Eastern Interconnection Planning Collaborative

# Planning the Grid for a Renewable Future

# Summary

The Eastern Interconnection Planning Collaborative (EIPC) and its member systems, through extensive study and discussion, identified challenges and recommendations that local, state and federal policymakers should consider when making decisions or taking actions that affect the transmission grid in light of a significant increase in the development of renewable generation.

Key challenges and recommendations outlined in this Report include:

**Increasing Challenges for System Operators and Planners**

- Wind and solar resources introduce new dynamics for grid operations and planning due to different technology and weather-dependency of these resources as compared to traditional generation; these differences need to be recognized, understood and addressed.
- Resource adequacy risks are shifting beyond only peak load periods, which will necessitate more detailed modeling and integrated resource planning.
- The transmission system's peak use times are shifting to non-traditional periods, and the system must maintain reliable delivery of electricity to consumers using solar and wind resources whose output is variable.
- Additional transmission infrastructure is needed to cost-effectively and reliably meet increased demands for electrification of the transportation and industrial sectors as well as significant wind and solar integration.

**Identified Needs/Recommendations for Policymakers**

- Enhanced education and collaboration between the utility industry, policymakers and regulators
- Increased focus by power system planners and engineers on the unique complexities of integrating wind and solar resources while maintaining grid reliability
- Transmission sufficient to reliably and cost-effectively integrate increasing levels of new local and remote renewable wind and solar resources
- Enhanced regional and interregional coordination to address aggressive public policy energy-related goals
- Collaboration among the electric industry, policymakers and regulators to ensure that future initiatives are achievable in a timely, cost effective and reliable way
- A seat at the policymaking table for power system operators and planners to articulate the system reliability needs and how they are changing, so that public policy has built-in processes to account for these needs

The EIPC is a first-of-its-kind collaborative made up of the major U.S.-based transmission planning coordinators responsible for the planning of the bulk power grid throughout the Eastern Interconnection. Given the size of the Eastern Interconnection (representing approximately two-thirds of the United States and Canada) and the significant diversity within the interconnection, the insights among the planning coordinators through this effort provide a robust view on the lessons learned in planning the transmission grid to support high-renewable systems.

The energy transition is well underway, and the electric industry has already implemented many lessons learned adapting to that change. Renewable wind and solar resources are rapidly growing throughout the Eastern Interconnection, as seen in Figure 1 below. While this growth is taking place in one form or another across the entire broad Eastern Interconnection footprint, it is not uniform in either the rate of adoption or technology type. This non-uniformity produces unique insights from different companies on their changing needs with more wind and/or solar resources entering their systems and how they foresee the future challenges as this growth continues.

This white paper focuses on the lessons learned through historical experience and studies of future conditions as they relate to the planning and operations of systems with a high penetration of renewables.

The EIPC believes that policymakers should be aware of both the opportunities and challenges of integrating greater amounts of renewables onto the grid. This understanding would assist policymakers, working with the electric industry and end-users, in developing holistic policies that ensure a transition in the generation fleet that maintains the reliability, efficiency and affordability of electricity.

There is no shortage of available literature presenting the opportunities provided by higher levels of renewable energy production. This EIPC paper seeks to better explain some of the challenges being experienced by those organizations with the responsibility to plan and operate the Eastern Interconnection power system. These challenges should not surprise industry leaders, as discussion of these topics has taken place in various working groups (made up of electric companies, academia, software developers, Department of Energy laboratories and other industry personnel) across the different interconnections in North America.

The challenges described below are not insurmountable, nor should they serve as a barrier to the movement toward a grid made up of environmentally cleaner resources. Nevertheless, grid operators and planners need to be more engaged in the discussions to ensure continued delivery of reliable, efficient and affordable electricity during a transition to high-renewable penetration levels.

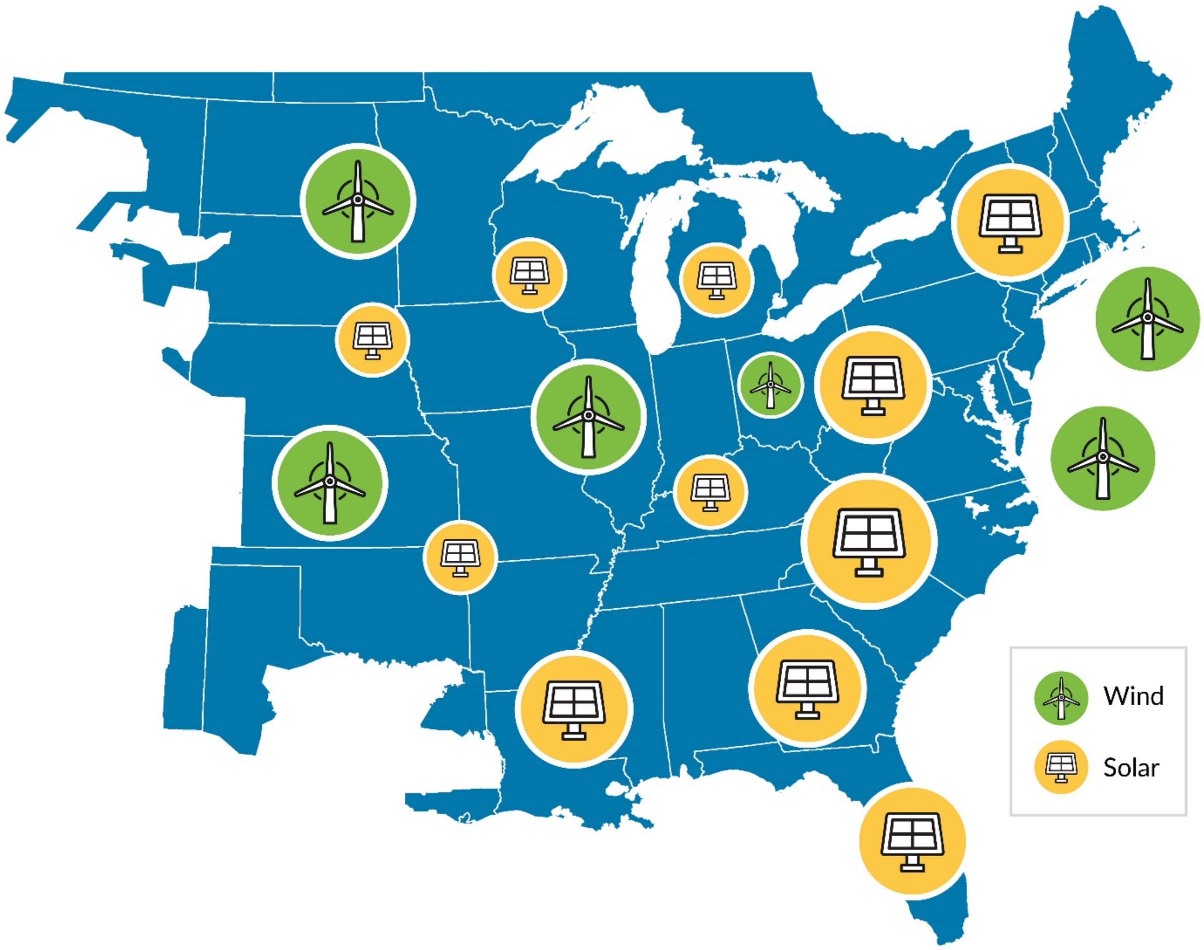


**Figure 1: Representative Renewable Growth Based on EIPC Member-Provided Data**

Each area of the Eastern Interconnection is enhancing its use of renewable generation as indicated in Figure 1:

- The Northeast region, with limited available land, sees proposals for offshore wind resources built near population centers, high-voltage direct current (HVDC) transmission potentially bringing additional hydro power from Canada, and more solar from distributed resources than from utility-scale facilities.
- The South and Southeast regions, with more limited wind resources, are realizing their solar potential with a future eye on possible low-speed and offshore wind.
- The Central Plains region, with high wind speeds, has driven large amounts of wind development, with expansion of additional wind resources moving forward aggressively.
- The Great Lakes region currently plans for a mix of solar and wind development.

## Challenges Experienced by System Planners and Operators

To enhance the policy discussion, the EIPC outlines three general challenges to renewable development informed from lessons learned by planners and operators throughout the Eastern Interconnection.

**Planning Transmission Necessary to Achieve High-Renewable Penetration** — System planners are increasingly challenged due to the rapidly changing resource mix. For one, planners have traditionally relied on the continued use of legacy synchronous generators, which were historically supported by strong transmission networks built to transmit power from these resources to load centers.

By contrast, renewable resources are optimally located to make the best use of wind or solar availability but are not necessarily located near existing transmission infrastructure. In some parts of the Eastern Interconnection, these resources — existing and planned — are clustered in areas that are remote from load centers and interconnect to the grid at locations at the extremities of today's grid. While well-planned transmission can lower the total cost to customers of renewable energy, integrating these resources onto the transmission grid properly may require transmission upgrades and/or non-traditional assessments, such as electromagnetic transient (EMT) studies.[1]

Studies have indicated a decline in grid performance for steady-state thermal loadings, voltage stability and transient stability when inverter-based renewable resources displace synchronous machines. The degradation in performance is due to a number of factors, including the loss of, or change in, location of reactive power resources, the lack of transmission facilities to transmit the energy to load, and/or the reduction in primary frequency response due to the loss of system inertia from the retirement of legacy synchronous generation.

As renewable technology evolves, inverter-based solar and wind resource design will need to be able to support system voltage and assist with primary frequency response due to system events (e.g., faults, generation trips). In addition, regulatory support is needed to ensure wide implementation of the appropriate control systems for such renewable resources.

The industry is also seeing changes in load composition due to the installation of home backup generators, home chargers for electric vehicles, the conversion of gas and oil heating to ground-/air-source heat pumps, the increased penetration of rooftop solar arrays, and whole-building battery backups.

These new loads and behind-the-meter resources are changing existing load patterns. They can be beneficial but do require more sophisticated modeling. As with operations, system planners must have adequate visibility into the locations and level of penetration of distributed energy resources so that the impact on the bulk system can be accurately modeled and controlled.

Another issue that has developed over the last few years deals with distributed energy resources and their impact on grid operations during system events. Due to existing interconnection standards at the time of installation, some distributed energy resources perform differently than other grid resources and trip offline before transmission-level resources, which can exacerbate outages or other grid disturbances.

[1] Planners study electromagnetic transients (EMT) to determine the impact of various interruptions on the transmission system, such as those caused by lightning and system faults.

Industry standards recently were updated to mitigate this issue, but state utility commissions must adopt the new requirements if they are to be effective.

The number of potential renewable projects seeking to connect to the power system has increased exponentially over the last 10 years. This has made studies more complex due to the large number of individual projects to be studied. The interconnection queues have been further burdened by the reality that only a portion of projects entering the interconnection queues eventually move toward project completion. Projects dropping out along the way trigger restudies to assess impacts of the remaining projects and the respective allocation of upgrade costs assigned to those interconnecting generators.

Currently, the lack of standardized performance requirements for renewable resources with inverter-based control systems has been the cause of significant delays in the interconnection study queues of system planners across the Eastern Interconnection due to the large variety and rapid change in designs. To address this issue, there must be transparency of the control systems by the designers and vendors, so that they can be validated by the resource owners and system planners to ensure system reliability.

Due to the nature of these system planning challenges, the process to integrate a renewable resource into the grid can take a significant amount of time. Balanced reforms to the interconnection processes are needed to address these challenges. There is also the potential that a renewable resource generation facility may be built before the transmission facilities necessary to support its operation which also drives the need for process reforms.

**Operating the System Reliably and Efficiently** — Operating the power system is becoming more challenging due to (a) limited availability of transmission, (b) the need for system operators to maintain the proper mix of generation resources to accommodate the variability of renewable resources, and (c) load and resource uncertainty based on weather conditions. System operators must carefully manage the impacts of renewable resources ramping up and down due to wind or solar variability, with a limited amount of flexible generation resources quickly available to follow these variations to maintain system reliability.

Monitoring and correcting for grid stability requires real-time assessments that are becoming more complex with the need — in real time — to study many more contingencies to determine adequate reserve requirements. Today, most distributed energy resources such as roof-top solar panels are not electrically visible to the system operator. In the future, these resources could serve as a valuable tool to help manage localized grid stability issues. Close coordination between transmission and distribution system operators will be essential to ensure system reliability and to achieve the potential value of these resources for consumers and for the grid as a whole.

The energy markets face future challenges in determining how to most effectively provide certain ancillary reliability services such as generator ramping, voltage support, reactive power, frequency response and system inertia. In the past, these ancillary services have been supplied by legacy synchronous resources either at no cost or through regulated rates. As resources become more diversified, the reliable and efficient delivery of electricity will require the development of additional market products to properly incentivize those ancillary services the grid needs. Additionally, falling marginal energy prices due to the increase in renewable resources has already put pressure on existing resources that rely on energy or capacity revenues to remain operational.

The capacity of and energy produced by renewable resources varies a great deal across North America and is highly dependent on the geographic location and type of resource. This makes it difficult to align the availability of renewable resources to the times when they are needed. New methodologies are being implemented and developed to accredit resources in line with their availability, and additional transmission is being developed to connect diverse renewable areas together; however, more change is still needed. In addition, flexibility (dispatchability) of all resource types will be necessary to ensure reliable integration of increasing levels of renewables and the continued reliability of the Bulk Power System. Pairing storage devices with new wind and solar resources can increase their effectiveness and add value to the reliability and efficiency of the bulk system, but these hybrid resources will require additional technological development to ensure that their capacity value is properly recognized.

**Learning to Plan and Operate Differently** — Planning and operating a rapidly changing grid requires time to learn, collaborate and share experiences. The industry participants and stakeholders (developers, resource owners, planners, operators, regulators, policymakers and consumers) each have unique perspectives, which all need to be recognized and discussed, so that policies, processes and procedures can move forward in unison to achieve the goals of a restructured electric energy system.

The retirement of key personnel with deep industry experience impacts engineering, operations and regulatory activities. It takes time and resources to develop personnel who can step into the role of someone with years of experience. Today's transmission planners are familiar with control systems for legacy synchronous generation and how they behave to support system reliability. Inverter-based resources are a new and quickly evolving technology, so planners and operators need to develop a better understanding of the wide variety of control schemes these resources employ in order to ensure continued reliability in the future.

# Recommendations for Policymakers

The EIPC outlined above some of the many challenges faced by its members in order to provide policymakers with a sense of the number and types of challenges associated with the integration of increased renewables driven by state and federal policies. The EIPC does not consider these challenges insurmountable, nor do they argue against moving forward with policies supporting renewables. However, the EIPC does believe that when policymakers craft timelines, goals and deadlines, it is essential for policymakers to consider and balance the need to ensure that the power grid can remain reliable.

The Eastern Interconnection is a single, interconnected grid with power flows constantly occurring both among neighbors and within individual systems, across the states and international borders. Unlike other types of interstate markets, the electricity market must maintain a perfect supply and demand balance at all times. Different jurisdictions have a long history of mutual support, but as wind and solar resources grow, the broader grid becomes more interdependent and will demand enhanced collaboration among all parties.

It is now harder for policies in one jurisdiction to be walled off from policies in another. This growing interdependence requires sufficient time for system planners and operators to conduct the necessary analyses to determine and implement appropriate adaptations to recognize the changing nature of the fleet. Accordingly, the EIPC offers the following three recommendations:

**Enhance Policy Coordination Across the "Three-Legged Stool" of Planning, Cost Allocation and Siting** — Enhancing planning alone will do little to manifest the significant transmission needed to achieve a high-renewable future unless policymakers also deal with the issues of:

- Who pays for the new transmission (referring to the allocation of the costs of the project among different customers), and
- Challenges in siting new transmission, including issues of property rights, land use, and environmental and social justice.

Current processes exist to allocate costs and site transmission, but as the amount, size and complexity of new transmission infrastructure grows, those processes are increasingly being challenged in some regions. Siting issues have often caused otherwise beneficial projects to fail before they are built. The cost allocation issue is one that definitely requires close coordination between the Federal Energy Regulatory Commission (FERC) and state Public Service Commissions or Public Utility Commissions (PSC/PUCs) as FERC has jurisdiction over wholesale transmission rates while the PSC/PUCs are responsible for bundled retail rates. The siting issue is one that is primarily within the authority of states and, in some cases, local authorities, except on federal and tribal lands.

As policymakers consider future initiatives to develop renewables or advance other policies, they must recognize the need for additional transmission investment to ensure that new generation can actually deliver electricity to customers. Transmission doesn't simply develop overnight, however, and it can take more than a decade for large projects to move from initial identification of need to actual operation. Without close coordination on cost allocation and siting issues, the best policies could easily flounder. Moreover, resolution of these issues requires both an understanding of the impacts of various transmission projects and effective communication with the various affected stakeholders

**Establish a System of Monitoring and Course Correction as Events Unfold** — The EIPC recommends that any policy initiative clearly provides regulators, the industry and stakeholders the opportunity to both monitor and correct course in a timely fashion if a particular path is leading to unnecessarily higher costs, limited choice for customers or negative reliability impacts. System planners and grid operators are available to provide the ongoing monitoring and identification of emerging issues that may trigger discussion of possible course corrections.

Grid dynamics, as well as emerging technologies, continue to evolve. For example, the costs of renewable technologies have declined significantly while new, promising technologies can enhance the throughput on both existing and new transmission lines. By contrast, the legislative process does not allow for a rapid response to changing markets and emergence of new technologies.

Regulators could consider a "Reliability Safety Valve" mechanism in any future legislation. The purpose of the Reliability Safety Valve is to recognize that any timeline embodied in statutes or regulations can potentially create unintended consequences that could impact the reliability of the bulk power system. The intent of the "timeout" to address an identified reliability problem isn't to block progress on the intended policy objective. Rather, it is designed to ensure a limited surgical opportunity to address particular reliability issues that may arise either during the regulatory process in developing a final rule or during its implementation.

**Enhance Collaboration** — Past experience has many good examples of cooperation to ensure that public policy and the physics of the power system work harmoniously together. As the pace of change continues to accelerate, it is more important than ever to work more proactively together. The EIPC recommends that policymakers considering renewable portfolio standards, carbon dioxide standards, or other similar energy-related goals take the affirmative step of inviting system planners and operators to provide input — in a clear and explainable form — as to the full-range of planning and operational challenges, costs and trade-offs associated with the proposed set of standards. Understanding the full range of implications can be extremely challenging which sometimes more high-level analyses used in the legislative process can overlook.

System planners should recognize the policymaker's role in establishing a clear direction, while assisting policymakers in a thorough, clear and understandable way to ensure that their decisions are informed by reliable, unbiased information from those planners and system operators who must ultimately carry out the policy directives. Resulting decisions should create a system that is, at all times reliable, efficient and meeting the needs of customers. Policymakers should affirm the assurance of grid reliability as reliability challenges evolve. New technology presents new opportunities and challenges. Reliability standards and detailed planning and verification are needed to safeguard, monitor and correct for reliability shortcomings.

An example of good, enhanced consultation is the proactive implementation of IEEE 1547,[2] in which state regulators helped codify new standards in advance of the formal implementation date to safeguard system reliability to known risks presented by DER.

[2] IEEE 1547-2018 is the Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces.

The EIPC encourages policymakers to be aware of the tools available to planners to analyze the impact of decisions made on both imports and exports of renewables, and to identify needed transmission builds and other changes to meet the policy objectives under consideration. These tools help bring the policy discussions and the physics of the grid together to ensure the reliability of the power system and to meet public policy objectives.

The members of the EIPC look forward to working with policymakers at the state, provincial and federal levels and pledge to serve as a resource to stakeholders as the evolution of the grid moves forward.

# About the EIPC

Formed under an agreement by 19 planning coordinators from the Eastern and Central U.S., the EIPC provides a forum for interconnection-wide coordination of system planning activities of its member regions in the Eastern Interconnection while also providing policymakers and regulators with relevant, complete and technically sound information.

**The EIPC membership includes:**

Associated Electric Cooperative Inc.

Cube Hydro Carolinas LLC

Dominion Energy South Carolina Inc.

Duke Energy Carolinas
Duke Energy Florida
Duke Energy Progress

Florida Power & Light Co.

Georgia Transmission Corp. (An Electric Membership Corporation)

ISO New England Inc.

Louisville Gas & Electric Company and Kentucky Utilities Company

Midcontinent Independent System Operator (MISO)

Municipal Electric Authority of Georgia

New York Independent System Operator Inc.

PJM Interconnection

PowerSouth Energy Cooperative

South Carolina Public Service Authority (Santee Cooper)

Southern Company Services Inc., as agent for Alabama Power Co., Georgia Power Co. and Mississippi Power Co.

Southwest Power Pool Inc.

Tennessee Valley Authority