

Regional Transmission Expansion Planning: Planning the Future of the Grid, Today

PJM plans the transmission system 15 years in advance, anticipating tomorrow's electricity needs for 13 states and Washington, D.C.



WORKING TO PERFECT THE FLOW OF ENERGY

The Regional Transmission Expansion Plan in Action

PJM's RTEP process ensures that the transmission system continues to deliver power reliably and economically far into the future. This region-wide planning approach gives us the opportunity to rely on economies of scale, leading to more efficient and cost-effective transmission planning and construction.

Reliability: Keeping the Lights On

PJM's core mission is reliability. The RTEP process and the system enhancements arising out of it serve that mission through:

- Reduced emergency procedures and alerts
- Increased operating margins
- Less need for remedial action schemes
- Improved interchange with neighboring grid systems

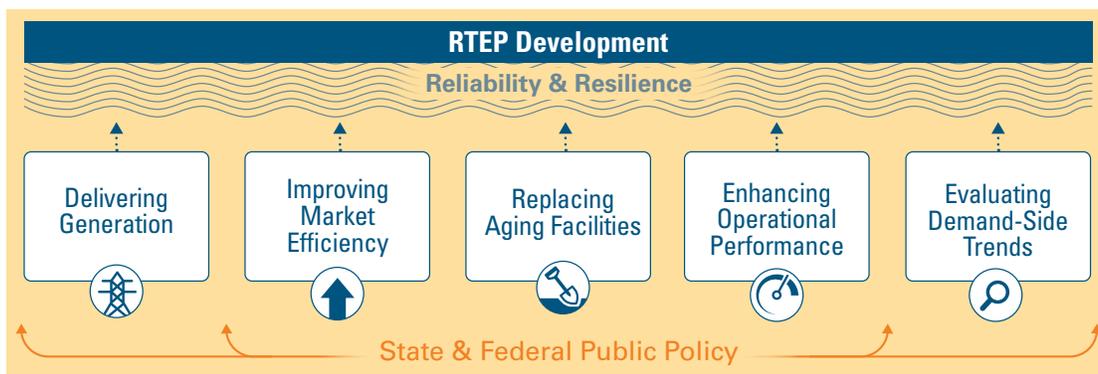
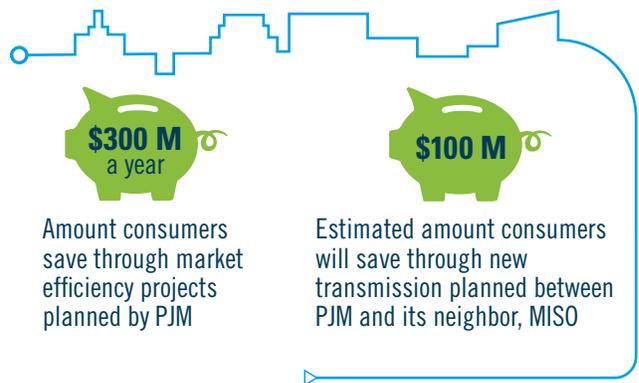
Diversity Enables Energy and Capacity Savings

Hundreds of transmission connections within the PJM region and with neighboring systems mean consumers in PJM receive the benefits from regional power markets and diversity in generation and load. In this case, diversity means different areas experience high customer demand at different times, so power from a zone with excess generation can be transmitted to places that need it more.

Reduce Congestion, Save Consumers Money

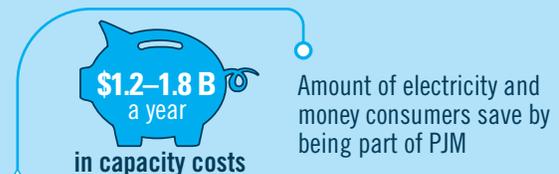
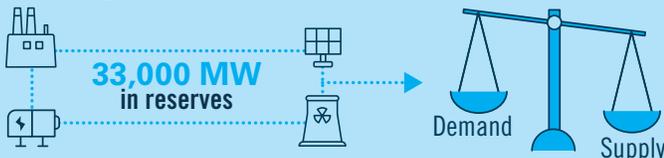
Congestion causes wholesale power prices to vary within PJM. It is caused by transmission system limitations that prevent the lowest-cost power from reaching all customers. PJM authorizes market efficiency projects to reduce congestion and ensure access to lower-cost power.

Getting Cheaper Power to Everyone



The RTEP process begins 15 years in advance to ensure we're planning for the future of the grid today.

Diversity Saves Money

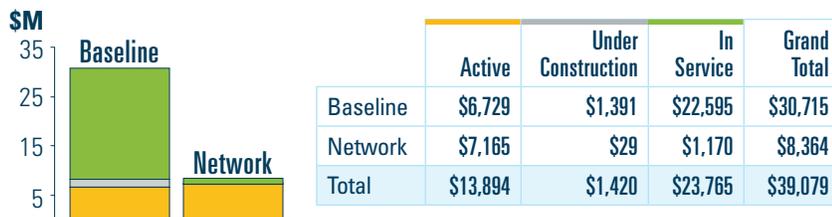


How the RTEP Process Works

Step 1: Identify Project Need

We identify transmission projects that will be needed to serve customers in the future. As part of that process, we ensure that the transmission system complies with national and regional reliability criteria to prevent overloaded facilities and potential blackouts. Many interrelated drivers go into identifying project needs.

Approved RTEP Projects (1999–2018)



What Kinds of Analysis Does PJM Do to Identify RTEP Projects?

RTEP analyses incorporate the latest information available on:

- Load forecast
- Demand resources
- Generating resources
- Bilateral transactions
- Transmission topology

PJM incorporates deliverability tests (simulating stressed, emergency grid conditions) to ensure power can be delivered when it is most needed, such as when local generation cannot meet customer demand.

What Are the Different Kinds of RTEP Projects?

The RTEP contains three types of transmission projects:

Baseline projects. These ensure compliance with national and regional reliability standards. These projects are identified to fix issues like overloads, bus voltage drops, excessive short circuit current, generator stability and congestion issues.

Network projects. These projects are identified to help new generation resources connect to the grid reliably.

Supplemental projects.

Supplemental projects are identified and developed by transmission owners to address local reliability needs, including customer service and load growth, equipment material condition, operational performance and risk, and infrastructure resilience. PJM reviews them to evaluate their impact on the regional transmission system.

Step 2: Develop Transmission Solution

After PJM identifies a baseline (including market efficiency) transmission need, PJM may open a competitive proposal window, depending on the required in-service date, voltage level and scope of likely projects. Throughout each RTEP window, developers can submit project proposals to address one or more needs. When a window closes, PJM evaluates each proposal to determine if any meet all of our project requirements. If so, PJM then recommends a proposal to the PJM Board. Once the Board approves a proposal, the designated developer becomes responsible for project construction, ownership, operation, maintenance and financing.

PJM identifies the affected parties who bear the responsibility for network system projects that permit the interconnection of new generation and other new transmission services.

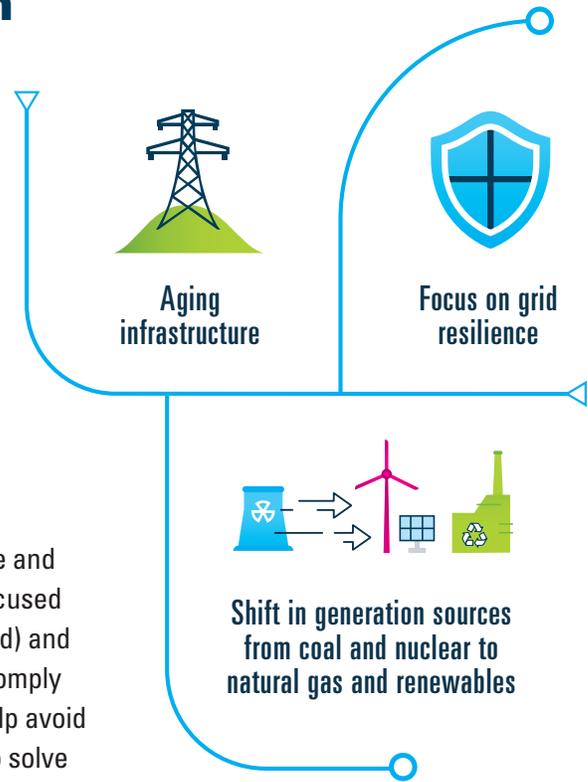
Supplemental projects are exceptions to this process. Transmission owners develop these projects themselves to address local reliability needs and are responsible for building them.



PJM's planning process evaluates the need for transmission enhancement based on the generation, DR, DER and other resources that already exist or are in the queue. Investment in new resources by developers is incentivized by market forces and public policy.

RTEP Helps the Transmission System Adapt to Change

The dynamics driving transmission expansion have been shifting rapidly. New large-scale transmission projects (345 kV and above) have become more rare as RTO load growth has fallen below one-half of a percent. Three main factors are driving new system enhancements: aging infrastructure, grid resilience and the shift in generation resources.

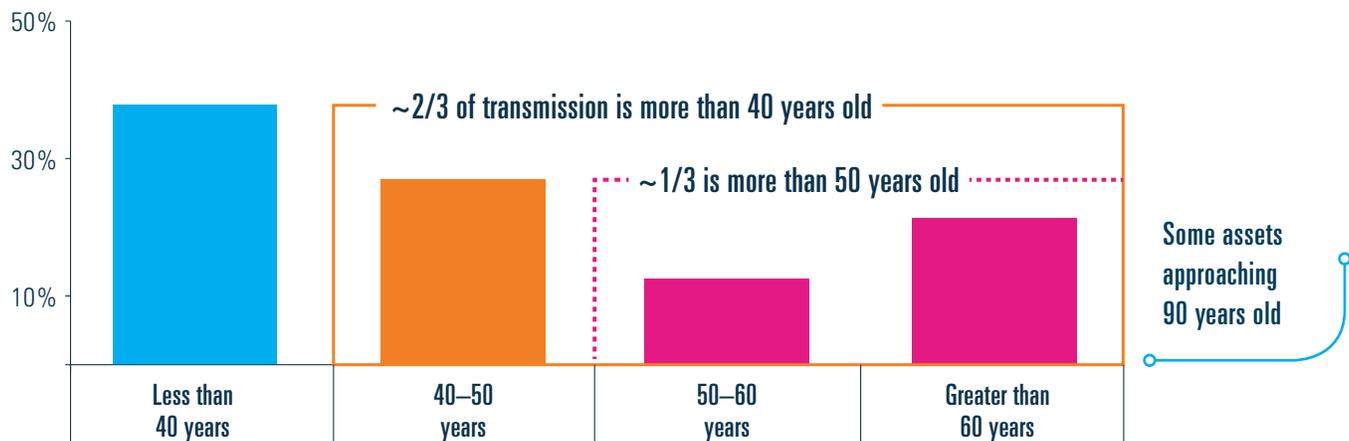


Aging Infrastructure

These days, instead of expanding the grid to accommodate more and more customer demand, transmission investment tends to be focused on replacing aging infrastructure (some approaching 90 years old) and upgrades to ensure reliability, improve transfer capability, and comply with local load-serving criteria. These system enhancements help avoid equipment failure and blackouts, and often, projects identified to solve one issue help address other system needs as well.

Aging Infrastructure in PJM

Facilities in PJM



Identifying improvements for safer, more reliable power



Increased power-flow capability. New lines and transformers, existing line reconductoring and bus reconfigurations

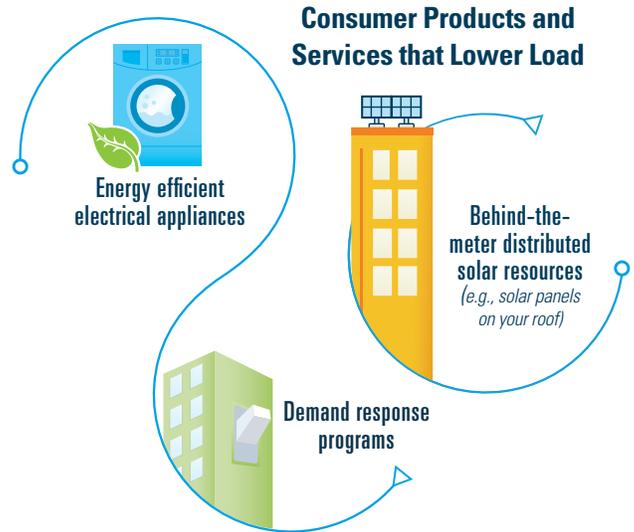
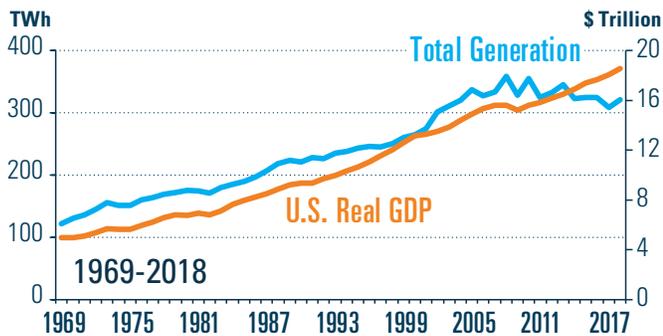


Voltage control and generating unit stability. New devices like shunt capacitors and static VAR compensators



Safe transmission line operation. New substation equipment like circuit breakers, switches, relay protection and control equipment and instrumentation

Mid-Atlantic Region Energy and U.S. Gross Domestic Product



Flat Consumer Demand

Consumer demand for electricity or “load” is no longer growing. In some places, like the Mid-Atlantic, it’s been declining for the last decade.

For many years, economic growth and load growth were connected, but they began to decouple in 2010. Economic drivers of load growth (gross domestic product, for example) are being offset by other factors (e.g., energy efficiency, demand response and behind-the-meter resources).

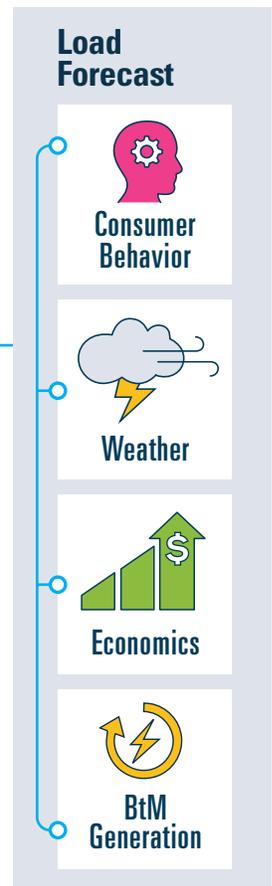
Predicting Load in a Time of Change

As consumer demand changes, accurately forecasting load becomes even more important to ensure the RTEP process yields a future of reliable and cost-effective grid operations.

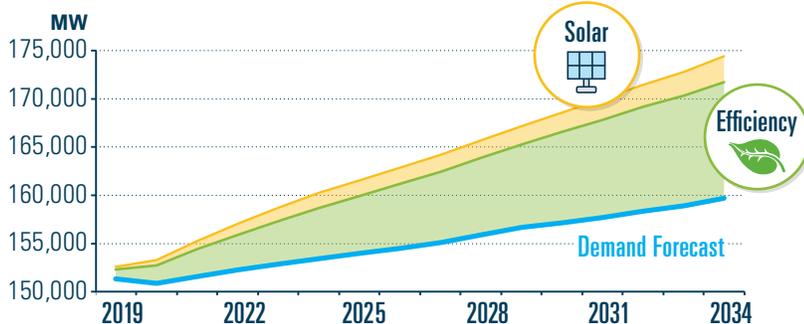
PJM considers a variety of factors to formulate expectations for future electricity demand. Our models directly reflect consumer behavior, weather, economics and behind-the-meter generation – including distributed rooftop solar – as well as the influence of energy efficiency and demand response programs.

Growth of Behind-the-Meter (BtM) Solar
4,500 MW
of distributed solar generation currently in service

95%
has been added since 2010.



PJM Summer Peak Demand Forecast



Transmission Makes Markets Possible

In 2018 Alone:

184,000 MW of connected generation delivered power

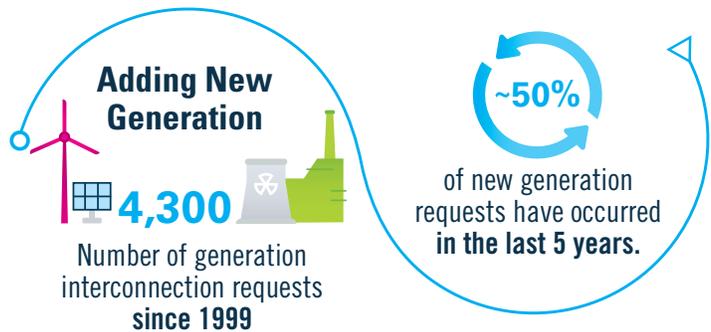
84,200+ miles of transmission lines planned by PJM

806,546 GWh of energy used by customers inside and outside of PJM

\$ **\$49.8 billion** bought and sold in PJM’s wholesale markets

More About How RTEP Enables Smooth Generation Shift

The PJM region is in the midst of an unprecedented generation shift: away from coal and nuclear and toward natural gas and renewables.

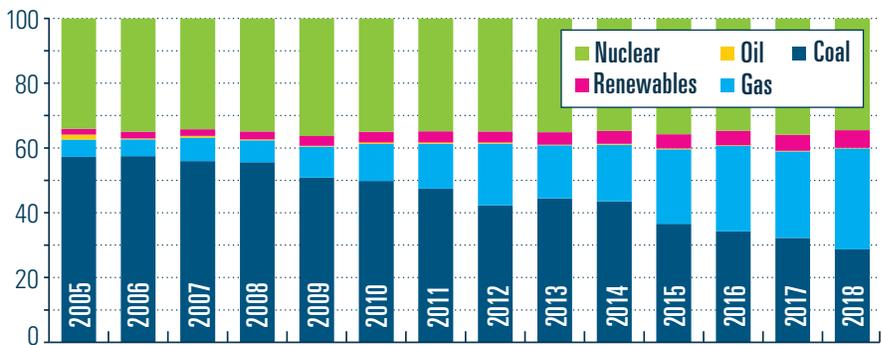


The transmission system has had to be flexible in order to adapt and continue to deliver power reliably. PJM's RTEP process identifies new transmission to maintain grid reliability, permitting older generators – mainly coal-fired – to retire without causing transmission line overloads, voltage issues or other reliability criteria violations.

Flexibility for New Generation Sources

The RTEP process includes a queue-based, new-service study process. This offers transmission developers the flexibility to pursue capacity, energy, ancillary services and other business opportunities in PJM.

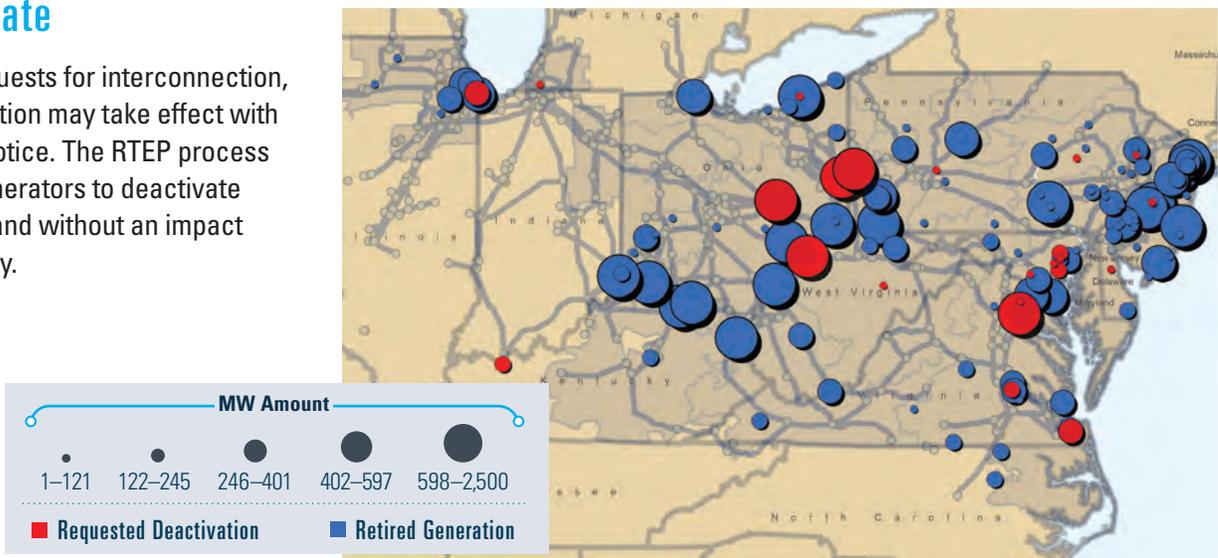
PJM Annual Fuel Mix



Flexibility as Generators Deactivate

Unlike requests for interconnection, a deactivation may take effect with 90 days' notice. The RTEP process allows generators to deactivate smoothly and without an impact to reliability.

All Generator Retirements Since 2010



\$39 B
since 1999.

The amount of new transmission identified to ensure the benefits of shared capacity, new generation, reduced emissions, wholesale markets and mutual support under high load and other stressed system conditions.

New Drivers for a Dynamic Planning Process

PJM and its stakeholders have worked to enhance the flexibility of the RTEP process, so it can continue to account for new drivers of transmission system enhancements:



Operational Preparedness for Disruptive Events

PJM is developing new metrics and RTEP process enhancements to help grid resilience in the face of operational challenges including extreme weather, cyber and physical attacks, and dependence on fuel delivery.



Energy Storage

Energy storage facilities – which can also seek capacity rights – are growing rapidly in PJM, and include everything from centralized facilities to small, kilowatt-level, behind-the-meter batteries. As growth continues, efficient grid operations will require increased electric system flexibility.



Electric Vehicles

The rise in the use of electric cars requires transmission to allow for the additional flow of power to and from charging stations. Electric vehicle charging cycles will impact daily load shapes and, consequently, transmission need. Such need is amplified if power is to be delivered from new, more-distant wind and natural gas-fired generation.



Space Weather

Geomagnetic disturbances and other space weather can introduce additional electrical current into the grid, which can cause overheating and tripping of transformers and other transmission facilities. PJM is not immune to space weather. We continue to implement NERC planning standards to mitigate the risk of instability, uncontrolled separation and cascading outages.

Energy Storage in PJM

Today



5,000 MW of pumped storage hydro



70 MW of thermal energy storage



300 MW of battery and flywheel energy storage

Tomorrow



As of Sept. 2019:
4 GW of hybrid renewables+ storage and
2 GW of stand-alone storage in new-services queue

Where Can I Find More Information?



Written Resources

Manual 14: Contains the specific business rules that govern study methodologies and solution development for baseline and new services queue-driven RTEP projects

<https://www.pjm.com/~media/documents/manuals/m14b.ashx>

PJM New Services Queue:

<https://www.pjm.com/planning/services-requests/interconnection-queues.aspx>

Operating Agreement, Schedule 6:

Codifies the provisions governing the PJM RTEP process

<https://agreements.pjm.com/oa/4771>

Open Access Transmission Tariff: Codifies new service requests

<https://www.pjm.com/directory/merged-tariffs/oatt.pdf>

Project Status: The status of baseline, network and supplemental projects

<https://www.pjm.com/planning/rtep-upgrades-status.aspx>

The Benefits of the PJM Transmission System:

2019 report quantifies the value of new and existing transmission equipment, lines and other assets

<https://www.pjm.com/~media/library/reports-notice/special-reports/2019/the-benefits-of-the-pjm-transmission-system.pdf>

Annual RTEP Reports: Additional detail on key projects

<https://www.pjm.com/library/reports-notice/rtep-documents.aspx>



Interactive Forums

Planning Community: A forum for stakeholders and PJM staff to collaborate. Includes self-service resources, knowledge articles and discussion boards. Request access at:

<https://pjm.force.com/planning/s/>

Planning Committee: Standing committee in the PJM stakeholder process that has the responsibility to review and recommend system planning strategies and policies as well as planning and engineering designs

<https://www.pjm.com/committees-and-groups/committees/pc.aspx>

The Transmission Expansion Advisory

Committee: Forum for stakeholders and PJM staff to exchange ideas, discuss study input assumptions and review results:

<https://www.pjm.com/committees-and-groups/committees/teac.aspx>

Subregional RTEP committees: Provide a forum for stakeholders to discuss local planning concerns:

Mid-Atlantic Subregional RTEP Committee:

<https://www.pjm.com/committees-and-groups/committees/srtepm-a.aspx>

Western Subregional RTEP Committee:

<https://www.pjm.com/committees-and-groups/committees/srtepm-w.aspx>

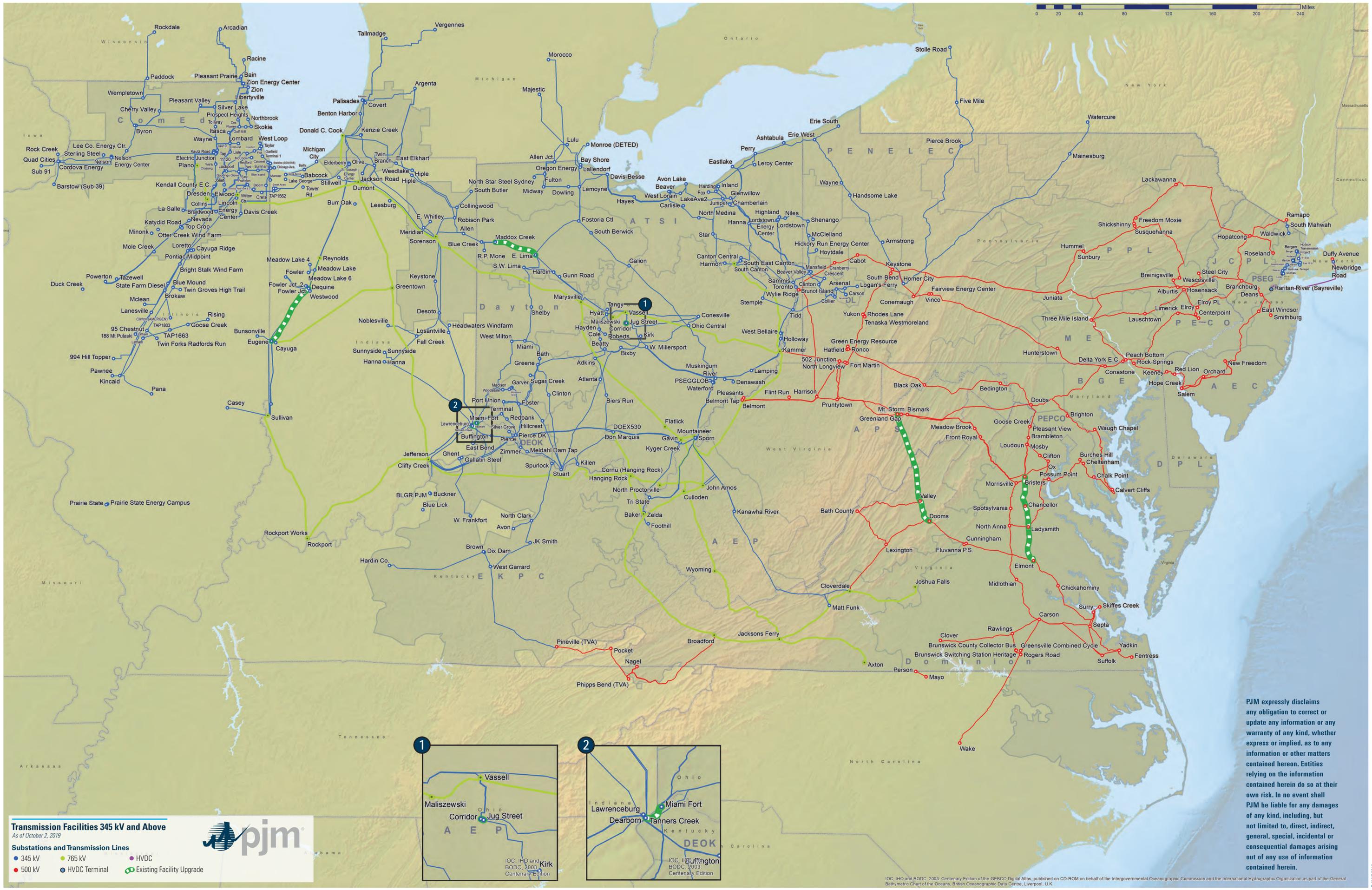
Southern Subregional RTEP Committee:

<https://www.pjm.com/committees-and-groups/committees/srtepm-s.aspx>

Member Relations

(610) 666 8980 | (866) 400 8980

www.pjm.com



Transmission Facilities 345 kV and Above
As of October 2, 2019



Substations and Transmission Lines

- 345 kV
- 500 kV
- HVDC
- HVDC Terminal
- Existing Facility Upgrade



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IOC, IHO and BODC, 2003. Centenary Edition of the GEBCO Digital Atlas, published on CD-ROM on behalf of the Intergovernmental Oceanographic Commission and the International Hydrographic Organization as part of the 'General Bathymetric Chart of the Oceans, British Oceanographic Data Centre, Liverpool, U.K.'