Grid Enhancing Technologies – An Overview

Executive Summary

After a decade or more of relatively flat growth, electricity demand is now surging at the fastest pace in decades as data centers and increased electrification put pressure on the grid.[1] To meet this increased demand, while keeping electricity reliable and affordable for customers, will require both maximizing the potential of today's grid and also developing and commercializing new technologies. As a result, there is growing interest in emerging energy technologies such as Grid Enhancing Technologies (GETs).

As energy demand grows and more generation resources wait in interconnection queues, increasing transmission capacity—by both using the current grid more efficiently and building new transmission—to reduce stress on the current grid is necessary. However, building new transmission lines is a time-consuming and costly endeavor,[2] in part due to often long and contentious siting and permitting procedures and other issues. In this context, GETs—which refers to a range of hardware and software that can increase the capacity, efficiency, and reliability of existing power lines—are getting increased attention as a near-term alternative.[3] GETs include advanced conductor materials, power flow control devices, dynamic line ratings, and new analytical software.

Grid Enhancing Technologies

Advanced Conductors

Advanced conductors – made from non-traditional materials like carbon fiber or aluminum alloy – can operate at higher temperatures and meet higher safety standards.[4] Retrofitting existing transmission lines with advanced conductors, a process known as "reconductoring," can boost current-carrying capacity without significant modification or rebuilding. Using advanced conductors on short-distance AC lines can potentially increase their capacity by 5-50%.[5] However, given their relatively recent availability, there is a lack of data on the long-term benefits and challenges of using advanced conductors. Globally, over 90,000 miles of advanced conductors have been deployed. Belgium pioneered the reconductoring practice in 2009.[6]

- **Examples of Vendors**: 3M Energy Solutions, TS Conductor, NanoAL, CTC Global, Southwire, NEXANS, LS Cable, VEIR, Prysmian and General Cable

Advanced Power Flow Control

Advanced Power Flow Control technology can control the magnitude of power flows along specific transmission lines and bypass electric bottlenecks. When a specific line gets overloaded, Advanced Power Flow Control devices add voltage onto that line to raise its impedance and reroute power onto other underutilized lines. By reducing electric congestion, it can increase the grid's overall capacity. A study by the Department of Energy (DOE) on the New York state grid shows that, "…dynamic line rating and power flow controllers reduce renewable energy curtailment by 43% and improve electricity rates…by alleviating congestion in the 2030 New York state grid vision…".[7]

- **Examples of Vendors:** SmartWires

Dynamic Line Rating Systems (DLRs)

The maximum capacity of a transmission line depends on temperature, tension, wind speed, and many other factors. Traditionally, transmission lines are given static line ratings which are based on predetermined weather conditions. For example, windy and cold days can cool the line, which increases the load capacity and raises its line rating, whereas hot days can decrease the load capacity and reduce its line rating. Dynamic Line Rating systems (DLRs) use sensors to monitor local weather conditions and provide real-time data on the power line's true current-carrying capacity.

This allows the system operator to safely exceed the power line's labeled limit and unlock more grid capacity. A study by the New York Power Authority (NYPA) showed that DLRs can increase line capacity by 50% when compared to static ratings. [8] Overall, DLRs can help, "…[avoid] transmission expansion investment costs on congested lines, reduce generation costs…and increase system reliability."[9]

In 2022, PPL Electric became the first U.S. electric utility to integrate DLR technology into real-time and market operations and send hourly, day-ahead forecasts generated from the DLR system to PJM interconnection to help coordinate more efficient generation and ensure reliability.[10, 11, 12] The deployment of DLR "…reduced congestion costs on one transmission line from about $66 million…to about $1.6 million…"[13]

- **Examples of Vendors**: Elia, Heimdall Power, Ampacimon, Lindsey, LineVision

Topology Optimization

Topology optimization software platforms help unlock more grid capacity by reducing congestion and re-routing power flow around bottlenecks. The software's smart algorithms assess the combinations of circuit breaker control settings and present the optimal configuration of transmission networks, which allows transmission operators to reduce congestion costs and minimize power curtailment. This task is too complex for traditional power-flow modeling software. Furthermore, Topology Optimization software does not require the installation of new hardware, which reduces costs. [14]

- **Examples of Vendors**: NewGrid, Pearl Street Technologies, Cognite, Envelio

Other Grid Enhancing Technologies

More broadly, GETs can include other technologies that help maximize transmission capacity and mitigate congestion, such as virtual power plants (VPP), distributed energy resources, and demand response measures.

Challenges and Opportunities

GETs are a set of tools that can help address transmission challenges, improving the efficiency and effectiveness of electricity delivery and increasing the reliability and resilience of the system.[15] Since GETs are currently available, they offer an immediate opportunity to accommodate increasing demand, ensure affordability and reliability, and maximize the potential of today's grid.

However, the adoption of GETs has proceeded slowly due, in part, to limited familiarity and experience with the various technologies. GETs also face challenges such as low awareness and misperceptions of technologies, lack of operational data and models, and risk aversion issues.

Opportunities

GETs offer numerous opportunities to expand transmission and distribution capacity by improving the current utilization of the system and efficiency.[16] Technologies such as DLR, topology optimization, and advanced power flow control can "…increase system utilization by allowing for transmission lines to increase power flow while still operating within safe capacity margins."[17]

Additionally, GETs can help defer and/or avoid the costs from rebuilding or upgrading transmission and distribution infrastructure. [18] This can help in alleviating upward cost pressures for ratepayers and electric companies. [19]

GETs can also improve system reliability and resilience. For example, advanced conductors are able to withstand higher wind speeds and higher temperatures. Furthermore, the use of GETs can help reduce renewable curtailments by increasing capacity on congested lines.[20]

Challenges

GETs face numerous challenges, one of which is that they are not a single technology but rather many different types of hardware and software that can be used individually or in combination. While this can be positive since it allows for unique combinations of GETs fitted for each location, "selecting the optimal set of technologies for a given situation will require assessments that can evaluate advanced transmission technologies against one another, as well as against traditional solutions".[21] Furthermore, some benefits from GETs – such as improved situational awareness, asset deferral, and improved resilience — are not easily quantifiable and thus assessments for GETs are incomplete. [22]

Additionally, there is a low awareness and understanding of grid solutions. Within the industry there is no widely accepted definition or taxonomy for grid enhancing technologies, which "perpetuates technology misperceptions and can drive an unintended investment outcome."[23]

Advanced grid technologies are not often evaluated in depth due to the lack of awareness of the technology and a lack of operational data from the hardware or software, which results in solutions "…not fully [being] considered and…difficult to quantify and/or monetize…"[24] Additionally, many grid operators are unaware of which GETs would be needed and how to integrate them into the existing grid.[25] Some consequences of this have been a lack of in-depth performance data which has led to real and perceived uncertainty by grid operators. [26]

There are risk aversion barriers to adopting GETs due to the fear that they may increase (real or perceived) system risk.[27] Electric companies and regulators face larger risks with adopting new innovative technology, due to the need to maintain system reliability for customers and given that grid operators "…bear all financial and operational risks of new technology deployments."[28]

EEI Member GETs Projects

1. **EEI Member**: PPL
   Technology Scope: Integrate DLR technology into real-time and market operations. Since October 2022, PPL Electric has been sending hourly, day-ahead forecasts generated from the DLR system to PJM Interconnection, the regional transmission organization, to help coordinate more efficient generation and ensure reliability.
   Technology: Dynamic Line Rating (DLR)
   - Press Release

2. **EEI Member:** American Electric Power Service Corporation (AEP)
   Project Scope: The proposed work will transform distribution management and the administration of DERs in huge swaths of the American East and Midwest, facilitating more reliable grid conditions, lower energy costs, and economic investment to impacted communities
   Technology: Advanced Distribution Management System (ADMS), Distributed Energy Resource Management System (DERMS), Fault location, Isolation, and Service Restoration (FLISR), Distributed Energy Resources (DERs)
   - Project Fact Sheet

3. **EEI Member**: Arizona Public Service Company (APS)
   Project Scope: Key components include installing 900 new or upgraded field devices, deploying fault location, isolation, and system restoration (FLISR) and volt/var optimization (VVO), implementing dynamic line rating (DLR) to provide real-time data on grid capacity, and developing a dynamic data platform. Use of DLR will allow APS to accommodate 10-15% additional load on congested DLR-equipped transmission lines. Using data gathered from DLR and smart grid deployments, APS will develop a dynamic data platform leveraging market-ready software to automate and inform business decisions around critical planning components.
   Technology: Dynamic Line Ratings (DLR), Fault location, isolation, and system restoration (FLISR), volt/var optimization (VVO), dynamic data platform
   - Project Fact Sheet

4. **EEI Member**: Central Maine Power
   Other partners: Versant Power
   Project Scope: The Governor's Energy Office and its utility project partners—Central Maine Power and Versant Power—will deploy leading-edge software and hardware technologies to create a more modern and dynamic grid that will drive robust deployment of distributed energy resources (DERs) and renewable energy deployment in Maine while increasing resilience and ensuring affordability for utility customers.
   Technology: Dynamic Line Ratings (DLR), Distributed Energy Resources (DER), Active Network Management (ANM), Advanced Distribution Management System (ADMS)
   - Project Fact Sheet

5. **EEI Member:** Duquesne Light Company
Project Scope: Duquesne Light Company's (DLC) Grid Visibility Program (GVP) will deploy grid-enhancing technologies (GETs) that will increase system capacity and enhance the use of clean energy. Increase transmission system capacity using dynamic line rating (DLR) technology, as demonstrated by DLC in a previous limited implementation.
Technology: Dynamic Line Rating (DLR)
    - Project Fact Sheet

6. **EEI Member**: Montana Dakota Utilities Co. and Innovative Energy Alliance
Project Scope: This project aims to significantly enhance the transmission capacity of a 54-mile segment from Hettinger to Elgin, North Dakota by replacing aged 69 kV conductors with 115 kV advanced carbon-core ACCC conductors. The initiative also upgrades three substations to accommodate the new voltage and integrate smart grid functions. Some of the specific upgrades include installing software, sensors, and interfaces for online weather data, allowing for dynamic line rating (DLR) and quicker system response
Technology: Dynamic Line Ratings (DLR), Reconductoring with Advance Conductor Technology, smart grid
    - Project Fact Sheet

7. **EEI Member**: Georgia Power Company
GETs Company: Southwire & LineVision
Project Scope: In response to Georgia's customer load growth and changes in electricity generation patterns, Georgia Power Company (GPC) will deploy grid-enhancing technologies (GETs) including dynamic line rating (DLR) technology and reconductoring. The project will help GPC meet critical capacity and flexibility for projected solar energy deployments and load growth in support of Georgia's economic growth.
Technology: Dynamic Line Ratings (DLR), Reconductoring with Advance Conductor Technology
    - Project Fact Sheet

8. **EEI Member:** Portland General Electric Company
Project Scope: This project will accelerate the transformation of electric utility infrastructure by deploying smart grid chips (SGCs). The SGC solution includes field grid devices incorporating a high-end computing processor and a suite of software platforms. The project supports PGE's ambitious clean energy targets by deploying an innovative technical approach that helps to optimize and integrate distributed energy resources (DERs).
Technology: Distributed Energy Resources (DERs), Smart Grid Chips (SGCs)
    - Project Fact Sheet

1. **EEI Member**: Avista Utilities & Idaho Power Company
GETs Company: SmartValve & Infravision

Project Scope: Reconstruct the Lolo-Oxbow 230kV transmission line, employing wildfire resilient designs and materials. Will use Infravision's TX drone system using drones to string new lines, limiting outages during construction. Deploy innovative advanced power flow controllers that can provide real-time system visibility and control to optimize power flow and energy dispatch. Will increase interregional transfer capacity by approximately 635 MW.
Technology: TX drone systems, Advanced power flow controllers

- Project Fact Sheet

2. **EEI Member**: NextEra Energy (FPL)
Project Scope: Integrating fault locators and manhole monitors in more than 600 vaults and 800 manholes will extend the life of underground transformers, enable timely conditional-based maintenance for underground infrastructure, and enable rapid prioritization of outage recovery efforts through real-time monitoring.
Technology: PowerVault (Fault locators and manhole monitors)
    - Project Fact Sheet

3. **EEI Member**: NextEra Energy (FPL)
GETs Company: Switched Source LLC
Project Scope: Switched Source will work with FPL to deploy Phase-EQ, distribution automation power flow controller technology in Florida. Phase-EQ intelligently optimizes power flow in distribution circuits, which will unlock over 200 MW of system capacity and improve reliability on circuits serving Disadvantaged. By addressing planning and operational challenges, this project will help shorten outages by 10% on impacted circuits, save 300,000 MWh of energy per year, and avoid about $20 million in operational expenses over 20 years.
Technology: Distribution Automation Tool (Phase-EQ)
    - Project Fact Sheet

4. **EEI Member**: National Grid
Project Scope: Will deploy innovative digital technology solutions to maximize the value of distributed energy resources (DERs). The project will build upon foundational grid modernization investments in advanced metering infrastructure (AMI), advanced distribution management systems (ADMS), distributed energy resource management systems (DERMS), and fault location, isolation, and service restoration (FLISR) currently underway in electric service territories across New York and Massachusetts.
Technology: DERs, AMI, ADMS, DERMS, FLISR
    - Project Fact Sheet

5. **EEI Member**: Southern California Edison and Pacific Gas & Electric (PG&E)
Other Partners: California Independent System Operator (CAISO), the California Public Utilities Commission.
Project Scope: Deploying advanced conductors and DLR across the system will increase transmission capacity of the targeted lines to allow more than 1 GW of incremental renewable energy interconnection. Further, improvements to the

transmission interconnection process can accelerate renewable energy project deployment and improve transparency in the CAISO queue.
Technology: Advanced Conductor Technologies, Dynamic Line Ratings (DLR)

- Project Fact Sheet

Endnotes

[1] "EIA Extends Five Key Energy Forecasts through December 2026," U.S. Energy Information Administration (EIA), January 15, 2025, https://www.eia.gov/todayinenergy/detail.php?id=64264.
[2] Omid Mirzapour, Xinyang Rui, and Mostafa Sahraei-Ardakani, "Grid-Enhancing Technologies: Progress, Challenges, and Future Research Directions," *Electric Power Systems Research* 230 (May 1, 2024): 3, https://doi.org/10.1016/j.epsr.2024.110304.
[3] Mirzapour, Rui, and Sahraei-Ardakani, 3.
[4] "EPRI Fact Sheet: Advanced Conductors," Grid-Enhancing Technologies for a Smart Energy Transition (EPRI, June 2024), 1, https://restservice.epri.com/publicdownload/000000003002030547/0/Product.
[5] "EPRI Fact Sheet: Advanced Conductors," 1.
[6] Emilia Chojkiewicz et al., "2035 and Beyond the Report: Reconductoring" (GridLab, April 2024), 42.
[7] Mirzapour, Rui, and Sahraei-Ardakani, "Grid-Enhancing Technologies," 7.
[8] Mirzapour, Rui, and Sahraei-Ardakani, 14.
[9] Mirzapour, Rui, and Sahraei-Ardakani, 14.
[10] "PPL Electric Utilities' First-of-Its-Kind Innovation Improves Reliability, Reduces Costs," PPL Newsroom, accessed April 23, 2025, https://news.pplweb.com/2023-07-11-PPL-Electric-Utilities-first-of-its-kind-innovation-improves-reliability,-reduces-costs.
[11] Katie Mulvaney et al., "GETting Interconnected in PJM" (RMI, February 2024), 32.
[12] Ethan Howland, "GETs Could Facilitate 6.6 GW of Clean Energy in Five PJM States, Saving $1B a Year: RMI," UtilityDive, February 15, 2024, https://www.utilitydive.com/news/gets-grid-enhancing-technology-dlr-pjm-rmi/707612/.
[13] Howland.
[14] "Advanced Transmission Technologies" (U.S. Department of Energy, December 2020), 14, https://www.energy.gov/sites/prod/files/2021/02/f82/Advanced%20Transmission%20Technologies%20Report%20-%20final%20as%20of%2012.3%20-%20FOR%20PUBLIC.pdf.
[15] "Advanced Transmission Technologies," i.
[16] Louis White et al., "Pathways to Commercial Liftoff: Innovative Grid Deployment," Pathways to Commercial Liftoff (U.S. Department of Energy, April 2024), 15.
[17] White et al., 15.
[18] White et al., 16.
[19] White et al., 16.
[20] Mirzapour, Rui, and Sahraei-Ardakani, "Grid-Enhancing Technologies," 17.
[21] White et al., 59.
[22] "Advanced Transmission Technologies," ii.
[23] White et al., "Pathways to Commercial Liftoff: Innovative Grid Deployment," 49.
[24] White et al., 52.
[25] White et al., 56.
[26] White et al., 49.
[27] White et al., 58.
[28] White et al., 59.