PJM's Advanced Technology Initiative
PJM Interconnection’s Advanced Technology Initiative provides opportunities for innovators - including PJM staff, member organizations, research and academic institutions, and industry experts - to advance power grid operations and wholesale electricity markets. The initiative builds on PJM’s history of innovation and reflects its commitment to community collaboration and enhancing the reliability and cost-effectiveness of the bulk power system. PJM supports innovation in-house, in partnerships and through its Emerging Technology Pilot Program.

**Dispatch Interactive Map Application™**

PJM has deployed a powerful new tool, the Dispatch Interactive Map Application, or DIMA™, developed to enhance the situational awareness of dispatchers. DIMA simplifies and consolidates important data from multiple sources into a single geospatial display, enabling operators to more quickly and easily identify problems and coordinate the operation of the region’s transmission system.

DIMA provides multiple layers of real-time information on several critical elements, including:

- **Electrical equipment** – DIMA displays real-time information from the PJM energy management system about electrical equipment such as transmission lines, substations, generators and a host of other sub-systems – all quickly configurable to suit the operator’s needs.

- **Weather** – PJM operators can view historic and future radar, detailed temperature and wind conditions, severe weather such as lightning, floods and storms, and National Weather Service bulletins.

- **Gas pipelines** – Being able to quickly understand how potential disruptions of this fuel supply could impact the operation of the power system is a new and critical skill for grid operators as an increasing amount of generation comes from natural gas.

- **Load management** – With the ability to provide reliability services alongside traditional generation resources, demand-side resources such as loads, behind-the-meter generation and energy storage are increasingly useful tools for operators to manage the grid.

The Dispatch Interactive Map Application consolidates important information about grid operations into a single, geospatial display, enhancing dispatchers’ situational awareness and enabling rapid assessment of potential problems.
Blockchain

PJM Environmental Information Services Inc. (PJM-EIS), a subsidiary of PJM, and the global nonprofit Energy Web Foundation are collaborating to develop a reference implementation of Energy Web (EW) Origin for the Generation Attribute Tracking System (GATS).

GATS, administered by PJM-EIS, is a paid subscription service that creates a generator-specific electronic certificate for every megawatt-hour of electricity produced by a generator. The system tracks the environmental and emissions attributes of generation, along with the ownership of credits as they are traded or used to meet government renewable-energy standards.

EW Origin is a custom, open-source decentralized toolkit that helps unlock renewables investments by reducing administrative and transaction costs, modernizing user experience and enabling greater access to renewable energy markets (including for smaller buyers and sellers below the megawatt-hour level).

The pilot will allow PJM-EIS to investigate the potential benefits of blockchain technology to improve the security, transparency and transaction costs of GATS. The collaboration aims to develop, test and make available a full implementation of the blockchain-based EW Origin toolkit.

Dynamic Line Rating

Dynamic Line Rating (DLR) technology uses advanced sensors and software to monitor real-time conductor temperature along a transmission line. It then uses this data to calculate an actual rating for the line based on environmental conditions, as opposed to modeled scenarios.

In this way, DLR technology can identify additional capacity on transmission lines that could potentially relieve congestion and create economic efficiencies. Such technology also can contribute to system resilience by providing better monitoring of the real-time capabilities of transmission assets.

Every transmission line is designed with a de facto rating that traditionally does not change very often and which is used by PJM and transmission owners in operating the grid. Introducing DLR technology could allow a more dynamic update of transmission line ratings – for example, hourly, daily, monthly or seasonally – that would improve the reliability and economic efficiency of system operations.

Today, DLR technology is used in only a select number of locations worldwide. PJM has partnered with transmission owner American Electric Power and DLR technology company LineVision to demonstrate the use of this technology and its potential benefits more widely.

To better understand the overall impact of DLR technology, PJM undertook a one-year study of a hypothetical installation on one of its most congested lines. The analysis found that use of the technology could reduce system congestion payments by more than $4 million – providing a rapid, two-month payback of the estimated $500,000 installation cost.

- **Solar heating** - Just as the sun warms the air and the Earth’s surface, heat from the sun’s rays will raise the temperature at the conductor’s surface.
- **Resistive heating** - As current passes through the conductor, heat is generated inside the conductor by electrical losses.
- **Convective cooling** - Nearby wind carries away warm air surrounding the conductor and can cause a dramatic cooling effect along the transmission line.
- **Radiative Cooling** - Even with no wind, transmission lines lose a portion of their heat to cooler ambient air.
Cascading Trees - Transmission System Planning for Resilience

The high-voltage transmission network that crisscrosses the country was planned based on a set of reliability and efficiency criteria. These criteria generally ensure that the transmission system is capable of withstanding a significant outage to one, or a few, critical pieces of equipment. However, these planning criteria do not assess what would happen to the system should a significant disruption of many pieces of equipment occur at once, or in quick succession, as might be triggered by an extreme weather event or a deliberate attack.

PJM and transmission owner Dominion Virginia Power have begun developing such an assessment, called “cascading trees.” The purpose of this new methodology is to assess the probability and consequence of cascading outages in electric systems. A cascading tree is the set of all likely cascading paths; these, in turn, describe a sequence of potential cascading outages that could reasonably be expected.

These possible outages are then classified as “bounded” or “blown-up” – that is, whether the propagation of a disturbance can be confined to a certain area or if the exact extent of the cascading cannot be determined.

The initial N-k event equates to the complete loss of a substation. Cascading trees quantify the probability of cascading and the extent of associated consequence, leading to a natural ranking of substations. Substations then can be grouped into different tiers, each having a different priority and a discrete set of mitigation actions. Dominion Virginia Power has used this methodology to identify and rank critical substations.

The best way to protect a critical substation is to not have one. PJM is currently developing a metric of resilience to complement and enhance a planning process that traditionally has been focused on reliability and efficiency. The intent is to incorporate cascading trees as a weighting factor in the metric of resilience.
Synchrophasors

With the aid of a $14 million U.S. Department of Energy stimulus grant, PJM and its member transmission owners have installed more than 400 phasor measurement units (PMU), or synchrophasors, in more than 120 substations in 10 states.

Synchrophasors provide data at a higher resolution and much higher reporting frequency than traditional SCADA (supervisory control and data acquisition) systems, painting a more detailed picture of the status of the grid at any given moment. PJM is developing advanced applications of this technology to improve the efficiency, reliability and resilience of the power system.

For example, model validation is a key and novel application of synchrophasors. Planning, operations and markets rely heavily on models; ensuring that these models accurately represent the physical behavior of the system is critical.

PJM is researching other applications, including disturbance detection and location, geomagnetic disturbance monitoring and wide-area controls.

Energy Storage

Efficient grid operations in an era of rapid growth of renewable energy resources will require increased electric system flexibility. PJM’s interest in energy storage of all forms reflects this notion.

Energy storage can help grid operators keep the power supply stable when wind, solar or other sources are changing their output due to weather conditions, or are simply unavailable. It can also improve the efficiency of the transmission system by increasing the utilization factor of existing transmission and distribution networks, as well as existing generation sources.

PJM has worked with various companies and national laboratories to advance the use of energy storage and ensure that the PJM wholesale market is capable of allowing all forms of energy storage to participate and compete in the marketplace.
Today, approximately 5,000 MW of pumped storage hydro, 300 MW of battery and flywheel energy storage, and 70 MW of thermal energy storage are qualified to participate in the PJM market. This includes everything from large central station generation plants connected at transmission to small kilowatt-level behind-the-meter applications.

In March 2018, the Federal Energy Regulatory Commission issued a new regulation, Order No. 841, mandating that all ISOs and RTOs create a market participation model in which energy storage resources can provide all of the market services that they are technically capable of offering. These new rules, which must be implemented by Dec. 2019, generally are seen as a regulatory step that will help enable further growth of energy storage in the U.S.

Electric Vehicles and Vehicle-to-Grid

In the past, PJM has partnered with companies including BMW North America and General Motors OnStar to demonstrate the potential of aggregated fleets of electric vehicles to respond to certain types of grid signals, such as demand response events, locational marginal prices or the real-time generation profile of renewable energy resources.

Given that electric vehicles will be a significant part of our future transportation systems, PJM looks forward to playing a role in powering these vehicles and enabling their ability to interact with the grid in innovative ways to maintain reliable and cost-efficient electricity.

Microgrids

The combination of increasingly cost-effective distributed generation, environmental motivations and increasing value of highly resilient electric power supply has continued to drive the deployment of microgrids.

Microgrids are small clusters of energy assets and loads that are controlled to achieve a variety of benefits for the owner/operator. One of the primary benefits of building a microgrid is the ability to provide reliable electric power during significant electric grid disturbances, such as storm outages.
PJM works with industry partners, universities and states to better understand how microgrids can impact the grid in a positive way and how they can derive value from the PJM wholesale market.

One such initiative is in PJM’s backyard at the Philadelphia Navy Yard, where the Philadelphia Industrial Development Corporation, GE Grid Solutions, Pennsylvania State University and other partners have created a Microgrid Center of Excellence. The center is demonstrating microgrid control technology coupled with distributed energy assets to improve grid resilience, security, reliability and efficiency, while also incorporating the use of on-site renewable energy.

**PJM Emerging Technology Pilot Program**

Since PJM is an independent and profit-neutral company, it does not directly fund pilot projects. Rather, it is an active participant in the project, providing human resources, analysis and other expertise. In certain cases, PJM offers its corporate campus or other physical resources as a test site for new technology.

PJM is involved in numerous proposed or active emerging technology pilot projects across its footprint. These projects cover a broad spectrum, including, but not limited to, energy storage, dynamic load response, renewables, transmission operations, load forecasting, microgrids and resilience planning.

These projects vary by topic, scope, funding source and duration, but they have a common theme of contributing to the reliable and cost-efficient operation of the electric grid into the future.

For more information on PJM’s Emerging Technology Pilot Program, please visit pilots.pjm.com.