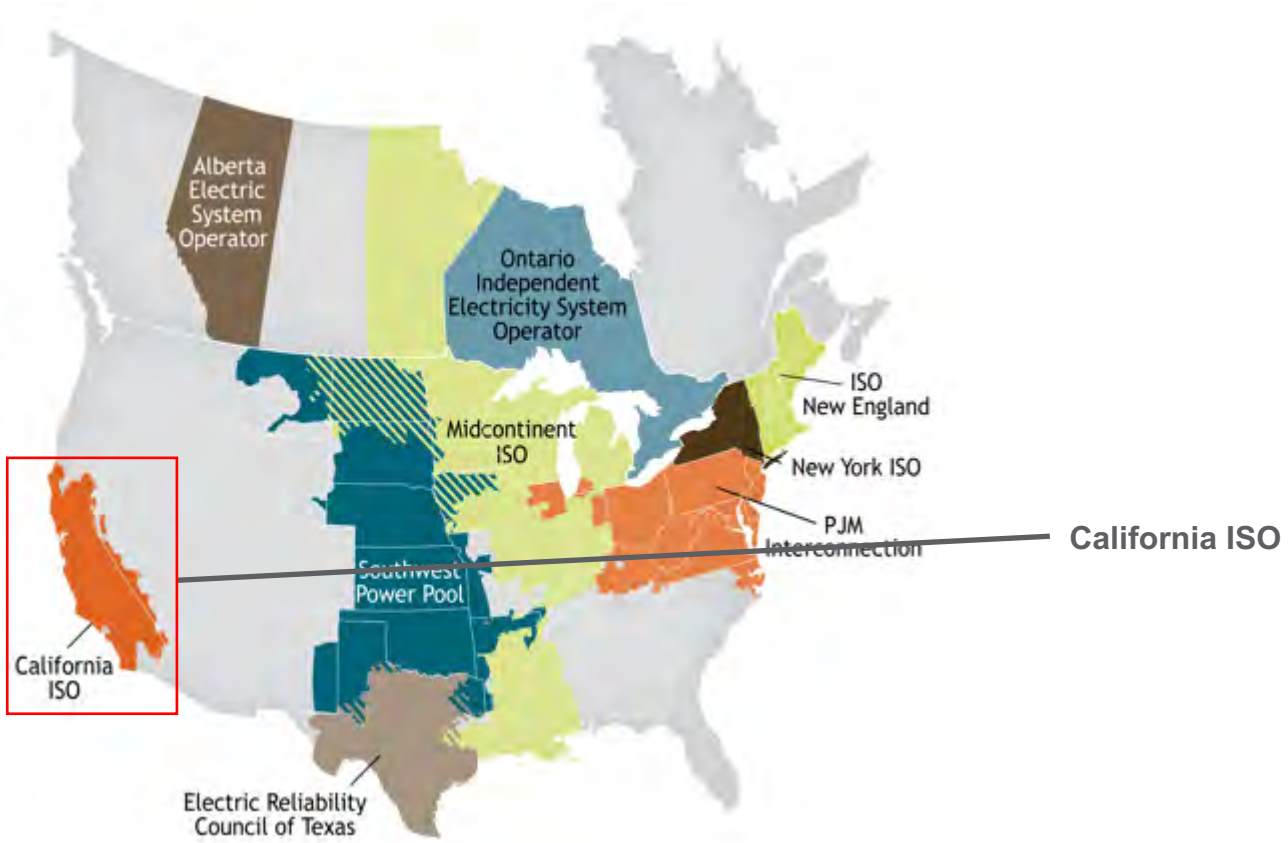
*Western Electric Coordinating Council
**Electric Reliability Council of Texas

Regional Transmission Summary – California ISO



- Ambitious clean energy goals: 50% by 2030 and potential for in-state demand to vastly exceed in-state renewables supply suggests opportunity for more imports from adjacent regions, particularly increasing transfer capacity with the Northwest.
- Increasing curtailments of in-state renewables at times of oversupply could create opportunities to move power to areas where it can be used.
- Expansion of the Western Energy Imbalance Market, which includes almost three-fourths of the load in the Western Interconnection, continues; introduction of a day-ahead market may create opportunities to streamline intraregional and interregional transmission planning.
- New wind and gas generation development has driven interconnection needs in recent years, but new solar represents the majority of capacity currently in the queue.
- Resilience concerns, including wildfires and gas-power interdependence, points to potential need for increased capacity at interfaces with other regions in WECC.
- Complications to expansion in region: Preference for non-wires alternatives, siting and permitting.

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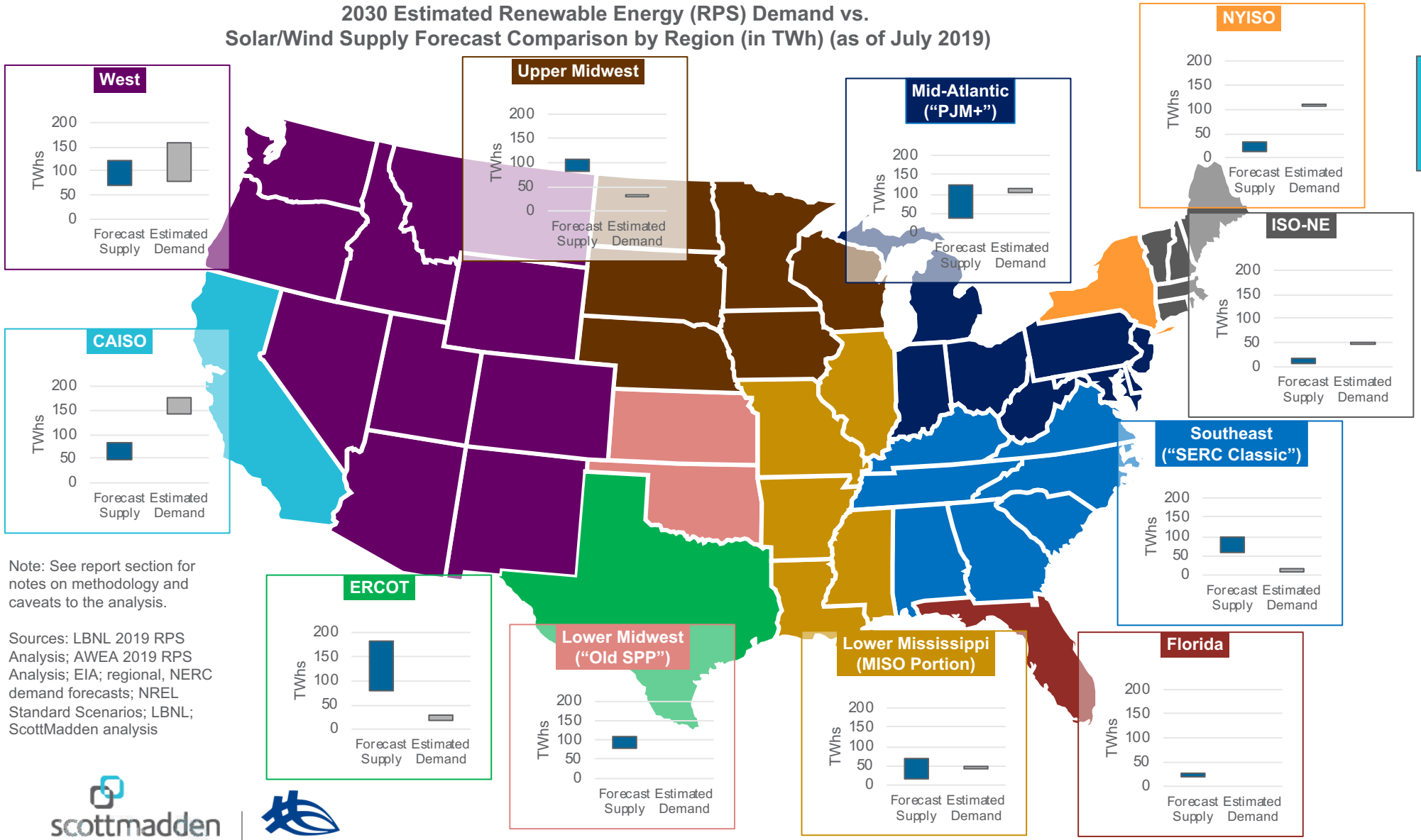
Interregional Considerations

- **Regional to interregional:** Generally, the regional view takes into account grid characteristics and resources. Policy across the country has evolved and been implemented based upon this regional view. However, as the need for integration of renewables and access to low cost energy resources grows, the need for interregional transmission is increasing. Renewables are not evenly distributed; they are concentrated in various regions which don't necessarily align with where the greatest needs are emerging.
- **Benefits of a larger grid footprint:** A larger grid footprint or balancing area provides advantages for both integration of all types of generation and resilience. A number of studies have pointed to the benefits of increased interregional transmission to accommodate higher penetrations of renewable resources:
  - A study of the Western Interconnection found that increasing balancing area coordination with more transmission connecting larger geographic areas helped diversify the variability of both load and resources and created cost savings due to increased reserve sharing.
  - A similar study of the Eastern Interconnection found that with increased (up to 30% with a significant portion being wind) renewable resources, greater levels of interconnection through transmission led to increased interregional power flows and illustrates that interregional transmission is one way to potentially reduce operational impacts of increasing RPS requirements.
  - More recently, the National Renewable Energy Laboratory has been conducting an Interconnection Seams Study, still to be completed. But it has identified opportunities for increased integration among the U.S. interconnections as providing opportunities for cost savings and possibly resilience, by bringing low cost resources, including remote renewables, to market.
- **Case studies:** Additional case studies point to benefits of interregional transmission capacity. The Western Energy Imbalance Market leverages excess transmission capacity to move excess midday solar energy from California to other areas of the West, as well as allowing for support for late-day ramping needs in California and elsewhere, leading to cost savings for all participants. Moreover, Europe has been expanding its transmission grid to aid in integrating hydro, offshore wind, and onshore wind as it seeks to meet European Union power sector emissions targets.
- **Renewable portfolio standard (RPS) supply vs. demand:** Finally, as RPS's become more ambitious and clean energy goals advance at the state and utility level, and renewables development is mixed and geographically diverse, RPS supply-demand "imbalances" are potential indicators of increased needs for import and export capability across regions

Interregional Considerations (Cont'd)

2030 Estimated Renewable Energy (RPS) Demand vs. Solar/Wind Supply Forecast Comparison by Region (in TWh) (as of July 2019)



Note: See report section for notes on methodology and caveats to the analysis.

Sources: LBNL 2019 RPS Analysis; AWEA 2019 RPS Analysis; EIA; regional, NERC demand forecasts; NREL Standard Scenarios; LBNL; ScottMadden analysis

2030 estimates
Clean energy demand (standards): 600 TWh (per LBNL) to 714 TWh (latter is ~17% of U.S. retail sales)

Key Takeaways

- As shown here, by 2030, many regions are projected to have adequate or excess renewable supply compared with "headline" clean energy demand.
- The West (including California), New England, and New York appear to have opportunities for additional supply, perhaps through imports from other regions.
- This analysis does not include corporate, utility, or state clean energy "goals" that do not have regulatory or legislative force; thus, additional potential regional demand for renewables may be higher.

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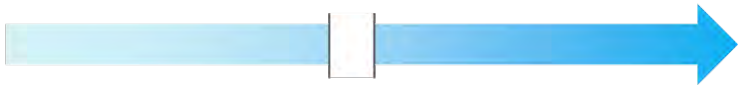
Resilience

- **FERC definition:** FERC defines resilience as the ability [of the electric system] to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such an event.
- **NERC's framework:** The North American Electric Reliability Corporation (NERC), the designated electric reliability organization, has proposed a framework envisions four elements, reflecting different parts of an event occurrence:
  - Robustness – the ability to absorb shocks and continue operating
  - Resourcefulness – the ability to detect and manage a crisis as it unfolds
  - Rapid Recovery – the ability to get services back as quickly as possible in a coordinated and controlled manner, taking into consideration the extent of the damage
  - Adaptability – the ability to incorporate lessons learned from past events to improve resilience
- **Regional variations:** Resilience issues vary between regions and even within large regions. Some resilience issues are common because they are global in nature. Many threats vary because of location and vulnerability of infrastructure, proximity to resources (including fuel), weather patterns, climatic trends, and seismic conditions. Many regions are concerned about extreme weather as reliability, and often termed as resilience, risks. In particular, extreme cold weather and its impact on an increasingly natural gas-dependent fleet as well as very high penetration of variable energy resources, are being studied.
- **Transmission as potentially enhancing resilience:** Transmission is a component of a more resilient system in providing access to reserves and energy during extreme conditions, leveraging weather diversity. Moreover, as facilities in an aging U.S. transmission system are replaced, they are being upgraded with capabilities that improve resilience, such as technologies for situational awareness and hardened structures.

Resilience vs. Reliability: Different Stakeholders, Cost-Bearers, Responsibilities, and Levels of Planning Maturity



Planning criteria	Well-established N-2 planning	Unspecified or incipient "black swan" planning
Scenarios considered	Stated contingencies	Unlikely/unknown contingencies beyond reliability planning
Primary focus	Prevention, protection, and risk mitigation	Critical infrastructure recovery; social stability
Potential value of event "insurance"	Estimable through system modeling	Difficult to ascertain; policy-driven
Costs borne by	Ratepayers	Taxpayers
Funded by	Utility capital expenditures	• Federal emergency funds • State infrastructure • Municipal, county government
First response responsibility	Utility	Government, community response
Stakeholder coordination	Utility, ISO led	Government led

There remains a planning gap between reliability and resilience. Transmission planners, operators, and owners continue to focus on reliability, including weather and fuel dependency, as those are most clearly actionable and related to electric infrastructure investment. Resilience has broader societal implications involving more stakeholders with government as a key facilitator. And its costs are more properly a societal decision. While transmission has an important role to play, it is only one piece of resilience preparation.

Sources: ScottMadden analysis; 2019 State of Reliability

Challenges

- **Siting and permitting:** The issues with siting and permitting across multiple jurisdictions have long been highlighted as challenges to building both intra- and interregional transmission.
- **Policy evolution needed:** The fact that transmission is needed across the country to support both reliability and integration of renewable resources is well-documented; the evolution of policy has not supported this basic understanding. Incentive policy, which drove significant investments through the 2000s is changing, and returns on equity and adders are being reduced.
- **Legacy of Order 1000:** Order 1000 interregional processes have not materialized to facilitate broader integration across markets. The same cost-allocation challenges, which we once discussed at the regional level, have now moved to the interregional level, identifying beneficiaries and allocating costs appropriately, particularly across regions with different methodologies is challenging.
- **Need for forcing function:** Until a forcing function requires these regions to develop a methodology that facilitates largely public policy projects, the hope of interregional transmission meeting national needs for transmission (to serve any purpose, let alone clean energy) will remain elusive.
  - State and local policy continues to stymie transmission development through siting and permitting processes that are poorly aligned.
  - Environmental interests stack up on both sides of the transmission development debate. Some organizations acknowledge the degree to which transmission is needed to facilitate renewables integration. Others focus on the environmental impacts of specific corridors, slowing or stopping permitting and construction. There is also a view that DERs can offset the need for central station (utility-scale) generation and transmission.
  - Economic development always points to local resources serving local load; states are focusing on in-state resources to meet RPS and clean energy targets, making the case for interregional collaboration more difficult.

What has changed in the last two years or so is the degree to which states, utilities, and other companies are committing to 100% carbon free portfolios. It is not possible to meet these goals without intraregional, and in some cases interregional, transmission connecting these resources to load.

Policy Implications

- **Targeted federal policy:** Significant transmission development followed the Energy Policy Act of 2005 and FERC incentives policy that followed; similar national policy could be beneficial in creating a framework for transmission development that would be supported by myriad stakeholders.
- **Fostering interregional transmission:** In the absence of a national framework, the following should be considered to spur interregional transmission development:
  - FERC should step forward and begin to assess more proactive approaches to creating the framework for interregional collaboration in light of company, state, and regional goals related to clean energy.
  - There is an opportunity to reconsider the current trend in transmission incentives if there is a desire to have companies undertake these large interregional projects.
  - Stakeholders focused on clean energy need to further articulate the critical role of transmission in facilitating company, state, and regional goals for clean energy.
  - As utilities (and others) put forward clean energy and carbon free goals, they should also highlight the role that transmission plays in facilitating this transition.
- **Education:** The network and other positive effects of transmission need to be more broadly understood and communicated.
- **Role of transmission:** As regions and states develop and communicate clean energy goals, they should work with the RTO/ISO to understand the degree to which these goals must be facilitated by transmission (both intra- and interregional).

There is the potential to align myriad stakeholders in support of transmission development. The benefits to these divergent groups need to be clearly communicated to garner support for this infrastructure.

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Structure of the Report

- This report is structured in sections.
  - Section 1 is this Executive Summary, which highlights key points of the report including a snapshot of the regions profiled herein.
  - Section 2, titled Industry Backdrop, describes four important trends in the electric industry in North America and how electric transmission plays a role or complements these trends.
  - Section 3, titled Regional Discussions, and further divided into regional subsections, provides an overview of the regions reviewed in this study (and summarized earlier in this executive summary) consisting of key statistics, a view of the region's transmission topography and investment, trends and drivers of renewables development, resilience issues, and a summary of issues for transmission in the region.
  - Section 4, titled Interregional Considerations, examines studies, case studies, and drivers for interregional transmission, considering grid needs driven by renewables supply and demand as well as resilience considerations.
  - Section 5, titled Resilience, examines non-region-specific resilience issues, including the industry's evolving resilience framework, selected events and how the grid enabled a robust response, and potential investment in grid capabilities to support resilience.
  - Section 6, titled Challenges and Policy Implications, looks at some of the issues regarding interregional planning, cost allocation, resilience planning, and local siting and permitting of transmission, and considerations for policymakers and stakeholders.

Notes and Acknowledgments

Notes

- This report uses publicly available sources and is dependent upon accuracy and completeness of these resources. Data and information provided in this report is valid to the best of our knowledge as of October 2019.
- The energy industry, and the power transmission sector in particular, is a dynamic, changing business, legal, and regulatory environment. Any changes and developments, including commission or agency findings and decisions, updated planning documents, and other resources relied upon herein occurring or released after October 2019 are not necessarily reflected in this report.

Acknowledgments

- The report was informed by input from WIRES member organization representatives. We extend our thanks to the WIRES Group, its members, and in particular the working group that was engaged in discussing and reviewing this report. Their assistance and insights, particularly into (but not limited to) regional dynamics, were invaluable. Errors and omissions in this report are ours alone.