

**A report by the staff of the
Public Utilities Commission of Ohio**

Advanced Transmission Technologies

February 26, 2026

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Introduction

The electric grid in the United States is undergoing rapid, unprecedented change driven by a convergence of factors, including massive new energy demand, aging infrastructure and retiring generation, growth of distributed energy resources, and the emergence of new technologies. As one facet of this grid transformation, many states are adopting policies requiring utilities and regulators to study advanced transmission technologies (ATTs) aimed at boosting the capacity of existing lines and/or optimizing new transmission build.

Recently enacted Substitute House Bill 15 (Sub. HB 15) requires the Public Utilities Commission of Ohio (PUCO) to conduct a study to evaluate the potential use or deployment of ATTs. The law defines ATTs as:

[S]oftware or hardware technologies that increase the capacity, efficiency, reliability, or safety of an existing or new electric transmission system, including grid-enhancing technologies such as dynamic line rating, advanced power flow controllers, and topology optimization; advanced conductors; and other technologies designed to reduce transmission congestion, or increase the capacity, efficiency, reliability, or safety of an existing or new electric transmission system.¹

In addition to defining the components of the study, Sub. HB 15 required the PUCO to conduct two public workshops to invite and review comments from stakeholders. The workshops were held on September 16, 2025, and September 19, 2025. At the workshops, several stakeholders spoke in support of ATTs as cost-effective alternatives to new transmission and as tools to maximize use of existing transmission assets. Two Ohio utilities with transmission assets in Ohio presented comments on their experience with ATTs, particularly advanced conductors. In addition, one vendor presented information on advanced conductors.

¹ R.C. 4906.01(M).

Background

An important foundation to a study of ATTs is that, under the Federal Power Act, the transmission of electricity used in interstate commerce is regulated by the Federal Energy Regulatory Commission (FERC). Significant activity around ATTs is occurring at the federal level.

In July 2023, FERC issued Order No. 2023 to address interconnection queue reform and promote new technologies through its generator interconnection procedures.² The final rule requires transmission providers to evaluate ATTs during interconnection cluster studies to determine if the use of ATTs could reduce interconnection costs for applicants by providing lower network upgrade costs.³ While the use of ATTs is at the transmission provider's discretion, the interconnection cluster study report must include an explanation of the results of the evaluation of ATTs "for feasibility, cost, and time savings as an alternative to a traditional network upgrade."⁴

In May 2024, FERC issued Order No. 1920 to require long-term regional transmission planning.⁵ Among other things, Order No. 1920 requires transmission providers to evaluate whether incorporating ATTs as potential solutions for identified transmission needs over a 20-year planning horizon would be a more efficient or cost-effective solution than traditional solutions.⁶ In addition, like Order No. 2023, transmission providers must include a detailed explanation of why ATTs were or were not incorporated into selected projects.⁷ The requirement to evaluate ATTs in transmission planning applies both to long-term regional planning under Order No. 1920 and to existing planning processes established by FERC under Order No. 1000, issued in 2011, which requires transmission providers to participate in a regional

² *Improvements to Generator Interconnection Procedures and Agreements*, Order No. 2023, 184 FERC ¶ 61,054 (2023).

³ FERC identifies the following advanced transmission technologies: static synchronous compensators, static VAR compensators, advanced power flow control devices, transmission switching, synchronous condensers, voltage source converters, advanced conductors, and tower lifting. Order No. 2023 at P 1578.

⁴ *Id.*

⁵ *Building for the Future Through Electric Regional Transmission Planning and Cost Allocation*, Order No. 1920, 187 FERC ¶ 61,068 (2024).

⁶ FERC identifies the following advanced transmission technologies: dynamic line ratings, advanced power flow control devices, advanced conductors, and transmission switching. Order No. 1920 at P 1198.

⁷ Order No. 1920 at P 1214.

planning process and produce a regional transmission plan.⁸ In applying the evaluation of ATTs to both near-term and long-term transmission planning, FERC seeks to “ensure that transmission providers more consistently consider the costs and benefits associated with incorporating the enumerated alternative transmission technologies into regional transmission facilities.”⁹

As a result of these federal actions, significant additional time and consideration will be given to ATTs and their potential use on the bulk power system across the country. In addition, extensive research on ATTs, including test sites and pilot projects, is underway. For example, the Electric Power Research Institute (EPRI) is an independent organization that conducts research and development related to the generation, delivery, and use of electricity. In 2025, EPRI launched a three-year initiative called Grid-Enhancing Technologies for a Smart Energy Transition, or GET SET, to test and demonstrate various technologies to better understand their life cycle and the impacts of their implementation on grid operations, operational costs, and reliability.¹⁰

Further, a wide array of organizations are focused on elevating conversations around ATTs as an important component of grid transformation. For example, the Energy Systems Integration Group (ESIG) recently formed the Advanced Grid Solutions User Group with support from the Idaho National Laboratory and the U.S. Department of Energy (USDOE) as a forum for users of advanced technologies to share information and technical expertise.¹¹ Many utilities also have their own groups focused on emerging technologies.

It is also important to note that Ohio and surrounding states are part of a regional transmission organization (RTO) called PJM Interconnection, LLC (PJM). As a deregulated state, Ohio relies on PJM and its competitive wholesale markets to secure generation resources and ensure grid reliability. Critically, while PJM plans and operates the regional transmission system, it does not own the transmission assets.

⁸ *Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities*, Order No. 1000, 136 FERC ¶ 61,051 (2011).

⁹ Order No. 1920 at P 1209.

¹⁰ EPRI, *GET SET (Grid-Enhancing Technologies for a Smart Energy Transition)*, <https://interactive.epri.com/get-set/p/1> (accessed February 17, 2026).

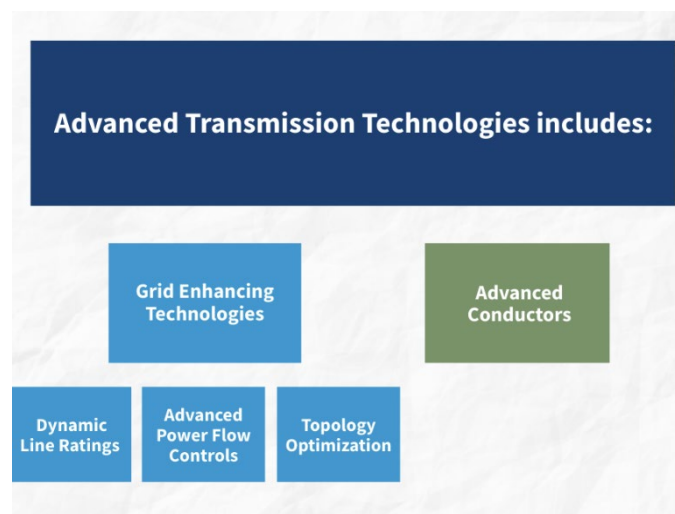
¹¹ ESIG, *GETs User Group*, <https://www.esig.energy/ags-user-group/> (accessed February 17, 2026).

Many topics around the deployment of ATTs are impacted by this interplay between PJM and the transmission owners.

Advanced Transmission Technologies

As defined above, ATTs commonly mean grid-enhancing technologies (GETs) such as dynamic line ratings, advanced power flow controllers, and topology optimization, and also include advanced conductors. While each of these technologies works in different ways, they can all be deployed quickly and cost-effectively compared to new transmission build. GETs can boost the capacity of existing transmission lines, enabling the transfer of more electricity without requiring new infrastructure. GETs “can be deployed within months to increase line capacity by 15% to 50%—providing near-term relief while long-term lines are planned and built.”¹² Similarly, advanced conductors, when used to reconductor existing lines, can increase capacity much faster than acquiring rights-of-way for new transmission build.

However, our electric grid is an intricately complex machine. ATTs are relatively new and deployment in the U.S. to date has been limited. Therefore, many utilities are cautious of how ATTs will perform and interact with grid operations in real time. Advanced conductors are also costly compared to conventional conductors, and GETs can increase the complexity of grid operations, so these types of tradeoffs must be duly evaluated.



¹² ESIG, *Utility Perspectives on Making Grid-Enhancing Technologies Work: Use Cases, Barriers, and Recommendations for Scalable Deployment* (2025), available at <https://www.esig.energy/wp-content/uploads/2025/07/ESIG-Grid-Enhancing-Technologies-report-2025.pdf> at 29 (accessed February 17, 2026).

Dynamic Line Ratings (DLR)

1. *Attributes, functions, costs, and benefits*

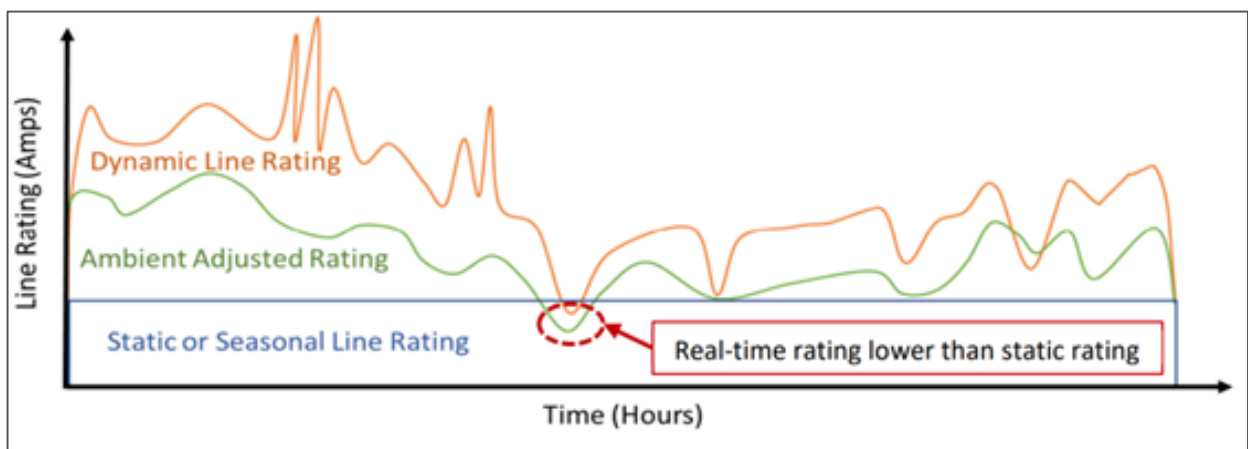
A transmission line rating is the maximum transfer capability of a power line as determined by its physical characteristics and reasonable assumptions about prevailing environmental conditions. Importantly, the line rating sets the ampacity limits of the line, or the maximum amount of electric current that a line can carry continuously without overheating and exceeding a given allowable operating temperature. Environmental factors like ambient temperature and the surrounding medium's thermal conductivity directly affect a line's ability to dissipate heat, which, in turn, impacts a line's ampacity as temperatures rise.

The line rating is just one component of a transmission facility's "facility rating," the facility being all relevant equipment involved in the line's operation (e.g., circuit breakers, line traps, transformers). Historically, transmission providers have incorporated static line ratings or seasonally adjusted ratings (e.g., winter/summer ratings) into their facility rating calculations. This meant that the ampacity limits of a line were established based on fixed, worst-case assumptions regarding the environmental parameters of a line over a set period of time. The actual conditions of the line (e.g., ambient temperature, wind speed, and solar radiation) that may significantly impact the line's ampacity were not considered.

More recently, ambient adjusted ratings (AAR) expand on traditional practices by incorporating near-term (i.e., the next ten days) forecasted ambient temperatures and solar radiation adjustments (day/night or hourly) to determine and adjust line ratings hourly, potentially allowing the line to carry more electric power. Most recently, dynamic line ratings (DLR) expand on AAR to determine real-time continuous ratings based on observed ambient conditions, including wind speed and direction, in conjunction with forecasted weather conditions at the line's location.

DLR is defined as "a transmission line rating that applies to a time period of not greater than one hour and reflects up-to-date forecasts of inputs such as (but not limited to) ambient air temperature, wind, solar heating, transmission line tension, or

transmission line sag.”¹³ DLR uses hardware and/or software to update the calculated ampacity limits of existing lines and establish new limits based on real-time and forecasted ambient conditions. The DLR data is then incorporated into facility rating calculations that would otherwise use predetermined calculations or methods. This can unlock up to 50% average capacity gains on a line and allow for the safe transfer of more power across the line under favorable conditions.¹⁴ Conversely, DLR could also reduce power flow when the DLR is below traditional ratings. Importantly, DLR does not guarantee an increase in transfer capability, since it accurately reflects current conditions whether they result in an increase, decrease, or insignificant change to the line’s transfer capabilities.¹⁵ DLR does not modify the line in any way; it provides situational awareness that may yield system benefits. How line ratings vary based on the methodology used is illustrated below.¹⁶



¹³ PJM, *Dynamic Line Ratings, Grid Enhancing Technologies: Technical Reference Guide* (2024), available at <https://www.pjm.com/-/media/DotCom/about-pjm/advanced-technologies/dlr.pdf> at 2 (accessed February 17, 2026).

¹⁴ WATT Coalition, *Unlock Power Line by Line: Dynamic Line Ratings*, <https://watt-transmission.org/about-dynamic-line-ratings/> (accessed February 17, 2026).

¹⁵ PJM, *Dynamic Line Ratings, Grid Enhancing Technologies: Technical Reference Guide* (2024), available at <https://www.pjm.com/-/media/DotCom/about-pjm/advanced-technologies/dlr.pdf> at 5 (accessed February 17, 2026).

¹⁶ USDOE, *Advanced Transmission Technologies* (2020), available at <https://www.energy.gov/oe/articles/advanced-transmission-technologies-report> at 8 (accessed February 17, 2026).

DLR systems are broadly categorized into sensor-based and sensorless deployments. Sensor-based deployments involve the installation of physical sensors on or near an existing transmission line that measure and relay information to a central monitoring system where the data is processed along with forecasted weather conditions to adjust line ratings accordingly. In software-based sensorless deployments, advanced algorithms and modeling are applied to existing data, such as virtual weather inputs from meteorological providers and grid data from grid operators, to estimate conditions and adjust a line's ampacity.

2. The potential to be used or deployed

DLR can be used in both grid operations and planning; however, the inherent variability of DLR presents challenges for transmission planning. DLR is an effective tool for grid operations because it can assist operators in quickly responding to demand spikes, outages, and emergencies and can alleviate grid congestion, which lowers operational costs. However, the amount of capacity that DLR can unlock and what percentage of time those gains are available are key to determining whether DLR is a viable solution to a transmission challenge. EPRI's recent research on utilities' DLR operations experience indicates that "DLR is well suited for situations where average transmission capacity needs are below 15%, where it is tolerable for capacity to decrease for periods of time, and/or where a constant known gain is not required."¹⁷

The importance of location when implementing DLR cannot be overstated. Deployments are ideally focused on locations where the conductor is the limiting factor in the line's rating and where congestion exists or is forecasted to exist. Locations with adequate cooling effects from wind patterns relative to the line are also better positioned to realize the full benefits of DLR. DLR has the advantage of being scalable, portable, and reversible; new lines can be added to a DLR deployment or the DLR technology can be repurposed/transferred to different lines once a transmission need at a given location is met. These further applications of the technology spread the costs and potential benefits beyond that of a singular installation.

¹⁷ EPRI, *Dynamic Line Ratings Status, Applications and Opportunities: A GET SET White Paper* (2025), available at <https://www.epri.com/research/products/000000003002031444> at 4 (accessed February 17, 2026).

As detailed further below, DLR deployment in the PJM region has been limited to date. According to PJM, technical considerations in DLR adoption include the initial costs, training, and necessary software changes.¹⁸ Other concerns expressed by Ohio utilities relate to the storage and use of large volumes of sensor data and whether the incremental benefits of DLR over AAR will justify the investment.

In 2021, FERC issued Order No. 881 to improve the accuracy and transparency of transmission line ratings.¹⁹ Order No. 881 requires transmission providers to implement AARs on their transmission lines, and RTOs to establish and implement systems that allow at least hourly updates to line ratings. While the order does not mandate the adoption of DLR, the adoption of AARs may lay the groundwork for future DLR adoption. Although PJM cannot prescribe the use of DLR or other ATTs, PJM has had an operations ratings framework that allows for the inclusion of ambient conditions for over two decades.²⁰

Ohio's transmission utilities are currently at various stages of DLR testing. AES and AEP have actively tested DLR at specific locations on their systems, whereas Duke and FirstEnergy have not but are participating in DLR testing and pilots through EPRI's GET SET program.²¹ In 2023, AES partnered with LineVision on a DLR project to install 42 sensors with LiDAR technology across five diverse lines in Ohio and Indiana.²² This initial deployment was intended to pilot the benefits that could be achieved with DLR on different types of grid assets and under varied environmental conditions.²³

¹⁸ PJM, *Dynamic Line Ratings, Grid Enhancing Technologies: Technical Reference Guide* (2024), available at <https://www.pjm.com/-/media/DotCom/about-pjm/advanced-technologies/dlr.pdf> at 3 (accessed February 17, 2026).

¹⁹ *Managing Transmission Line Ratings*, Order No. 881, 177 FERC ¶ 61,179 (2021).

²⁰ PJM, *Dynamic Line Ratings, Grid Enhancing Technologies: Technical Reference Guide* (2024), available at <https://www.pjm.com/-/media/DotCom/about-pjm/advanced-technologies/dlr.pdf> at 2 (accessed February 17, 2026).

²¹ In 2016, AEP partnered with PJM and LineVision to perform a pilot on a 345 kV line that focused on understanding DLR technology. In 2018, AEP partnered with PJM and Lindsey in a pilot where DLR sensors were installed on a 138 kV line. PJM, *PJM Comments on Dynamic Line Rating Technologies* (2019), available at <https://www.ferc.gov/sites/default/files/2020-09/Murphy-PJM.pdf> at 1 (accessed February 17, 2026).

²² The project used LineVision's LUX patented sensor platform, which uses LiDAR sensor technology and mounts to transmission towers rather than to live lines.

²³ AES and LineVision, *Lessons from First Deployment of Dynamic Line Ratings* (2024), available at <https://www.aes.com/sites/aes.com/files/2024-04/AES-LineVision-Case-Study-2024.pdf> at 4 (accessed February 17, 2026).

According to AES’s report on the pilot, “the installation of the LineVision sensors was a safe, simple, and efficient process” with a total installation time of less than two weeks, where the sensors began collecting data immediately upon installation.²⁴ In terms of outcomes, on the 345 kilovolt (kV) line evaluated in the pilot, DLR achieved an average capacity increase of 61% over the line’s static rating. It also achieved an approximate average capacity increase of 23% over the line’s AAR.²⁵ On the 69 kV line evaluated in the pilot, DLR did result in periods of time where the average capacity of the line was reduced from its static rating or AAR.²⁶

3. *Potential reductions in project costs, timelines, permitting, maintenance*

To date, there is one fully operational DLR project in the PJM region that offers insight into DLR implementation. This project was executed in 2022 by PPL Electric Utilities (PPL) in Pennsylvania, in partnership with Ampacimon, on lines selected due to high costs of predicted congestion. PPL deployed DLR because they could achieve identified capacity increases in one year, at low cost, and without coordinating a transmission outage.²⁷ The comparative costs, timelines, and capacity benefits PPL considered for the project are illustrated below.²⁸

	 Reconductor	 Rebuild	 Dynamic Line Rating
Time to Implement	2-3 Years	3-5 Years	~1 Year
Downtime	Extended Outages	Extended Outages	No Outages
Cost	\$0.5 M per mile	\$2-3 M per mile	<\$1 M
Est. Capacity Benefit	+ 34%	+ 106%	+ 10-30%

²⁴ *Id.* at 9, 10.

²⁵ *Id.* at 12.

²⁶ *Id.* at 16.

²⁷ WATT Coalition, *Unlocking Power: A Playbook on Grid Enhancing Technologies for State and Regional Regulators and Policymakers* (2024), available at <https://watt-transmission.org/wp-content/uploads/2024/11/Unlocking-Power-Line-by-Line-Dynamic-Line-Ratings.pdf> at 9 (accessed February 17, 2026).

²⁸ *Id.*

Advanced Power Flow Control (APFC)

1. *Attributes, functions, costs, and benefits*

Conventional power flow control, through mechanical phase angle regulators or phase-shifting transformers, to change the way power flows through the transmission system (i.e., steering) has been used in the electric utility industry for 100 years. Over time, electronics-based devices were developed for this purpose. Today, many utilities use flexible alternating current transmission system (FACTS) devices to more quickly and precisely optimize electricity flow across the grid, minimize line losses, and enhance overall system performance.

FACTS devices can be used to reduce congestion in specific locations, including mitigating reliability constraints. Reducing congestion reduces congestion-related costs and increases the potential to use more output from generation resources at or near that location. In addition, FACTS devices can provide dynamic voltage control and reactive power support, operational tools critical to stabilizing the local grid during fluctuations and disturbances. By optimizing the flow of electricity through existing infrastructure, FACTS devices increase grid efficiency and can lessen the need for or defer new transmission lines.

An array of technologies in the family of FACTS devices exists. One category is voltage source converters (VSC) that can generate alternating current (A/C) voltages without the need to rely on an A/C system. A static synchronous compensator (STATCOM) is a VSC. A static synchronous series compensator (SSSC) is another VSC. As the name implies, a SSSC injects voltage directly into the path of the current (i.e., in series) as opposed to in parallel like STATCOM devices. For purposes of this study, we will consider APFC to mean series compensation devices, such as SSSCs.

APFC/SSSC could be considered “next generation” FACTS solutions, offering faster, continuous power flow control (in milliseconds) and designed to be flexible and modular to adapt to the changing needs of the grid. APFC devices divert power flow away from congested lines to circuits with spare capacity by injecting voltage into a transmission line to increase or decrease the reactance in the line.²⁹ By altering the

²⁹ PJM, *Advanced Power Flow Controllers, Grid Enhancing Technologies: Technical Reference Guide* (2024), available at <https://www.pjm.com/-/media/DotCom/about-pjm/advanced-technologies/apfc.ashx> at 2 (accessed February 17, 2026).

reactance, APFC devices serve to “push” and “pull” on pre-identified lines to enable an increase or decrease in flow and alleviate thermal overloads.³⁰ Smart Wires’ SmartValve™ is the most well-known and widely deployed APFC solution.³¹ First deployed in 2016, as described above, it injects voltage directly into the transmission facility to achieve the desired reactance in order to “push” power off overloaded lines or “pull” power onto underutilized lines.

EPRI’s GET SET white paper *Advanced Power Flow Controllers Status, Applications, and Opportunities* lists benefits and use cases for APFC, including advantages over traditional solutions. For example, APFC devices may be rapidly deployed, are scalable, are modular for relocation as system needs evolve, and may have lower overall costs, including maintenance costs, when compared to traditional solutions like constructing new transmission lines/substations, upgrading transmission lines/substations, or installing other FACTS devices.³²

2. *The potential to be used or deployed*

APFC is a relatively new and evolving technology and, to date, experience with APFC in the U.S. is limited. SmartValve™ devices have been installed in power systems in various countries, including the UK, Australia, Canada, Colombia, and the U.S.³³ However, there are currently no APFC devices deployed in the PJM region, and none in use by Ohio utility affiliates with transmission assets outside the PJM region.

Like all GETs, location is important in the deployment of APFCs. While APFCs are modular and can be installed along any transmission line, they are most applicable in highly interconnected meshed networks with multiple different routes across different transmission lines to route power. They are less effective on transmission networks with few alternative paths for power to flow.³⁴

³⁰ *Id.* at 6.

³¹ Smart Wires, *SmartValve™: Advanced Power Flow Control*, <https://www.smartwires.com/smartvalve/> (accessed February 17, 2026).

³² EPRI, *Advanced Power Flow Controllers Status, Applications, and Opportunities: A GET SET White Paper* (2025), available at <https://www.epri.com/research/products/000000003002031443> at 8-9 (accessed February 17, 2026).

³³ *Id.* at 5.

³⁴ E3, *Cost and Benefits Assessment of Grid-Enhancing Technologies in Maine* (2025), available at https://www.maine.gov/mpuc/sites/maine.gov/mpuc/files/inline-files/2025.08.26_MPUC_GETs_Assessment_final.pdf at 12 (accessed February 17, 2026).

According to EPRI, “one of the most significant barriers to the deployment of APFCs, especially in the United States, has been the lack of utility understanding of how to consider and operate this technology.”³⁵ There are no industry-wide specifications or standards for APFCs, and with a relatively small number of deployments, no established track record of experience for utilities to draw on.

In discussing ATTs with the Ohio transmission utilities, they expressed interest in learning more about APFC devices through the EPRI GET SET initiative, including important testing of the devices in real-time conditions. Knowledge will also be gained through information sharing with other utilities as experience is gained around the country, such as through the ESIG Advanced Grid Solutions User Group discussed above. Like all ATTs, the utilities emphasized that the beneficial use of APFC is case specific based on a needs assessment. APFC devices are designed to address a specific need on a utility’s system, such as a reliability constraint or persistent congestion. While these conditions may not currently exist in Ohio, conditions are continually monitored as load and generation patterns change.

The utilities also acknowledged that APFC technology has evolved, and pilot projects in the PJM region are anticipated in the near term. As noted above, PJM cannot prescribe the use of APFC devices. Rather, PJM provides criteria to consider when evaluating the technology in collaboration with the transmission owner (TO). “Ultimately the impacted TO will need to determine if the installation of such a device is an acceptable addition to their transmission grid since the TO will own the equipment and be responsible for its maintenance and operations.”³⁶

3. *Potential reductions in project costs, timelines, permitting, maintenance*

In 2024, the Midcontinent Independent System Operator (MISO) produced a *Transmission Cost Estimation Guide* that estimated the unit cost of various grid supporting devices. In that publication, STATCOM devices were estimated at

³⁵ EPRI, *Advanced Power Flow Controllers Status, Applications, and Opportunities: A GET SET White Paper* (2025), available at <https://www.epri.com/research/products/000000003002031443> at 3 (accessed February 17, 2026).

³⁶ PJM, *Advanced Power Flow Controllers, Grid Enhancing Technologies: Technical Reference Guide* (2024), available at <https://www.pjm.com/-/media/DotCom/about-pjm/advanced-technologies/apfc.ashx> at 5 (accessed February 17, 2026).

\$226,013/MVAr and APFC/SSSC devices were estimated at \$159,750/MVAr, representing 30% savings.³⁷

Transmission Topology Optimization (TTO)

1. *Attributes, functions, costs, and benefits*

Like power flow control, the use of topology control in operating the electric grid is not new. Through a transmission operator's energy management system, operators are constantly studying and optimizing the system (e.g., pre-contingency conditions) to determine what actions can/should be taken while maintaining thermal, voltage, and stability limits. Whereas power flow control devices are hardware, topology control is accomplished via software that alters use of the transmission network by switching high voltage circuit breakers in and out of service to redirect power flow (i.e., switching). Topology control software advances manual switching processes and is an operational tool used to reduce or eliminate congestion in real or near real time.

Transmission switching has both reliability and economics-based drivers. However, historically, the use of topology control to address reliability issues has been limited because switching actions beneficial to the grid that pose no additional risks have been difficult to identify. Namely, transmission switching may reduce system congestion in one place but shift some level of congestion to another part of the system.

Further, the number of potential switching actions is very large. For illustration, EPRI's *GET SET Transmission Topology Optimization: State-of-the-Art White Paper* uses the following example: "if there is a congested region of the network requiring consideration of 10 breakers, with each breaker in either an open or a closed state, then there are $2^{10}=1024$ possible configurations."³⁸ As a result, grid operators have typically

³⁷ MISO, *Transmission Cost Estimation Guide for MTEP24* (2024), available at <https://cdn.misoenergy.org/20240501%20PSC%20Item%2004%20MISO%20Transmission%20Cost%20Estimation%20Guide%20for%20MTEP24632680.pdf> at 26 (accessed February 17, 2026).

³⁸ EPRI, *Transmission Topology Optimization, State-of-the-Art White Paper: A GET SET White Paper* (2025), available at <https://www.epri.com/research/products/000000003002031445> at 8 (accessed February 17, 2026).

used a “fixed-topology assumption” as opposed to pursuing transmission switching (i.e., shifting the topology) in addressing reliability violations.³⁹

Topology control is more widely used to address the economic impact of congestion. PJM’s *Topology Control & Optimization, Grid Enhancing Technologies: Technical Reference Guide* explains that “PJM utilizes Real-Time Topology Control (RTTC) software that runs every 15 minutes, or ad hoc, to suggest switching solutions based on current system conditions.”⁴⁰ According to PJM, “[t]his switching is done in order to reduce or eliminate congestion costs while maintaining reliability.”⁴¹ Because switching to relieve congestion costs has the potential to determine “winners” and “losers” in the PJM energy market, PJM publishes a list of pre-determined transmission switching solutions for market transparency. Operationally, switching actions suggested by the software may or may not be feasible for a variety of reasons and thus are manually reviewed by PJM prior to implementation. PJM must also coordinate topology changes with transmission owners to fully understand the impact of any switching action before it occurs.

TTO advances topology control software by using advanced algorithms to determine an “optimal localized network topology configuration” on a periodic basis.⁴² The goal of TTO is to automatically identify viable and beneficial topology reconfigurations by continually evaluating the current state of the system. Like motorists use Google Maps or Waze to reroute around traffic delays in real time or near real time, having similar information about the status of the transmission system offers similar benefits, including increased operational flexibility, lower generation costs by reducing or eliminating congestion, and increased or full use of existing transmission system capacity. EPRI’s *GET SET Transmission Topology Optimization: State-of-the-Art*

³⁹ *Id.* at 3.

⁴⁰ PJM, *Topology Control & Optimization, Grid Enhancing Technologies: Technical Reference Guide* (2024), available at <https://www.pjm.com/-/media/DotCom/about-pjm/advanced-technologies/topology-control-and-optimization.pdf> at 2 (accessed February 17, 2026).

⁴¹ *Id.*

⁴² *Id.*; EPRI, *Transmission Topology Optimization, State-of-the-Art White Paper: A GET SET White Paper* (2025), available at <https://www.epri.com/research/products/000000003002031445> at 3 (accessed February 17, 2026).

White Paper further describes TTO benefits and provides summary information on numerous case studies.⁴³

2. *The potential to be used or deployed*

While interest in TTO and its potential for reducing congestion costs exists among RTOs and transmission owners, the actual implementation of TTO is still in the very early stages. In a large system like PJM, the continuous evaluation of network topology to generate reconfiguration options would be computationally complex, generate a massive amount of data, require extensive coordination between PJM and transmission owners, and strain the timeline of PJM's day-ahead energy market.

One way that topology reconfiguration software is currently being deployed is not through the RTO or utility, but through market participants. For example, NewGrid is a vendor whose topology optimization software called *Router* is used to propose solutions to transmission congestion/constraints that, unless mitigated, often result in the curtailment of renewable generation. In the MISO region, market participants like NewGrid can submit reconfiguration proposals for consideration by MISO. If the RTO approves and implements the requested reconfiguration, economic benefits are achieved for NewGrid's clients through reduced congestion costs.⁴⁴ A similar process is under development in the Southwest Power Pool (SPP) region.

3. *Potential reductions in project costs, timelines, permitting, maintenance*

In May 2024, NewGrid compiled 22 topology optimization case studies demonstrating examples of congestion cost savings as well as cost savings achieved by reconfiguring flows during planned transmission outages.⁴⁵ In 2024, the MISO process

⁴³ EPRI, *Transmission Topology Optimization, State-of-the-Art White Paper: A GET SET White Paper* (2025), available at <https://www.epri.com/research/products/000000003002031445> at 6 (accessed February 17, 2026).

⁴⁴ NewGrid, *Congestion and Overload Mitigation with Optimal Transmission Reconfiguration in MISO and SPP* (2024), available at <https://www.ferc.gov/media/presentation-congestion-and-overload-mitigation-optimal-transmission-reconfiguration> (accessed February 17, 2026).

⁴⁵ NewGrid, *Topology Optimization Case Studies* (2024), available at <https://newgridinc.com/wp-content/uploads/2024/05/topology-optimization-case-studies.pdf> (accessed February 17, 2026).

allowing stakeholders to request targeted reconfigurations of the transmission system to reduce congestion delivered an estimated \$24 million in congestion savings.⁴⁶

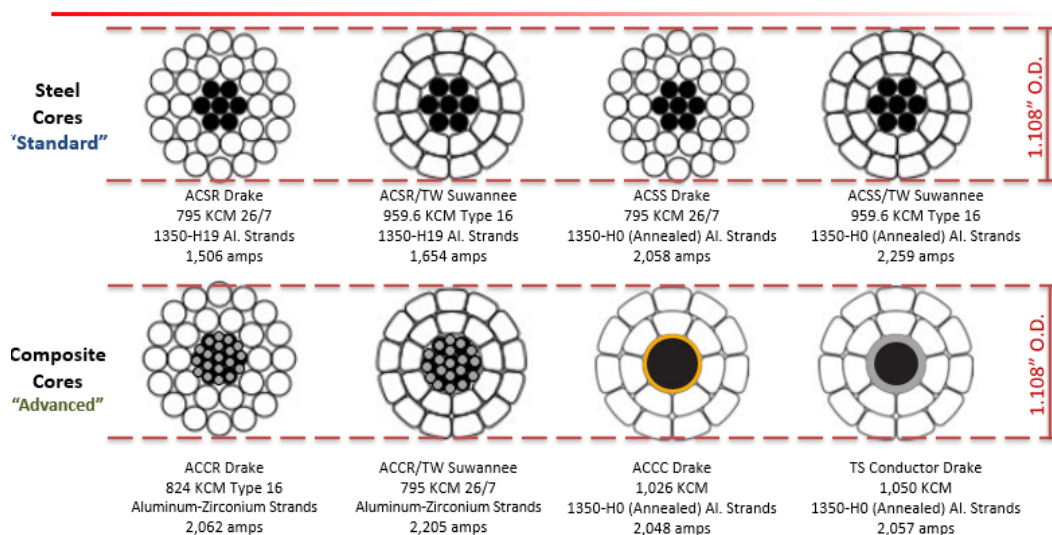
Advanced Conductors

1. *Attributes, functions, costs, and benefits*

Different types of transmission conductors have been used over time, starting with copper and all-aluminum, and evolving to aluminum conductor steel reinforced (ACSR) in the early 1900s and then the use of aluminum alloys. Today, the use of different types of conductors varies by utility, but ACSR is still a default conductor used across the country. In addition, many steel core conductors that are technological advancements beyond ACSR exist, including: ACSR with trapezoidal wire (ACSR-TW), aluminum conductor steel supported (ACSS) conductors, and ACSS with trapezoidal wire (ACSS-TW).

In the early 2000s, new conductors were developed using composite material instead of steel. These conductors are strong and light and designed to operate continuously at higher temperatures without a reduction in mechanical strength. Different vendors have developed these “high temperature, low sag” conductors, such as 3M’s aluminum conductor composite reinforced (ACCR), CTC Global’s aluminum conductor composite core (ACCC), and TS Conductor’s aluminum encapsulated composite core (AECC). The illustration below shared by AEP provides a useful comparison of conductor types.

⁴⁶ ESIG, *Utility Perspectives on Making Grid-Enhancing Technologies Work: Use Cases, Barriers, and Recommendations for Scalable Deployment* (2025) available at <https://www.esig.energy/wp-content/uploads/2025/10/ESIG-Grid-Enhancing-Technologies-report-2025.pdf> at 3 (accessed February 17, 2026).



The term “advanced conductor” is not easily or consistently defined. From a technical view, EPRI defines advanced conductors as “conductors designed to operate at elevated temperatures (typically above 150°C)” and notes that:

[A]ll advanced conductors allow for additional current capacity by allowing for higher operating temperatures than traditional conductors. Advanced conductors, in addition to higher allowable operating temperatures, also generally exhibit lower sags for the same conductor temperature when compared to the traditional conductors.⁴⁷

In Order 2023-A, FERC defined advanced conductors broadly to include:

[P]resent and future transmission line technologies whose power flow capacities exceed the power flow capacities of conventional transmission line technologies...

[W]e further clarify that advanced conductors are advanced relative to conventional aluminum conductor steel reinforced conductors and include, but are not limited to, superconducting cables, advanced composite conductors, high temperature low-sag

⁴⁷ EPRI, *Advanced Conductors Status, Applications and Opportunities: A GET SET White Paper* (2025), available at <https://www.epri.com/research/products/000000003002031441> at 3 (accessed February 17, 2026).

conductors, fiber optic temperature sensing conductors, and advanced overhead conductors.⁴⁸

In Order 1920-A, FERC used the same definition but added advanced steel cores, stating:

[A]dvanced conductors include, but are not limited to, superconducting cables, advanced composite conductors, advanced steel cores, high temperature low-sag conductors, fiber optic temperature sensing conductors, and advanced overhead conductors.⁴⁹

Sub. HB 15 defined advanced conductor to mean:

[A] conductor with a direct current electrical resistance that is at least ten per cent lower than existing conductors of a similar diameter on the electric transmission system while simultaneously increasing the energy carrying capacity by at least seventy-five per cent.⁵⁰

In the AEP illustration above, each of the conductors is the same diameter, but none achieves a 75% increase in capacity (amps) over the other. To achieve a 75% increase in capacity, a conductor would need to be replacing lines that are ACSR (or older) but less than 1.108" diameter. We note that, as discussed, in some instances ACSS and ACSS-TW may be considered advanced conductors. However, for purposes of this study, we will adopt the distinction illustrated above of advanced conductors meaning composite core conductors.

As explained above, advanced conductors using composite cores can operate at higher temperatures; thus, the capacity of the line is increased via higher operating temperatures as opposed to using a larger diameter wire. As EPRI's *Advanced Conductors Status, Applications and Opportunities: A GET SET White Paper* explains, "most

⁴⁸ *Improvements to Generator Interconnection Procedures and Agreements*, Order No. 2023-A, 186 FERC ¶ 61,199 (2024) at P 631.

⁴⁹ *Building for the Future Through Electric Regional Transmission Planning and Cost Allocation*, Order No. 1920-A, 189 FERC ¶ 61,126 (2024) at P 608.

⁵⁰ R.C. 4906.01(N).

proprietary advanced conductors' options offer capacity increases that would otherwise not be achievable with conventional or non-proprietary conductors."⁵¹

These conductors are also lightweight and have a lower coefficient of expansion than steel (i.e., the material size changes less with temperature fluctuations and does not shrink or expand). As a result, advanced conductors produce less line sag, especially at higher temperatures, and thus require shorter structures. For these reasons, advanced conductors are often considered for reconductoring projects, as they provide the benefit of additional capacity without the added cost of replacing towers and structural supports. They are also considered for transmission spans with certain clearance or terrain restrictions. As EPRI explains, "[t]he obvious advantages are the manageable sag and tension considerations for projects that have limited clearances."⁵²

While advanced conductors offer the significant benefit of increased transmission capacity along existing rights-of-way, they also face several challenges, including higher cost per unit of conductor, more complex installation and handling requirements (i.e., more brittle), and variable performance in winter conditions (e.g., ice sag).

2. *The potential to be used or deployed*

In December 2023, Idaho National Lab issued a report, *Advanced Conductor Use Case Studies*, documenting the conductor selection profiles of 44 of the largest transmission owning utilities in the U.S.⁵³ Based on the report, a significant number of utilities have deployed or plan to deploy advanced conductors. For example, 41% have deployed or plan to deploy 3M's ACCR, and 34% have deployed or plan to deploy CTC Global's ACCC.⁵⁴ The report also noted that:

In the U.S., experience with advanced conductor technologies appears to be high, although many utilities have only limited

⁵¹ EPRI, *Advanced Conductors Status, Applications and Opportunities: A GET SET White Paper* (2025), available at <https://www.epri.com/research/products/000000003002031441> at 7 (accessed February 17, 2026).

⁵² *Id.*

⁵³ Idaho National Laboratory, *Advanced Conductor Use Case Studies* (2023), available at https://inl.gov/content/uploads/2024/02/23-50856_R4a_-Use-Case-Studies.pdf (accessed February 17, 2026).

⁵⁴ *Id.* at 5.

deployments of any given technology. It seems common for a utility to perform only one or two projects with a given conductor without adopting it more broadly.⁵⁵

This is consistent with the feedback we received from transmission owning utilities in Ohio. These utilities all noted that conductor selection is a nuanced determination specific to the situation, including cost considerations. Most have standard conductors for specific applications and currently consider advanced conductors to be non-standard. Some of the utilities have piloted advanced conductors or used them for reconductoring projects but continue to view carbon cores cautiously from a reliability standpoint and believe more testing is needed. Others noted installation concerns and the need for field crews to learn proper handling of the technology.

Idaho National Lab reports, however, that “AEP is believed to be the largest domestic user of ACCC conductors, having installed ACCC on 26 lines for a total of 447 circuit miles of transmission,” in addition to its use of ACCR and ACSS conductors.⁵⁶ AEP is the largest owner of 765 kV transmission lines in the country, including those that span Ohio. AEP also developed the Bolt™ transmission structure for 345 kV lines, a tower configuration designed to reduce line losses and increase power flow while using smaller structures. In 2015, AEP completed the largest ACCC reconductoring project in the U.S., which was two 120-mile 345 kV lines in the Lower Rio Grand Valley in Texas, increasing capacity by 40% without needing new rights-of-way.⁵⁷

Overall, the transmission owning utilities in Ohio see applications for advanced conductors in certain situations and acknowledge that these opportunities could achieve project savings due to advanced conductors using less steel, shorter towers, and shorter spans. They also emphasized that advanced conductors require special handling and that a track record of positive performance is needed, along with training on installation, inspection, and maintenance, before the technology is widely deployed.

⁵⁵ *Id.*

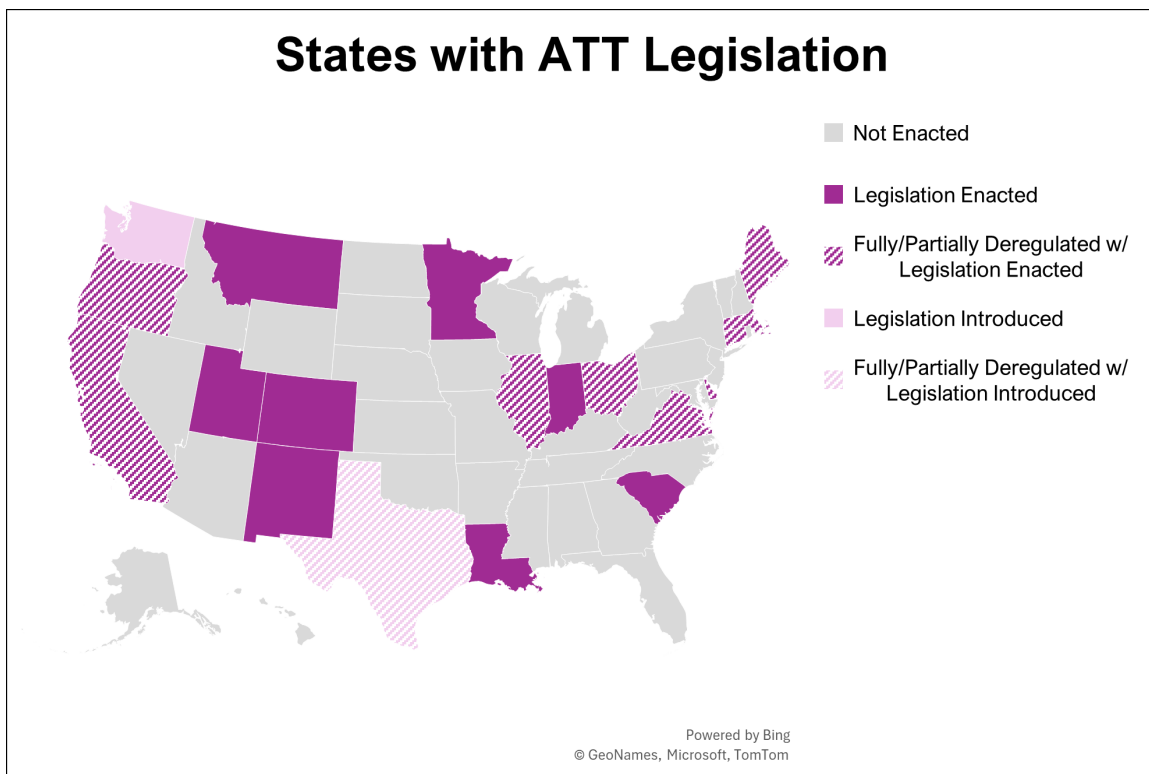
⁵⁶ *Id.* at 8.

⁵⁷ *Id.*; ESIG, *Utility Perspectives on Making Grid-Enhancing Technologies Work: Use Cases, Barriers, and Recommendations for Scalable Deployment* (2025), available at <https://www.esig.energy/wp-content/uploads/2025/07/ESIG-Grid-Enhancing-Technologies-report-2025.pdf> at 3 (accessed February 17, 2026).

3. Potential reductions in project costs, timelines, permitting, maintenance

The many variables involved in addressing transmission needs, including conductor selection, require complex engineering analysis. The cost of the conductor is one variable along with the cost of supporting structures (existing or new) that go into determining total installation costs. Reduced line losses from advanced conductors are also calculated, along with line sag and tension requirements specific to the project. In a 2024 study, Energy Innovation and GridLab concluded that “[a]dvanced conductors tend to be about two to three times the cost of conventional conductors, but when compared to the cost of a new transmission line to add a similar capacity increase, reconductoring with advanced conductors can be 50 to 75 percent cheaper.”⁵⁸

Other Deregulated States



⁵⁸ Energy Innovation and GridLab, *Supporting Advanced Conductor Deployment: Barriers and Policy Solutions* (2024), available at <https://energyinnovation.org/wp-content/uploads/2024/08/5.3-Reconductoring-policy-report.pdf> at 3 (accessed February 17, 2026).

In addition to activity at the federal level, since 2024, a wave of state activity has occurred across the country regarding ATTs, with momentum in 2025 as 18 states introduced bills and 12 states, including Ohio, signed them into law.

Legislation in other states generally requires some level of consideration of ATTs as an alternative to traditional transmission solutions and may offer incentives for their consideration and/or streamline their deployment. Deregulated states are among the states adopting policies that require utilities to study, plan, or deploy cost-effective ATTs to boost reliability, mitigate congestion, defer costly transmission build, and/or integrate renewables. Key actions by deregulated states are outlined below:

POLICY FOCUS	KEY REQUIREMENTS	STATES
STUDY	Requires state agencies, public utility commissions and/or utilities to investigate and report on the potential use of ATTs.	California (SB 1006) Delaware (HJR 3) Illinois (SB 25) Maine (SP 257, SP 84) Massachusetts (S 2967)
UTILITY PLANNING	Requires utilities, public utility commissions and/or grid operators to study the economics and feasibility of ATTs during resource, grid investment and/or transmission planning.	California (SB 1006) Connecticut (SB 4) Illinois (SB 25) Maine (HP 1153) Massachusetts (S 2967) Oregon (HB 3336) Virginia (HB 862)
COST RECOVERY	Requires public utility commissions to consider ATTs submitted in utility base rate or capital improvement proceedings and allow cost recovery or performance incentives for the cost-effective deployment of such technologies.	Connecticut (SB 4) Massachusetts (S 2967)
PERMITTING REFORM	Requires siting authorities to evaluate ATTs during their siting proceedings and/or simplifies the use of alternatives to transmission facility construction/modification by expediting ATT applications or reducing permitting requirements.	Connecticut (SB 4) Massachusetts (S 2967) Oregon (HB 3336) Virginia (HB 1822)

Ohio's neighbors are also considering ATTs. In Indiana, Senate Bill 422 was signed into law in 2025. It requires utilities to include a description of the potential use of ATTs in their integrated resource plans, considers ATTs as eligible investments under the law for cost recovery purposes, and directs the Indiana Utility Regulatory Commission (IURC) to conduct a study to evaluate the potential use or deployment of ATTs. The IURC recently issued a solicitation for proposals to conduct this study.

In Pennsylvania, legislation is anticipated to be introduced soon that would require electric utilities to evaluate and consider the use of ATTs on new and existing service lines, including within siting applications filed with the Pennsylvania Public Utility Commission (PAPUC). Under the expected bill, if the PAPUC determined ATTs would eliminate the need for new infrastructure, the PAPUC would be authorized to deny or conditionally approve a utility's siting application.⁵⁹ Additionally, legislation that would require utilities to invest in GETs as a part of their long-term infrastructure improvement plans is also being considered.⁶⁰

End-use Customer Investment

The unique challenges facing the electric utility industry will require new and innovative approaches from regulators, utilities, and interconnecting customers. Many vendors are working closely with end-use customers, utilities, and RTOs on ways to deploy ATTs to optimize both existing transmission assets and new transmission build.

For example, in June 2025, Google announced a partnership with CTC Global to accelerate the deployment of advanced conductors.⁶¹ This collaboration began with a request for information process open to utilities, transmission operators, local policymakers, and state economic development offices to propose high impact reconductoring projects that could be completed to add significant capacity in the near term. For example, if a utility has an identified transmission need that will result in a line being rebuilt/reconducted but advanced conductors are not proposed (typically because they are cost-prohibitive), this program provides an opportunity for the incremental cost of advanced conductors to be privately sponsored. "Selected partners

⁵⁹ Pennsylvania House of Representatives, Memo Circulated by Representative Elizabeth Fiedler, *Lowering Electric Bills by Adopting Advanced Transmission Technologies (ATT)*, <https://www.palegis.us/house/co-sponsorship/memo?memoID=47809> (accessed February 17, 2026).

⁶⁰ Pennsylvania State Senate, Memo Circulated by Senator Timothy Kearney, *Utility Planning for Affordability with Grid Enhancing Technology*, <https://www.palegis.us/senate/co-sponsorship/memo?memoID=47413> (accessed February 17, 2026).

⁶¹ CTC Global, *CTC Global and Google Announce Strategic Collaboration to Deploy ACCC® Advanced Conductors & Boost Grid Capacity and Reliability*, <https://ctcglobal.com/ctc-global-and-google-announce-strategic-collaboration-to-deploy-accc-advanced-conductors-boost-grid-capacity-and-reliability/> (accessed February 17, 2026).

and projects will gain access to a powerful combination of resources to help accelerate deployment, including cost assistance, workforce training and technical analysis.”⁶²

As discussed above, technology like NewGrid’s topology optimization software, in coordination with a process established by PJM, may also be of interest to end-use customers in the region for its potential to address costly transmission congestion/constraints and unlock additional supply when it becomes limited, such as during planned maintenance outages or extreme weather events.⁶³

PUCO Support and Other Aspects of ATTs

Prior to the enactment of Sub. HB 15, each owner of transmission facilities in the state was required to submit data on all planned transmission lines and associated facilities of 125 kV and above expected over the next 10 years as part of their annual long-term forecast report (LTFR).⁶⁴ Sub. HB 15 expanded these reporting requirements to include “an evaluation and report of the potential use of, or investment in, one or more advanced transmission technologies to enable the electric utility to safely, reliably, efficiently, and cost-effectively meet electric system demand through its major utility facilities.”⁶⁵ The LTFR must identify which ATTs were considered as a part of the utility’s review of its major utility facilities for the next five years and include a cost evaluation comparing costs of traditional transmission investments and costs of the ATTs. The report must also include a congestion mitigation study to identify areas of congestion or likely congestion on the utility’s system and evaluate the potential for ATTs to cost-effectively address the congestion or likely congestion. Under the Sub. HB 15 requirements, the PUCO will ensure that the evaluation of ATTs is properly reported in each utility’s annual LTFR, allow stakeholders to provide comments, and approve each utility’s congestion mitigation implementation plan.

⁶² Google, *We’re Partnering with CTC Global to Increase and Improve U.S. Electrical Grid Capacity*, <https://blog.google/feed/ctc-global-partnership-us-electrical-grid-capacity/> (accessed February 17, 2026).

⁶³ NewGrid, *Congestion and Overload Mitigation with Optimal Transmission Reconfiguration in MISO and SPP* (2024), available at <https://www.ferc.gov/media/presentation-congestion-and-overload-mitigation-optimal-transmission-reconfiguration> (accessed February 17, 2026).

⁶⁴ R.C. 4935.04; Ohio Adm.Code 4901:5-5-04(A)(2).

⁶⁵ R.C. 4935.04(C)(7).

Sub. HB 15 also expanded the requirements under Ohio’s power siting process to include an evaluation of ATTs. With respect to transmission developers of major utility facilities, the Ohio Power Siting Board (OPSB) must find and determine that “the facility must consider implementing cost-effective advanced transmission technologies to maximize the value, expand capacity, or improve the reliability of the facility.”⁶⁶ These requirements will provide significant new information and an opportunity for PUCO and OPSB technical staff to better evaluate the nature and purpose of proposed transmission projects, including whether ATTs could be deployed to the benefit of Ohio ratepayers.

The PUCO’s Office of the Federal Energy Advocate (Ohio FEA) represents Ohio’s interests in matters before PJM and FERC, including activities related to ATTs. The office also works closely with the Organization of PJM States, Inc. (OPSI) to build knowledge and consensus on issues impacting the PJM region, and a major component of that ongoing effort is transmission planning. PUCO Commissioner Dennis Deters currently serves as president of OPSI.

Transmission planning for Ohio and the region is done by PJM. PJM transmission planning engineers annually produce a regional transmission expansion plan (RTEP) that entails an extensive evaluation and competitive solicitation process related to the upcoming transmission needs of the region. The Ohio FEA monitors the development of the RTEP and, throughout the process, can engage with PJM on transmission projects selected to meet regional reliability needs. In the competitive solicitation for the 2025 RTEP, where transmission owners and competitive transmission developers responded to PJM’s identified transmission needs, 134 proposals were submitted, including ten projects using ATTs (five advanced conductor projects and five high-voltage direct current projects).⁶⁷ The Ohio FEA is also engaged in PJM’s compliance with FERC Order No. 1920 on long-term regional transmission planning, including evaluation of whether PJM’s transmission solution selection process may need to adapt or evolve to better incorporate consideration of ATTs.

⁶⁶ R.C. 4906.10(A)(4).

⁶⁷ PJM, *Reliability Analysis Report: 2025 RTEP Window 1* (2026), available at <https://www.pjm.com/-/media/DotCom/committees-groups/committees/teac/2026/20260106/20260106-2025-rtep-window-1-reliability-analysis-report.pdf> (accessed February 17, 2026).

Conclusion

The PUCO strongly encourages an “all tools in the toolbox” approach to meeting surging demands on the electric grid, including the deployment of ATTs. While grid transformation will undoubtedly require significant new transmission build, that buildout should be done by optimizing existing transmission assets to the greatest extent possible, including leveraging ATTs to expedite the interconnection of new loads and meet short-term needs while longer-term upgrades are developed. As a result of FERC actions and the requirements of Sub. HB 15, significant additional information will be provided by utilities and developers to aid in the consideration of ATTs and the evaluation of opportunities where they can be beneficially deployed. Finally, the PUCO would like to thank the members of the General Assembly for their leadership, interest, and engagement in this important matter.

The PUCO also appreciates the concerns of utilities in deploying new technologies. Utilities are responsible for the reliable and affordable operation of the grid 24/7/365 and must be able to predict how the grid will respond to the deployment of devices at any location. The PUCO agrees with FERC’s statement in Order No. 2023 that “this final rule mandates a process of evaluation of alternative transmission technologies, not outcomes in specific cases, and does not create a presumption in favor of using an alternative transmission technology as a substitute for a traditional network upgrade deemed necessary in a specific case.”⁶⁸

⁶⁸ Order No. 2023 at P 1584.

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