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Northwest **Power** and
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October 7, 2025

MEMORANDUM

TO: **Council Members**

FROM: **Joe Walderman and Annika Roberts**

SUBJECT: **Grid Enhancing Technologies**

BACKGROUND:

Presenters: Joe Walderman & Annika Roberts, Council Staff
Jake P. Gentle, Idaho National Labs
Phil Anderson & Erik Schellenberg, Idaho Power

Summary: In our capacity constrained world, there is interest in and need for grid solutions that can be implemented quickly and cheaply. Large-scale transmission projects and upgrades can take many years and can be extremely cost and capital intensive. Grid enhancing technologies (GETs) and advanced reconductoring can help the region get more out of the existing system in the near term and delay or displace the need for larger infrastructure projects and upgrades. Staff has gathered a few regional experts to discuss their work GETs with the intention of starting the conversation of how GETs can be considered in the Ninth Power Plan.

Relevance: There is interest in the upcoming plan to explore the effects of different transmission trajectories on resource selection. This analysis may identify constraints that transmission could mitigate. GETs can serve as a piece of the transmission solution, one that many utilities in the region are exploring.

Workplan:

B.1.1. Advance ninth power plan development by developing scope, models and inputs, and other data and assumptions.

More info: Idaho National Lab, “Advanced Conductor Scan Report”: https://inl.gov/content/uploads/2024/10/23-50856_R12a_-AdvConductorsScanProjectReportCompressed.pdf

Idaho Power: News Release—“Idaho Power and Pitch Aeronautics Team up to Improve Transmission Capacity”: https://www.idahopower.com/news/idaho-power-and-pitch-aeronautics-team-up-to-improve-transmission-capacity/

Grid Enhancing Technologies

Joe Walderman & Annika Roberts

October 2025 Council Meeting

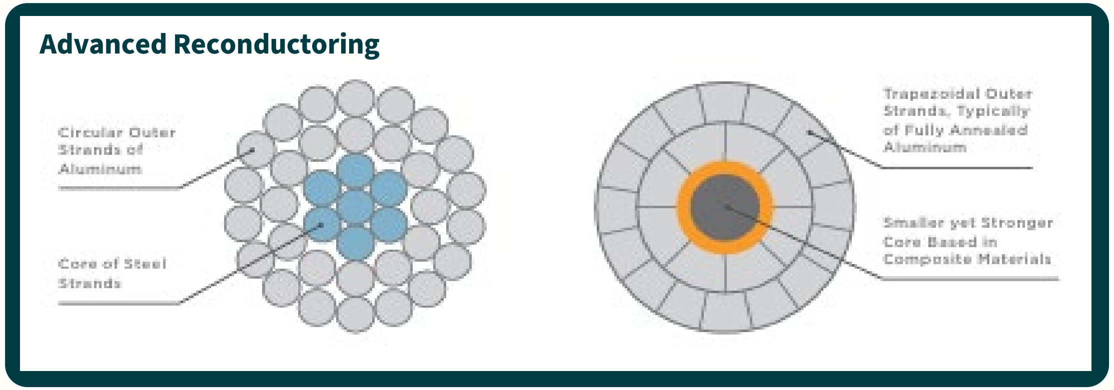
Northwest **Power** and
Conservation Council

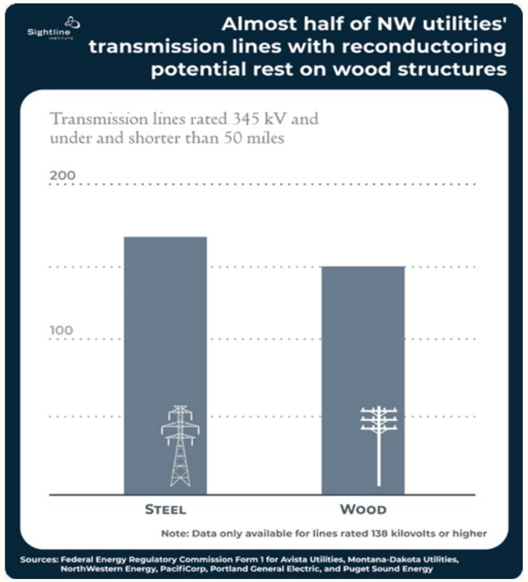
Agenda

- Overview with Joe & Annika
- Idaho National Labs
- Idaho Power
- Q&A

What are GETs?

- Hardware and/or software that can increase the capacity, efficiency, reliability or safety of existing transmission lines
  - Increases transmission capacity and reduces congestion
  - Can be deployed quicker and more cheaply than building new transmission
- Why GETs
  - In a capacity constrained world where big transmission projects are slow to be built but the capacity need is more immediate, grid enhancing technologies and advanced reconductoring can help the region get more out of the existing system in the near term and delay or displace the need for larger infrastructure projects
  - This won't solve all of the region's capacity problems, or entirely defer the need for new transmission, but can maybe help span the gap in the interim

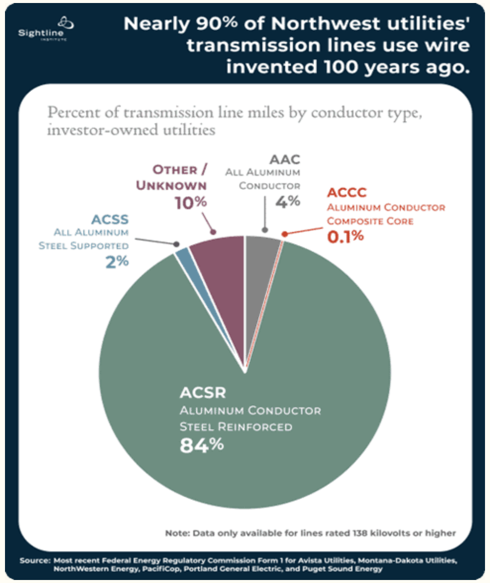

Advanced Reconductoring


Almost half of NW utilities' transmission lines with reconductoring potential rest on wood structures

Transmission lines rated 345 kV and under and shorter than 50 miles

Note: Data only available for lines rated 138 kilovolts or higher

Sources: Federal Energy Regulatory Commission Form 1 for Avista Utilities, Montana-Dakota Utilities, NorthWestern Energy, PacifiCorp, Portland General Electric, and Puget Sound Energy


Nearly 90% of Northwest utilities' transmission lines use wire invented 100 years ago.

Percent of transmission line miles by conductor type, investor-owned utilities

Note: Data only available for lines rated 138 kilovolts or higher

Source: Most recent Federal Energy Regulatory Commission Form 1 for Avista Utilities, Montana-Dakota Utilities, NorthWestern Energy, PacifiCop, Portland General Electric, and Puget Sound Energy

Types of GETs

GETs Type	Definition	Timing	Capacity Δ	Applicability
Advanced Reconductoring	Replace steel conductor cores with smaller, lighter composite cores Enables higher operating temps and avoids additional line sag	18-36 months	About 2x increased capacity	Lines with capacity constraints caused by thermal limitation (ie short lines, <50 miles, up to 345 kV) 20% of national transmission lines are viable candidates *(INL advanced reconductoring study)*
Dynamic Line Rating	Real-time calculation of a transmission lines thermal capacity based on local conditions More current can flow through lines on a day with lower temps, low solar radiation, and wind	3-6 months	15-30% increased capacity	Has greatest impact in climates w/ meaningful temp changes and/or high wind speeds
Adv. Power Flow Controls (PFC)/Topology Optimization (TO)	Hardware: uses power electronics to direct power away from congested lines Software: uses AI to reconfigure the grid by rerouting power by opening and closing circuit breakers to divert power from congested lines		PFC: 10-25% TO: 5-50% increased capacity	Best suited for transmission lines below 550 kV Can only be applied to meshed grid configurations (ie systems with multiple paths for power to flow) Economically viable for 50% (PFC) or 90% (TO) of US lines *(DOE Liftoff study)*

Policy Landscape

Federal—FERC:

Order 2023 (2023): Requires that “alternative transmission technologies” be considered when utilities are evaluating interconnection requests.

Order 881(2021): Requires transmission owners, both inside and outside of organized markets, to use ambient-adjusted ratings (AAR) to improve the accuracy of transmission line thermal ratings.

Order 1920 (2024/25): Requires transmission providers to evaluate GETs in the near-term and long-term regional planning processes.

Senate bill S.3918/HR.2703 (The Advancing GETs Act)—Proposed: would require FERC to establish a shared saving mechanism for GETs and require transmission owners to report congestion data if passed.

Region

Washington:

SB5466 (2025): Allows WA UTC to provide an incentive rate of return for utilities investing in grid-enhancing technologies and advanced transmission upgrades. Also exempts certain powerline upgrades and reconductoring projects from the State Environmental Policy Act if the stay within existing rights-of-way, though still requires them to notify the DAHP and consult with local tribes before beginning work.

Oregon:

HB3336 (2025): Requires power companies to file a plan for using GETs with the OR PUC identifying which grid-enhancing updates are most cost-effective and can be carried out by January 2030. Also requires local governments to review certain GETs applications without public hearings, to ease their installation.

Montana:

SB301 (2025): Streamlines the regulatory process for building or upgrading transmission facilities rated over 69kV, empowers the MT public service commission to evaluate proposals within a 300-day window.

HB729 (2023): Allows utilities to seek rate recovery for advanced conductor deployments if they deliver quantifiable benefits.

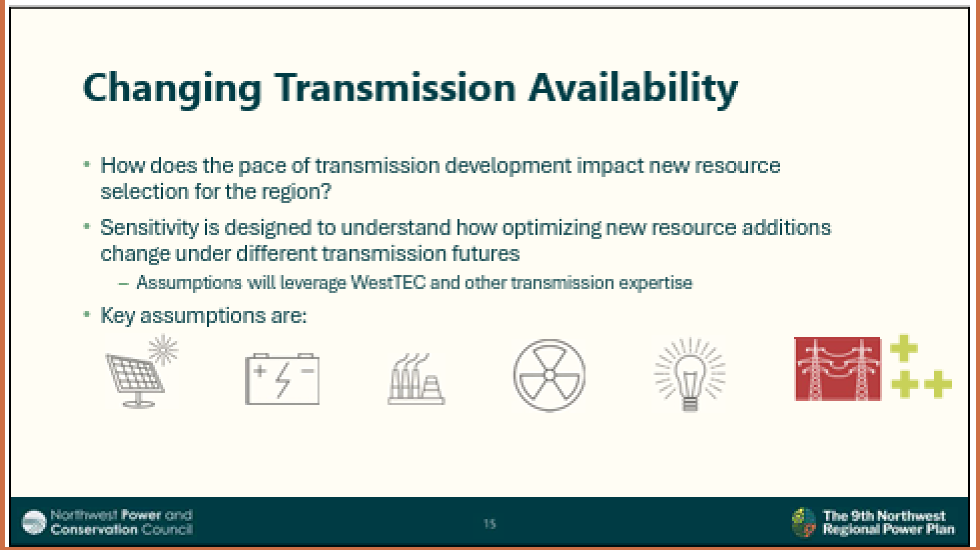
GETs in the Plan

- Not representing any grid enhancing tech or reconductoring as a competitive resources in the plan
  - Why?
    - We are not transmission engineers
    - The implementation of these technologies is varied and often very specific to the need of the utility doing the implementing and the characteristics of the line being enhanced

- However, that doesn't mean GETs will be left out of the Plan
  - WestTEC: any reconductoring or GETs included in the WestTEC transmission resource we're capitalizing on will be included in our modeling
  - Scenario modeling *will* reveal things about transmission needs, leaving a space to discuss GETs in the narrative of the Plan
    - There may be resource selection results that could be similarly served by enhanced transmission (like small-scale batteries being built to get around known congestion points)
    - There are things to be learned from the varied transmission looks in scenario analysis

Resource and Transmission Risk Scenario

Reminder:



Changing Transmission Availability

- How does the pace of transmission development impact new resource selection for the region?
- Sensitivity is designed to understand how optimizing new resource additions change under different transmission futures
  - Assumptions will leverage WestTEC and other transmission expertise
- Key assumptions are:

Northwest Power and Conservation Council

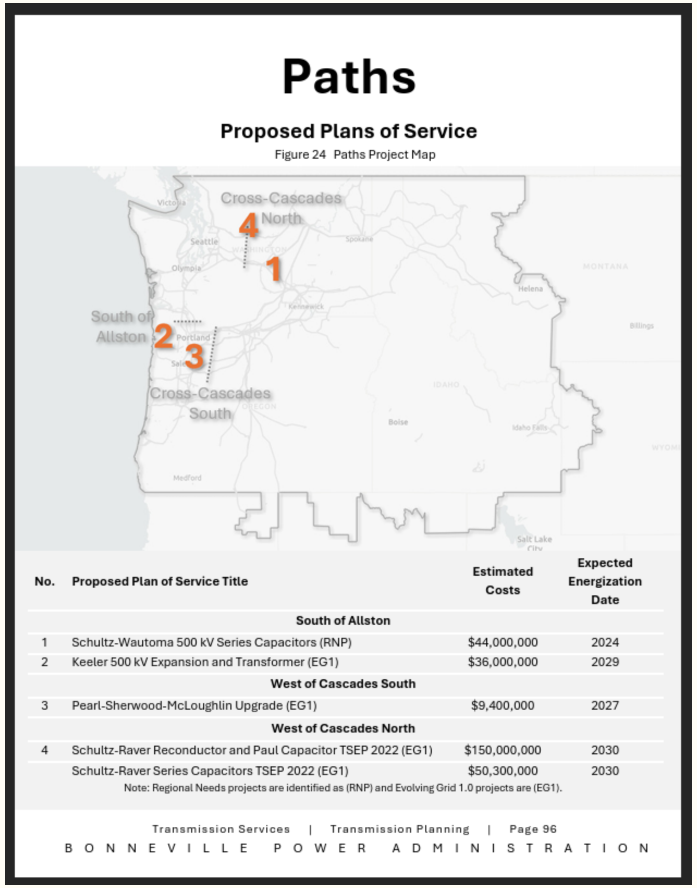
15

The 9th Northwest Regional Power Plan

- The changing transmission availability sensitivity aims to test how more or less transmission impacts resource builds
- Upgrade projects represented in the Transmission Plus sensitivity include:
  - Upgrades to M2W
  - Cross Cascades North & South
- GETs can be a piece of that solution
  - GETs can be deployed more quickly and cheaply than entirely new transmission projects

Transmission Plus:

Based on WestTEC 10-year priority projects



Paths

Proposed Plans of Service

Figure 24 Paths Project Map

No.	Proposed Plan of Service Title	Estimated Costs	Expected Energization Date
	South of Allston		
1	Schultz-Wautoma 500 kV Series Capacitors (RNP)	$44,000,000	2024
2	Keeler 500 kV Expansion and Transformer (EG1)	$36,000,000	2029
	West of Cascades South		
3	Pearl-Sherwood-McLoughlin Upgrade (EG1)	$9,400,000	2027
	West of Cascades North		
4	Schultz-Raver Reconductor and Paul Capacitor TSEP 2022 (EG1)	$150,000,000	2030
	Schultz-Raver Series Capacitors TSEP 2022 (EG1)	$50,300,000	2030

Note: Regional Needs projects are identified as (RNP) and Evolving Grid 1.0 projects are (EG1).

Transmission Services | Transmission Planning | Page 96

BONNEVILLE POWER ADMINISTRATION

North Cascades

- Schultz-Raver Reconductor & Paul Capacitor (2030)
- Schultz-Raver Series Capacitors (2030)

South Cascades

- Pearl-Sherwood-McLoughlin Upgrade TSEP (2027)

M2W

- New Moose Gully Compensation Substation
- Wire replacement on Dworshak—Taft No. 1
- Substation upgrades/expansions (Hatwai & Bell Substations)

Meet Our Panelists

Idaho National Lab

- Jake P. Gentle
- Senior Technical Manager with INL's Secure and Resilient Grid Integration Portfolio and Distributed Energy Systems Area
- Sharing a high-level perspective on GETs and how utilities nationally might best employ GETs
- The national lab offers broad expertise on this topic—that will help place our region in the broader national picture

Idaho Power

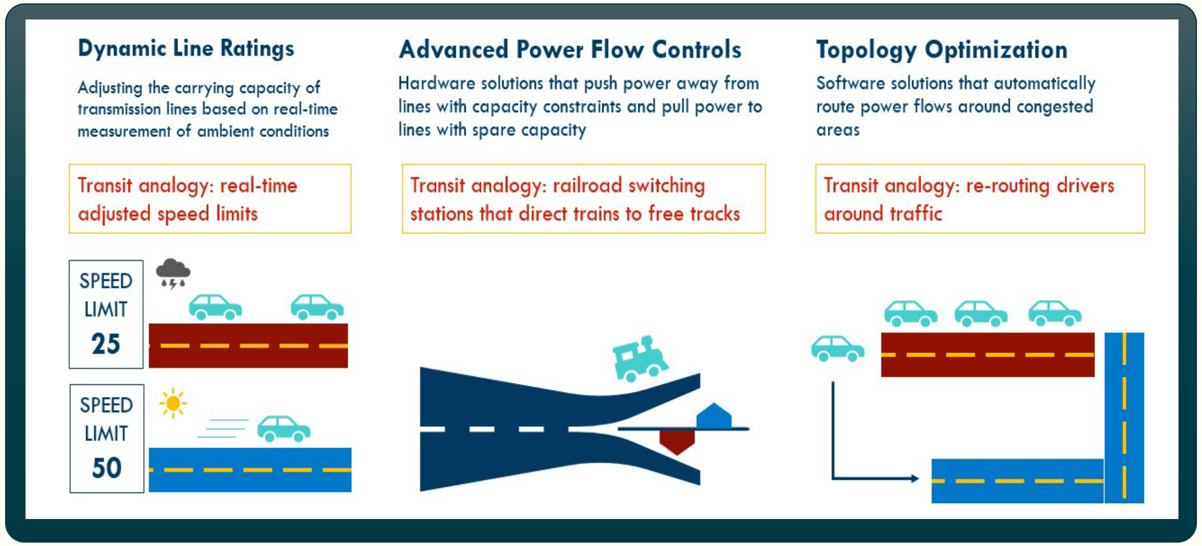
- Phil Anderson & Erik Schellenberg
- Engineers with Idaho Power's system planning team
- Sharing Idaho Power's experience with dynamic line rating and details on their current GETs DOE grant project
- Excited to hear how a regional utility is utilizing GETs

Idaho National Labs

Idaho Power

More Resources

- Idaho National Labs: “Advanced Conductor Scan Report”
- Applied Grid Solutions, ID National Labs
- Utility Perspectives on Making GETs Work, ESIG
- Idaho Power: News Release—“Idaho Power and Pitch Aeronautics Team up to Improve Transmission Capacity”
- EPRI: “Introduction to Grid Enhancing Technologies”
- RMI “GET a GRIP”
- DOE GridLab: “2035 Reconductoring Technical Report”



Dynamic Line Ratings

Adjusting the carrying capacity of transmission lines based on real-time measurement of ambient conditions

Transit analogy: real-time adjusted speed limits

Advanced Power Flow Controls

Hardware solutions that push power away from lines with capacity constraints and pull power to lines with spare capacity

Transit analogy: railroad switching stations that direct trains to free tracks

Topology Optimization

Software solutions that automatically route power flows around congested areas

Transit analogy: re-routing drivers around traffic

INL/CON-25-88465

Oct 15, 2025

Jake P. Gentle
Senior Technical Manager
Idaho National Laboratory

S M Shafiul Alam
Senior Power Systems Engineer
Idaho National Laboratory

Modernizing the Grid: Transmission Capacity and Dynamic Line Rating Research at INL

Supporting National Energy Independence and Grid Resilience

Northwest **Power** and
Conservation Council

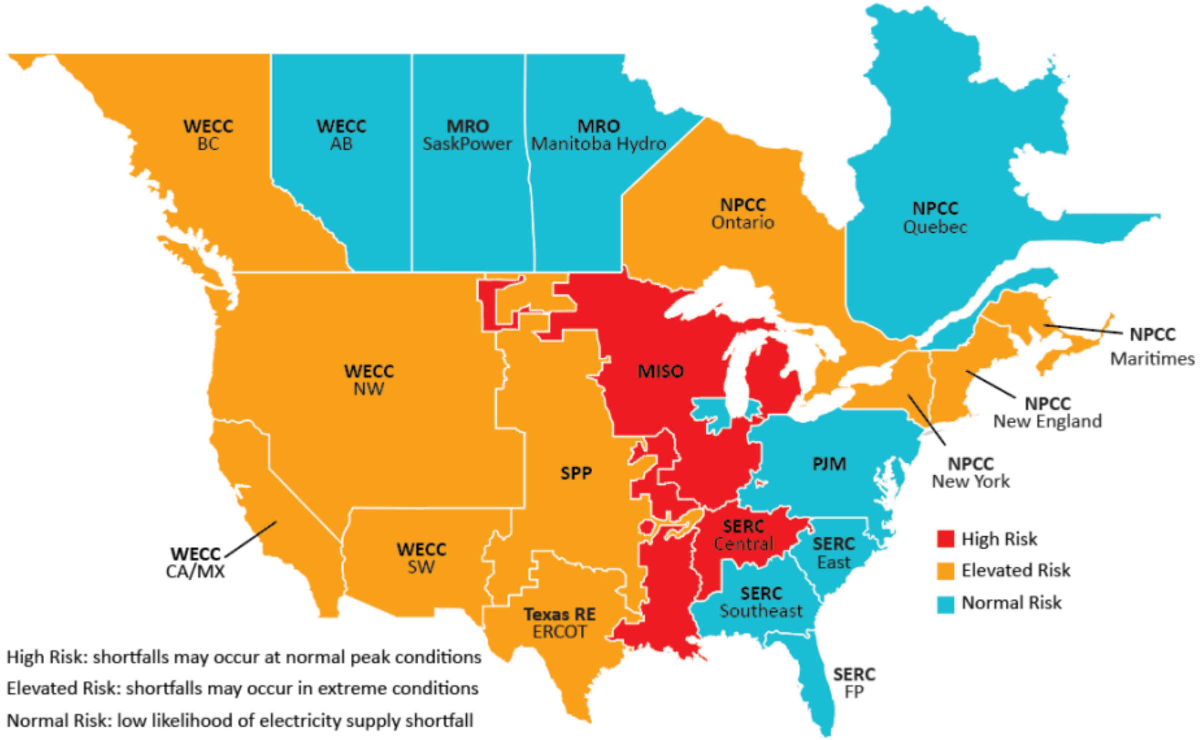
Idaho National Laboratory

https://www.nwcouncil.org/meeting/council-meeting-2025-10-15/

A Congested Outlook: Integrating a changing energy mix

Grid Transmission Capacity:	Aging infrastructure must be replaced or augmented to meet the increased power demand, ensuring a reliable and resilient grid that can support the growing energy needs of the nation.
Adding More Generation:	Changes to energy generation portfolios, including the integration of renewable energy sources, must be seamlessly incorporated into the existing power grid to enhance energy security and reduce dependence on foreign energy sources.
Geography Matters:	Renewable energy sources are often located far from load centers, necessitating extensive transmission infrastructure to carry electricity from generation sites to consumers, resource adequacy and transmission access is essential.
Slow Rate of Interconnection:	As more variable generation sources join the grid, congestion concerns are expected to rise substantially. Addressing this challenge is crucial to maintaining grid reliability and ensuring the efficient delivery of reliable energy to consumers.
Cybersecurity Concerns:	Systems that are still in the early stages of deployment and operations, may not have matured culture to support cybersecurity risk management. Strengthening cybersecurity measures is essential to protect the nation's energy infrastructure from potential threats and ensure the continued integration of new energy sources.

Changing Grid: Resource Adequacy and Reliability Concerns



High Risk: shortfalls may occur at normal peak conditions

Elevated Risk: shortfalls may occur in extreme conditions

Normal Risk: low likelihood of electricity supply shortfall

Figure 1: Risk Area Summary 2024–2028[8]

Trends Increasing Risks

- Significant load growth
- Dispatchable generator retirements
- Growth in variable energy resources
- Extreme weather events (e.g., electric-gas interdependency, curtailments)
- Slow transmission buildout

2023 NERC Long Term Reliability Assessment

Adapted from slides generated by Kerry Cheung, U.S. DOE Office of Electricity

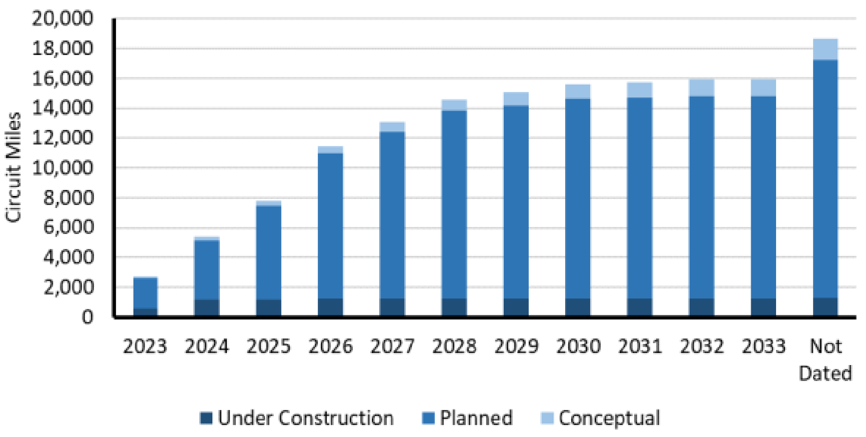


Figure 27: Future Transmission Circuit Miles >100 kV by Project Status

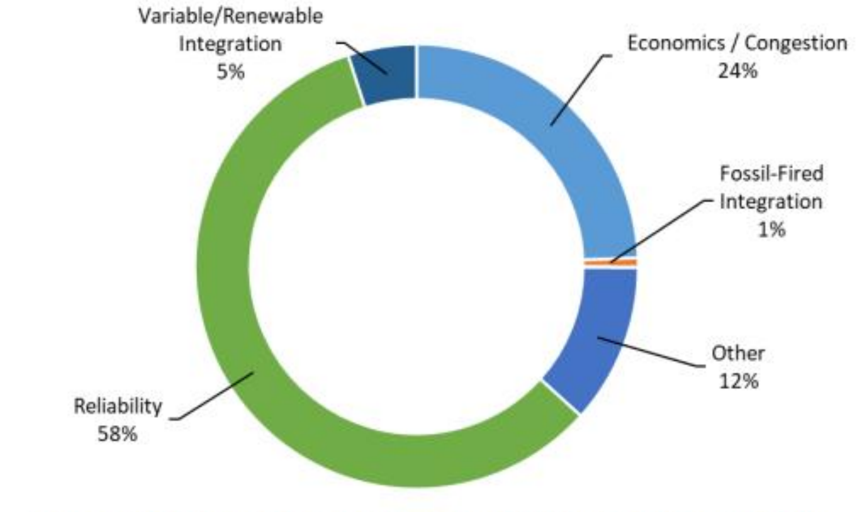


Figure 28: Future Transmission Circuit Miles by Primary Driver

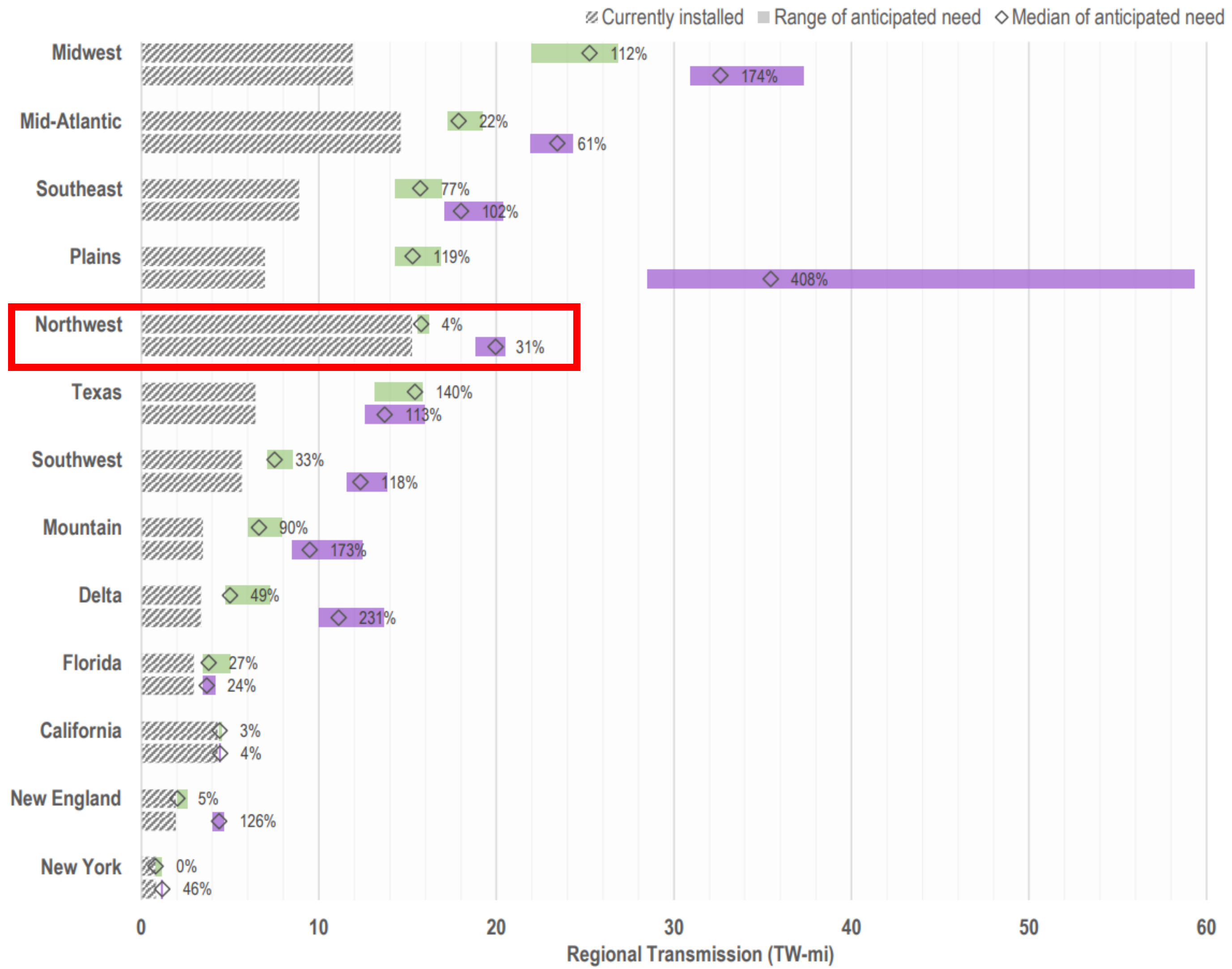
Improved Transmission Planning Needed

FERC Order 1920-A (Nov. 2024)

- Requirement to identify opportunities to modify in-kind replacement of existing transmission facilities to increase their transfer capability, known as “right-sizing.”
- Consider the use of Grid Enhancing Technologies (GETs) such as dynamic line ratings, advanced power flow control devices, advanced conductors and transmission switching.

Adapted from slides generated by Kerry Cheung, U.S. DOE Office of Electricity

Transmission Capacity Is Needed



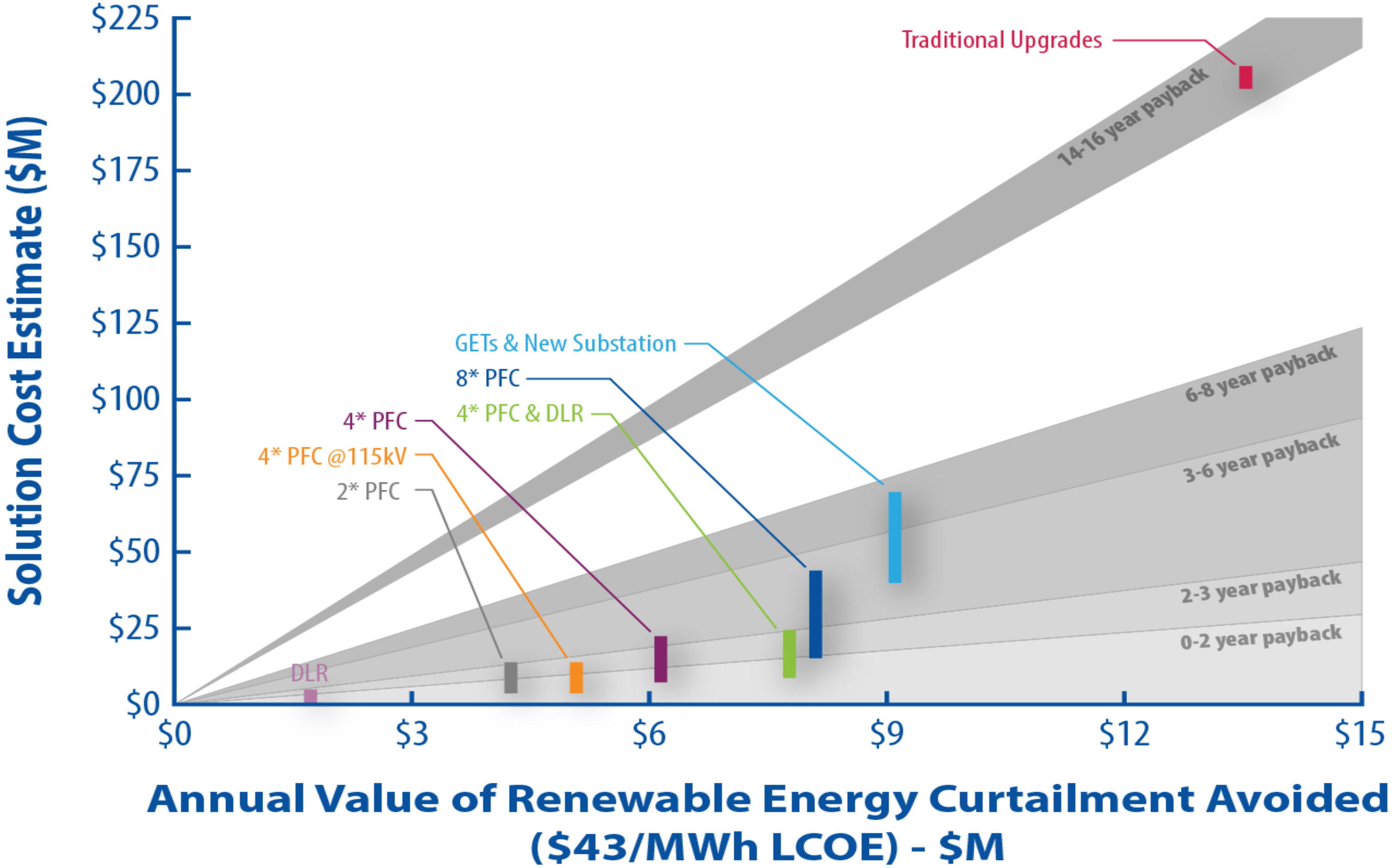
Anticipated within-region transmission need in 2035 for two scenario groups

Range of new transmission need for future scenarios with moderate load and high clean energy growth (green, top for each region) and high load and high clean energy growth (purple, bottom). Median % growth compared to 2020 system shown.

Key findings from the DOE National Transmission Needs Study (2023):

- **Northwest Region is expected to increase by 4% by 2035** assuming a moderate growth in demand and high growth in renewables.
- These 2035 deployment needs increase even more under high load growth scenarios, specifically for the **Northwest (31%)** region.

GETs: Relieving Grid Congestion



INL: 21-50332_CurtailAvoidanceCost_r4

- GETs cases provide optionality in addressing curtailment at a fraction of the cost
- Similar story across other system economic metrics
- Payback period appears to be faster for GETs
  - GETs lifecycle shorter than traditional upgrades
- Range of costs identified for each of the GETs cases

https://www.energy.gov/sites/prod/files/2019/08/f66/Congressional_DLR_Report_June2019_final_508_0.pdf
https://www.energy.gov/sites/default/files/2022-04/Grid%20Enhancing%20Technologies%20-%20A%20Case%20Study%20on%20Ratepayer%20Impact%20-%20February%202022%20CLEAN%20as%20of%20032322.pdf

GETs: Relieving Grid Congestion

Grid Enhancing Technologies (GETs) include, but are not limited to:

1. Power Flow Control (PFC) and optimized transmission switching
2. Storage technologies
3. Advanced line rating management
    - Ambient Adjusted Ratings (AAR)
    - Dynamic Line Ratings (DLR)
4. Advanced Conductors

Power Flow Control is a set of technologies that push or shift power away from overloaded lines and onto underutilized lines/corridors within the existing transmission network. Multiple power flow control solutions exist.

Dynamic Line Ratings (and Ambient Adjusted Ratings) Utilizes hardware and/or software used to appropriately update the calculated thermal limits of existing transmission lines based on real-time and forecasted weather conditions

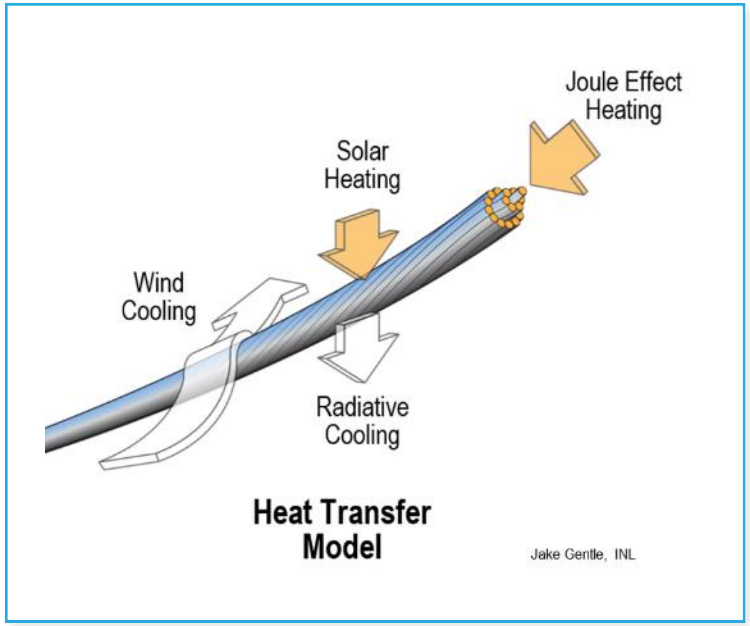
Contingency - the loss of a transmission component

Monitored Element - the elements overloaded when a contingency happens

Flowgate – the contingency and monitored element pair that limit power transfer across the transmission system (from wind/solar to load in this example)

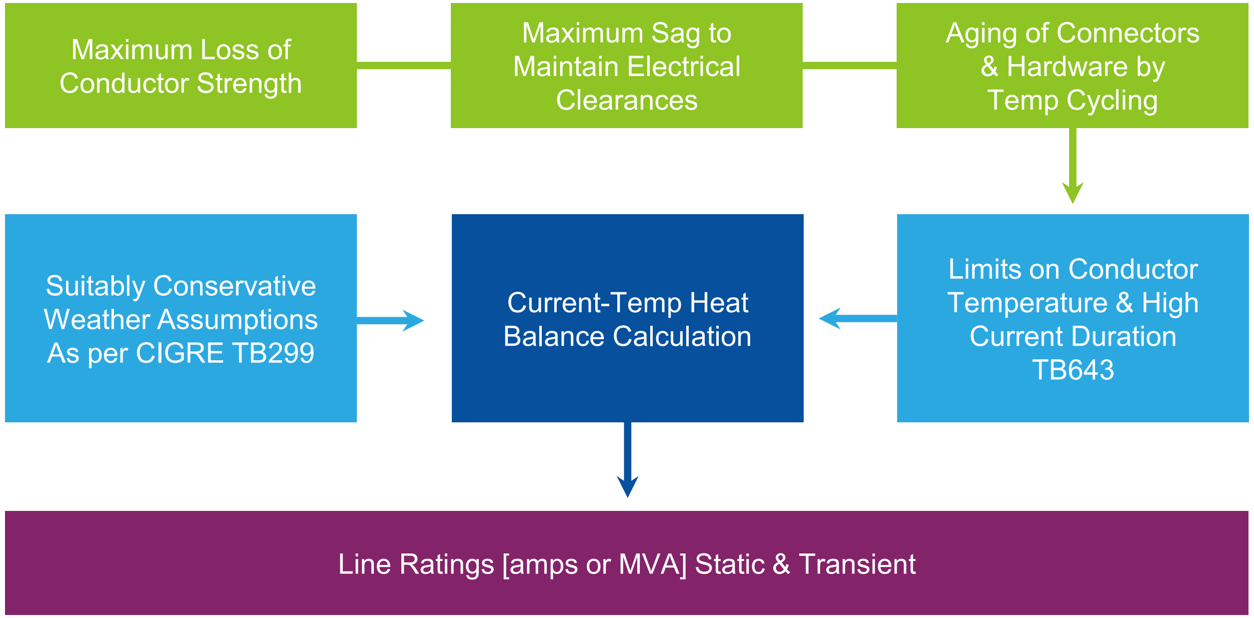
GETs definition from FERC Notice to Convene a Workshop on Grid-Enhancing Technologies: https://cms.ferc.gov/media/7198

What is a Line’s Thermal Rating?



Heat Transfer Model

Jake Gentle, INL



Maximum Loss of Conductor Strength

Maximum Sag to Maintain Electrical Clearances

Aging of Connectors & Hardware by Temp Cycling

Suitably Conservative Weather Assumptions As per CIGRE TB299

Current-Temp Heat Balance Calculation

Limits on Conductor Temperature & High Current Duration TB643

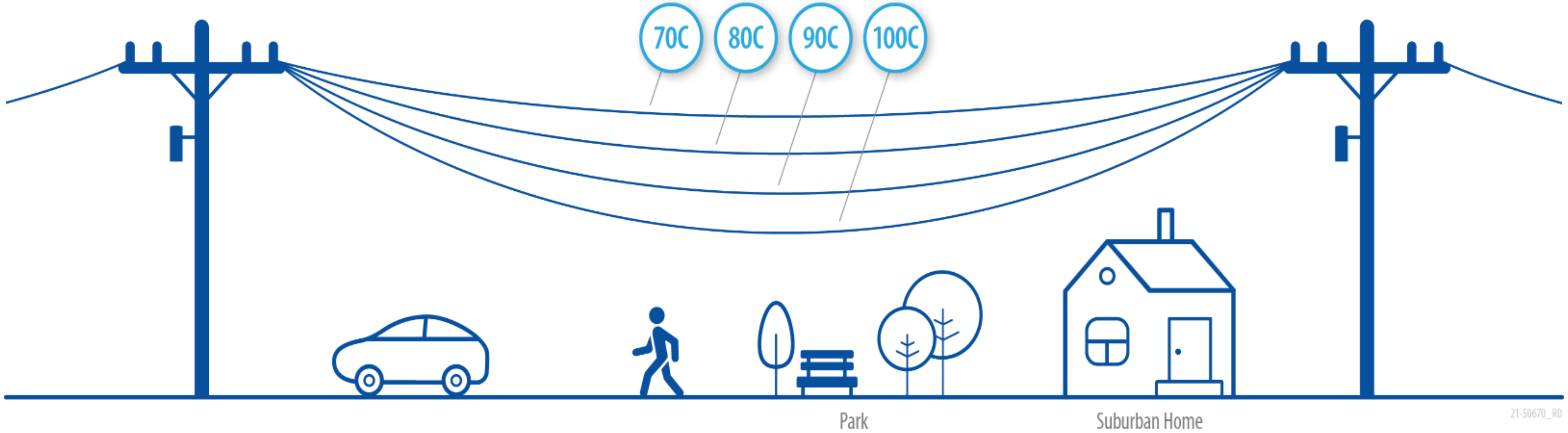
Line Ratings [amps or MVA] Static & Transient

Dale Douglass, DPC

- **Maximum current a line can carry** where the resulting line conductor temperature doesn’t exceed a specified maximum conductor temperature.
- The maximum conductor temperature is calculated **to limit cumulative damage** to the conductor system **assuring minimum electrical clearances** are maintained.

Ratings Come Down to Only a Few Things

Clearances



Roger Renwick, AltaLink

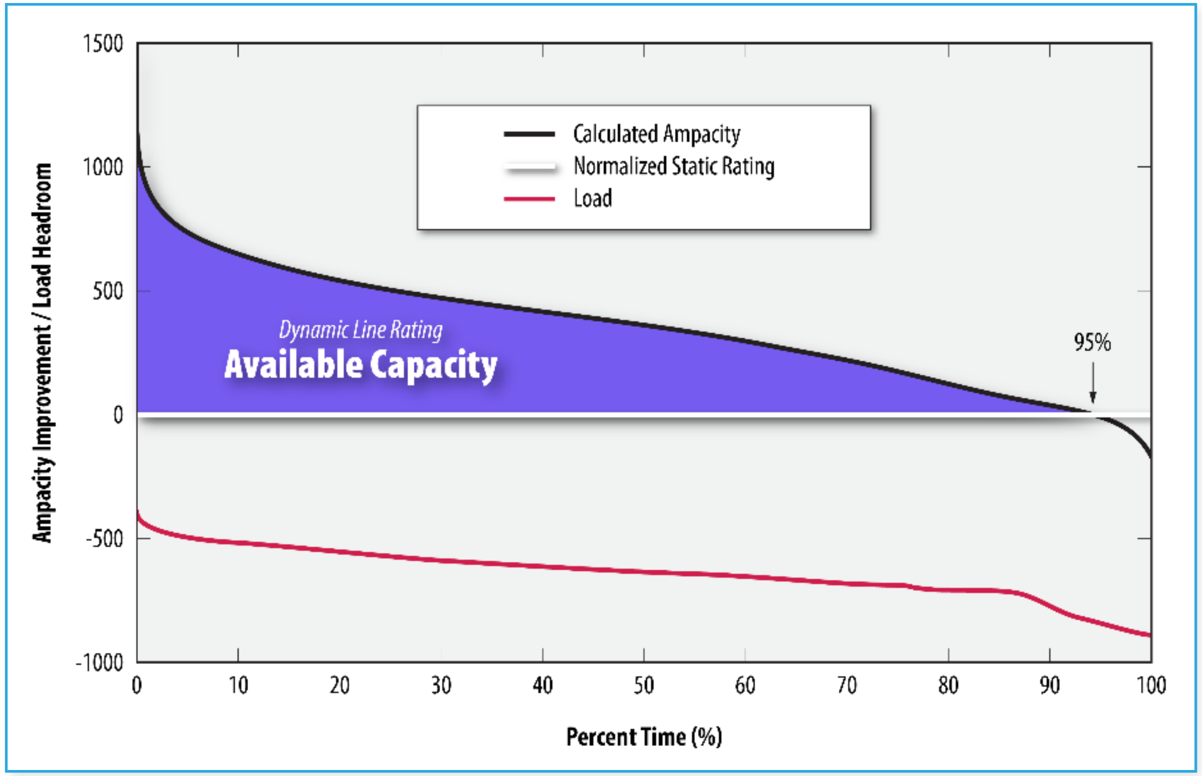
Why Should We Increase Our Ratings?

To safely increase line utilization

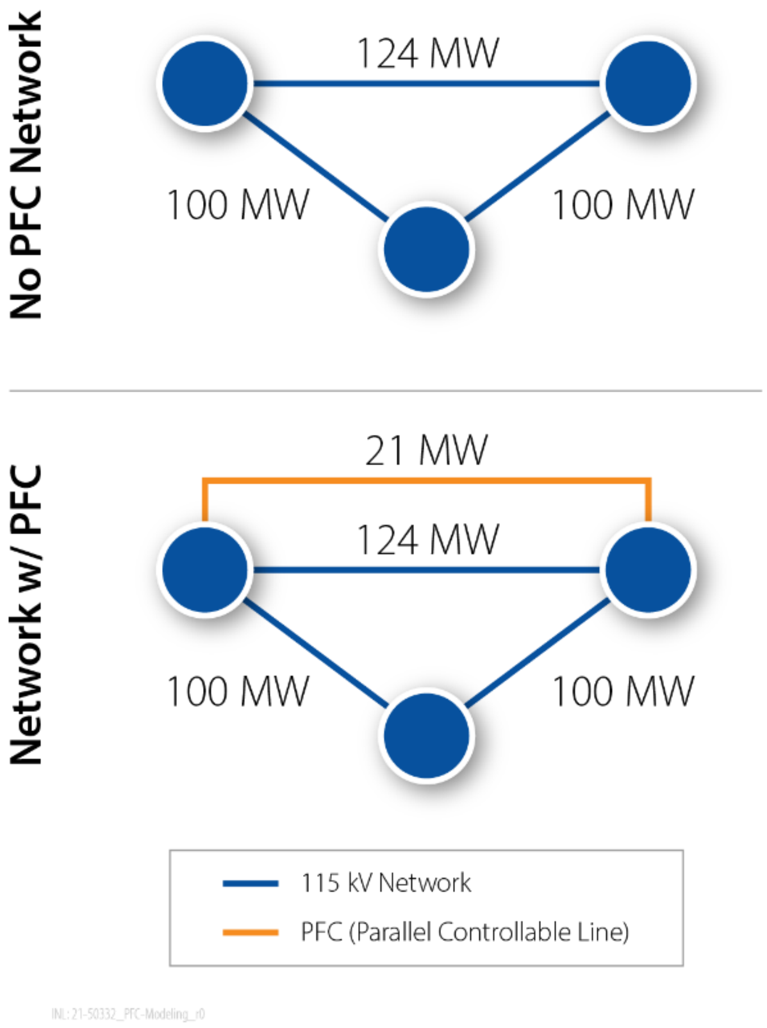
- Power Flow Optimizations
- More access to lower priced generators
- Contingency analysis

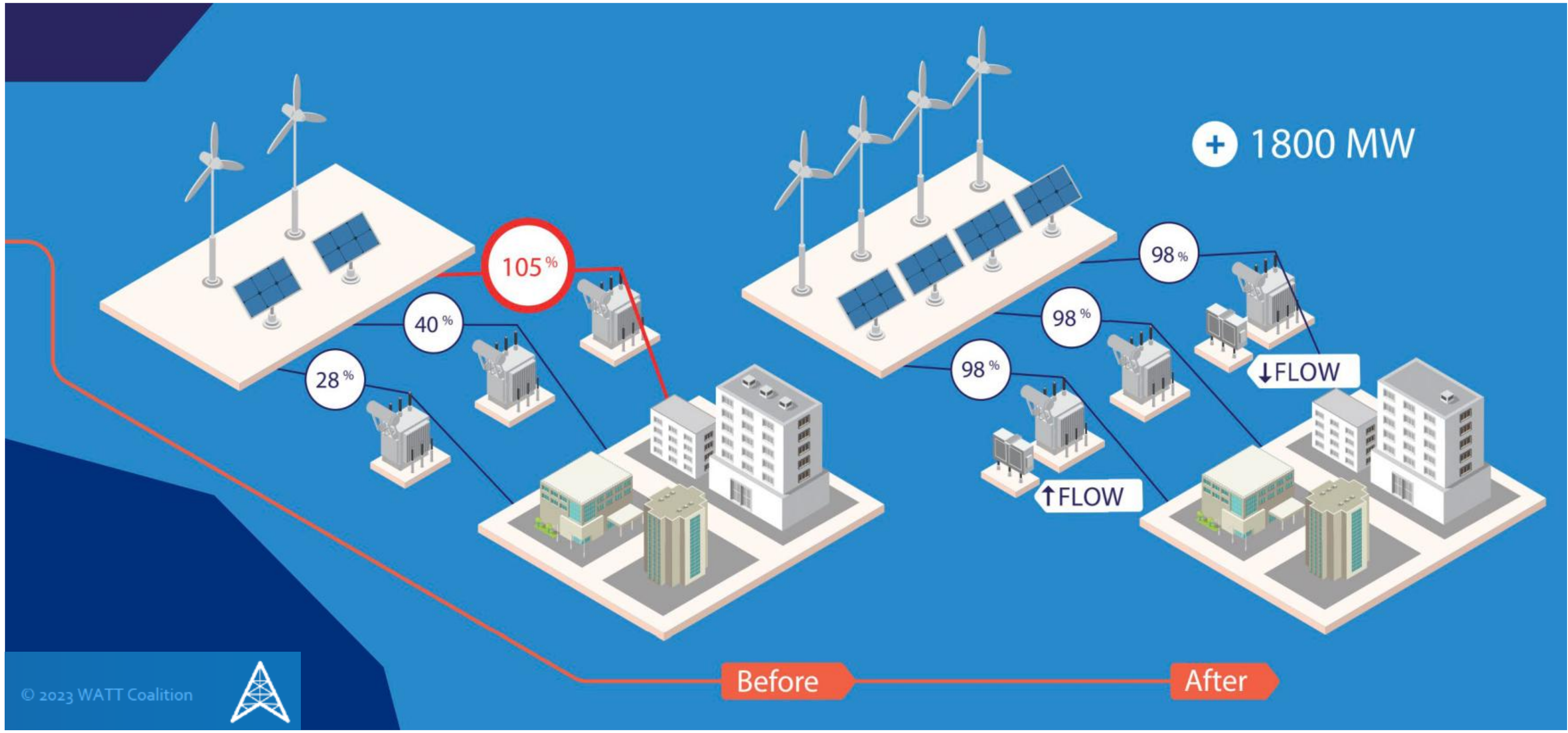
DLR accurately reflects the real-world

- Risk mitigations (equipment failure/fatigue)
- Safety & reliability



Advanced Power Flow Control





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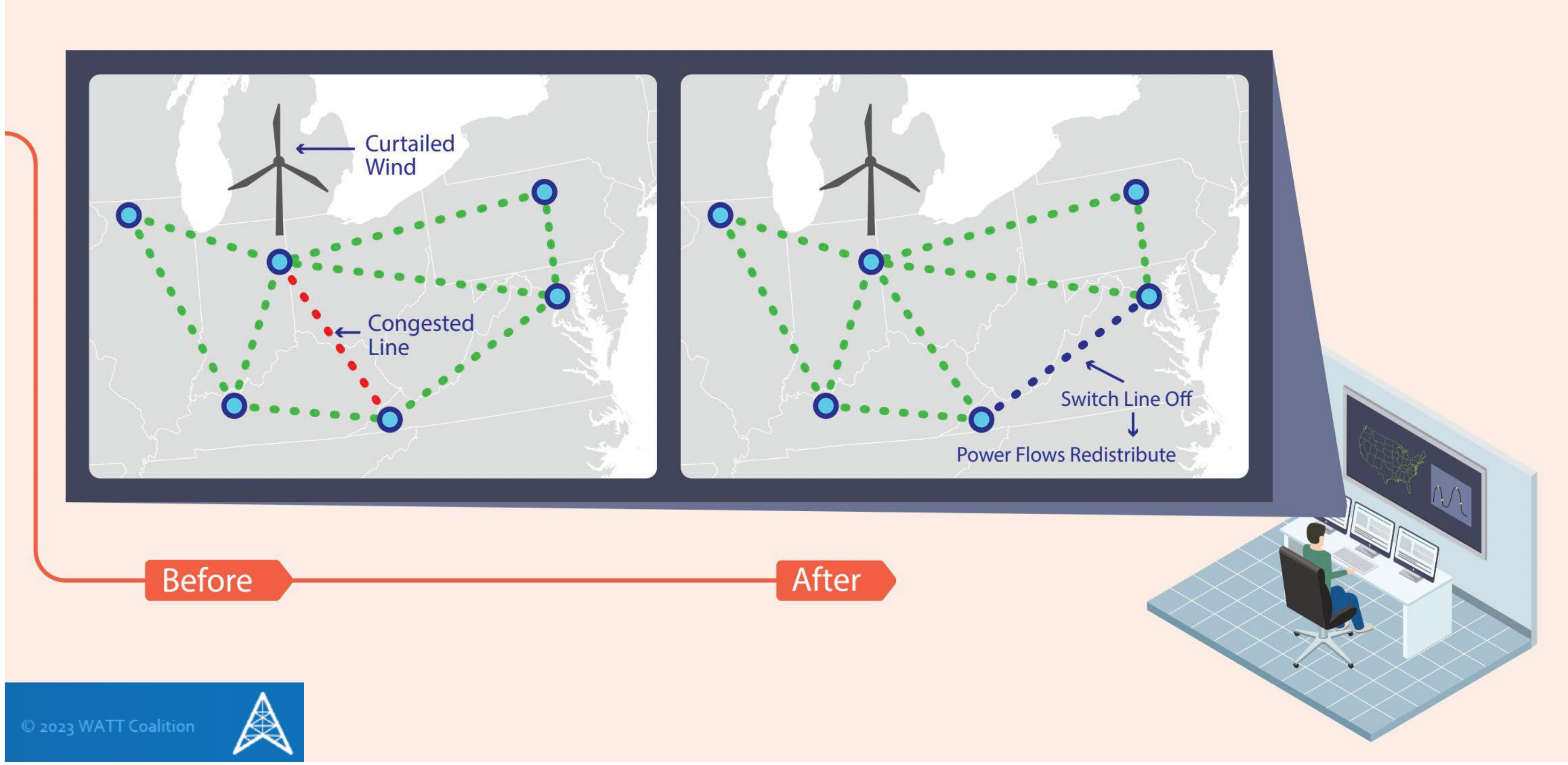
PFC allows system operator to reroute flows across the transmission network by changing line impedance

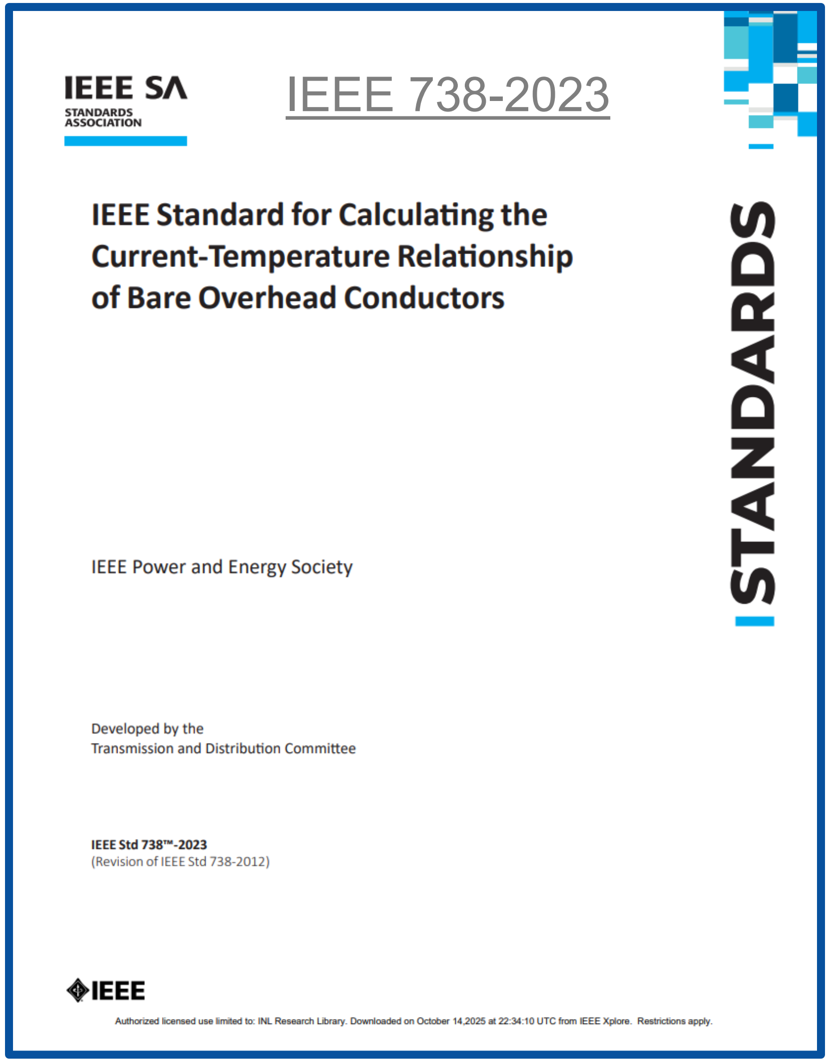
Topology Optimization

- ❑ Software finds and evaluates reliable reconfigurations to reroute flow around congestion
- ❑ Reconfigurations can be implemented by opening or closing circuit breakers.
  - ❑ Analogous to temporarily diverting traffic away from congested roads to make traffic flow smoother.
- ❑ Provides a high-level, actionable overview of whether there are reconfiguration options to mitigate the congestion patterns.



Legal and Regulatory Context

- FERC Order 881, Mandates transmission providers to implement ambient-adjusted ratings.



IEEE 738-2023

IEEE SA
STANDARDS ASSOCIATION

IEEE Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors

IEEE Power and Energy Society

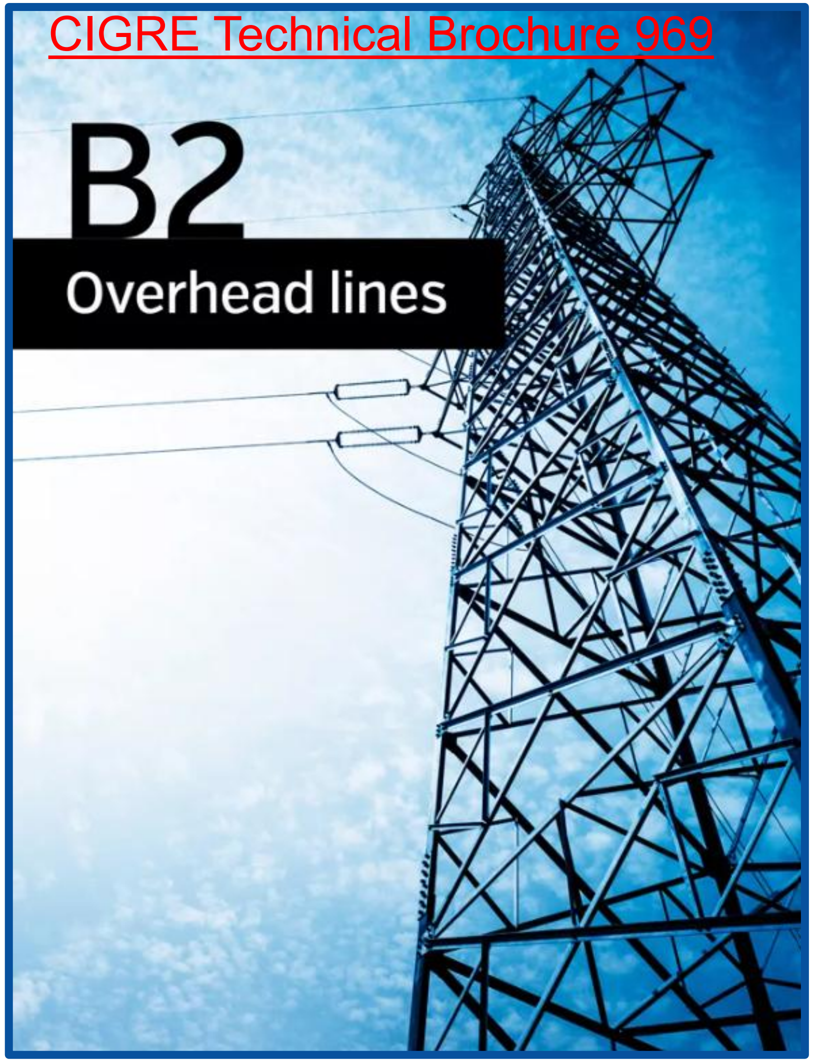
Developed by the
Transmission and Distribution Committee

IEEE Std 738™-2023
(Revision of IEEE Std 738-2012)

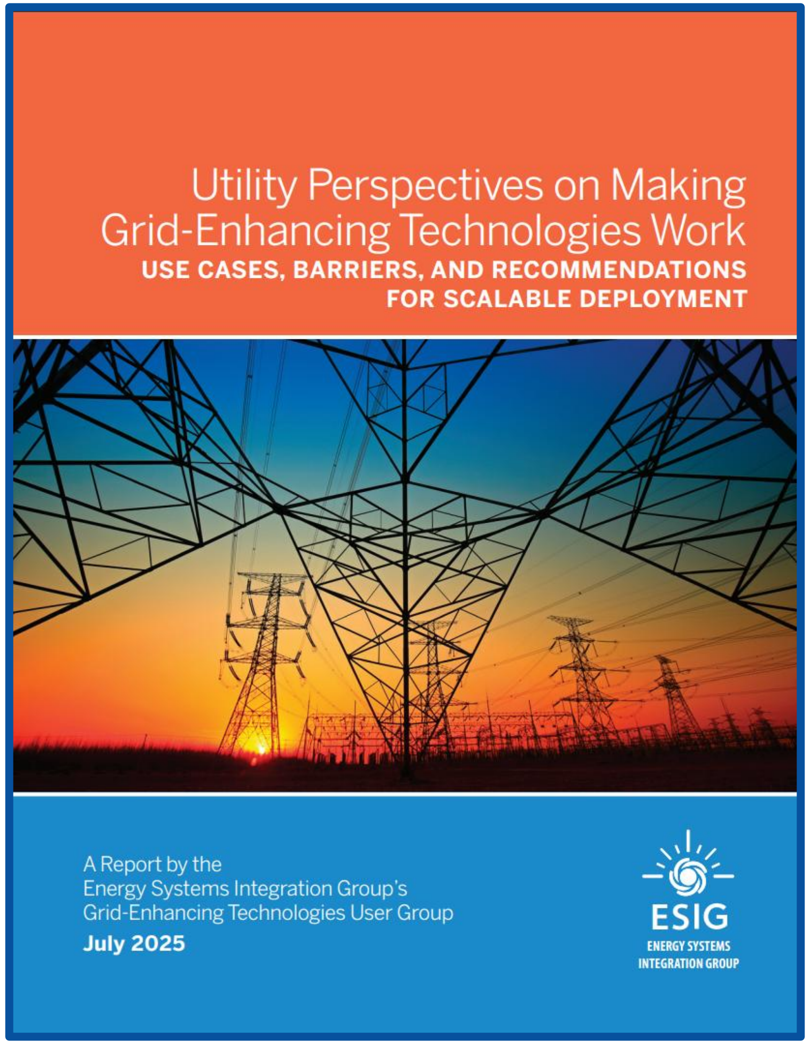
STANDARDS

IEEE

CIGRE Technical Brochure 969



B2
Overhead lines

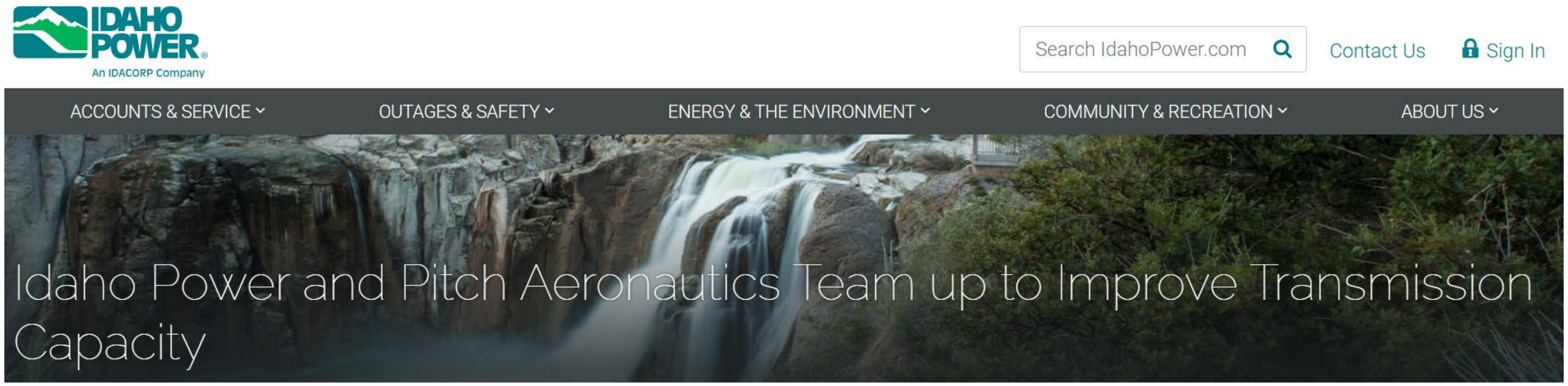


Utility Perspectives on Making Grid-Enhancing Technologies Work
USE CASES, BARRIERS, AND RECOMMENDATIONS FOR SCALABLE DEPLOYMENT

A Report by the
Energy Systems Integration Group's
Grid-Enhancing Technologies User Group
July 2025

ESIG
ENERGY SYSTEMS INTEGRATION GROUP

Collaboration with Pitch Aeronautics and Idaho Power



Idaho Power and Pitch Aeronautics Team up to Improve Transmission Capacity

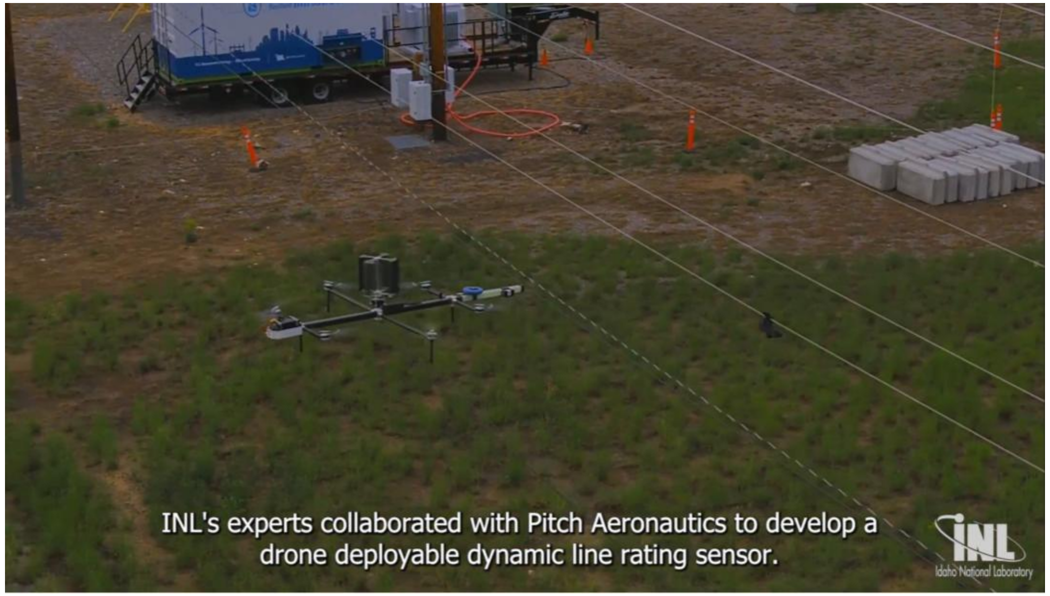
Home › News › Idaho Power and Pitch Aeronautics Team up to Improve Transmission Capacity

- News Briefs
- News Releases
- Bill Inserts & Connections

April 2, 2025

The Boise-based technology company is using custom drones to install sensors on some of the utility's transmission lines to provide essential data that can make energy transmission more efficient.

BOISE, Idaho — Idaho Power and Boise-based Pitch Aeronautics are launching a high-tech project that could increase the utility's ability to safely and reliably increase the amount of power they can move across existing transmission lines, especially during periods of high demand.



INL's experts collaborated with Pitch Aeronautics to develop a drone deployable dynamic line rating sensor.

DOE News Release: https://www.energy.gov/oe/grid-enhancing-technologies-improve-existing-power-lines

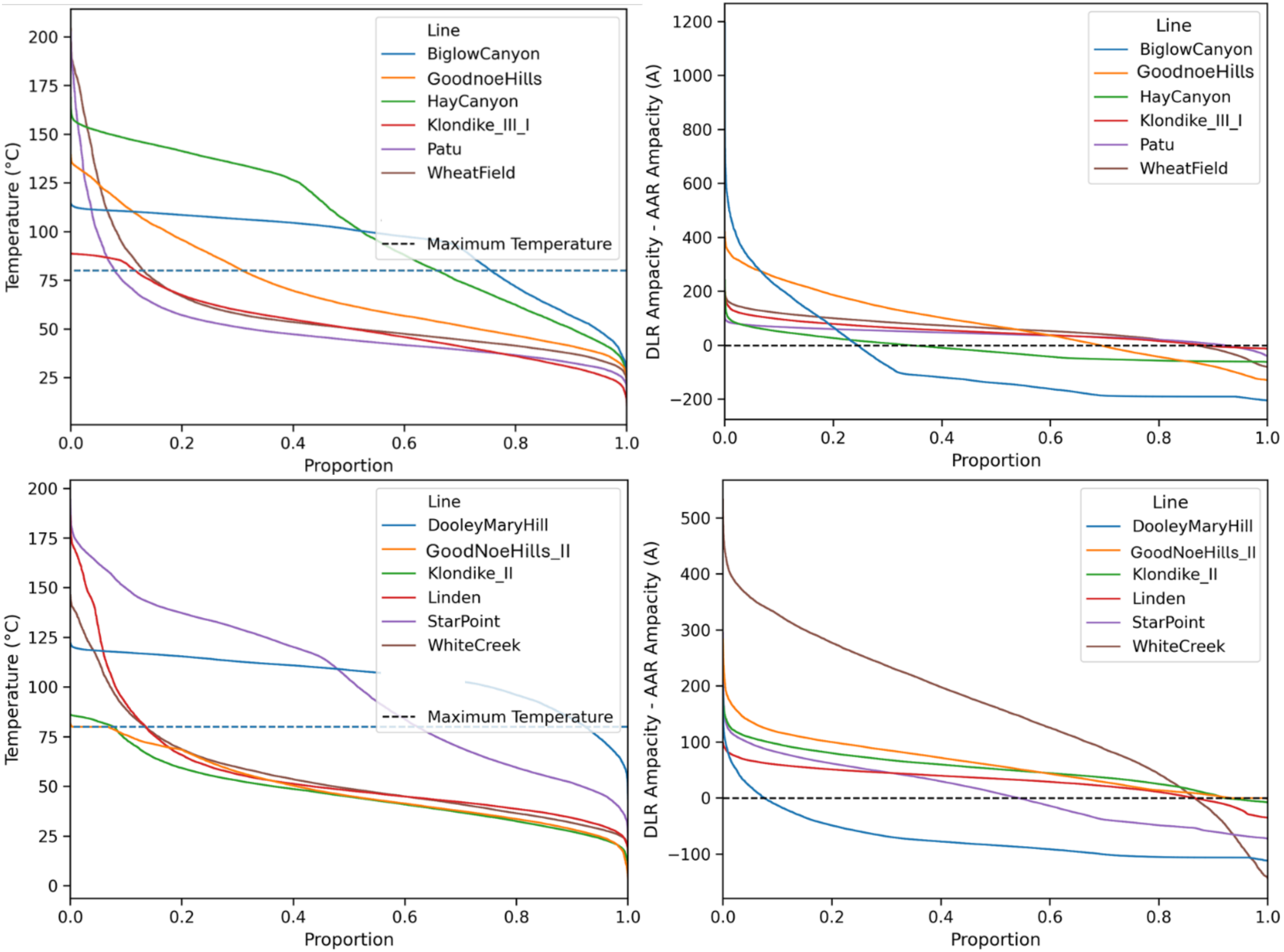
INL's Critical Infrastructure Test Range Complex (CITRC)

YouTube: Drone Deployable DLR Sensors

DLR Case Study: BPA Wind Farms Along Columbia Gorge

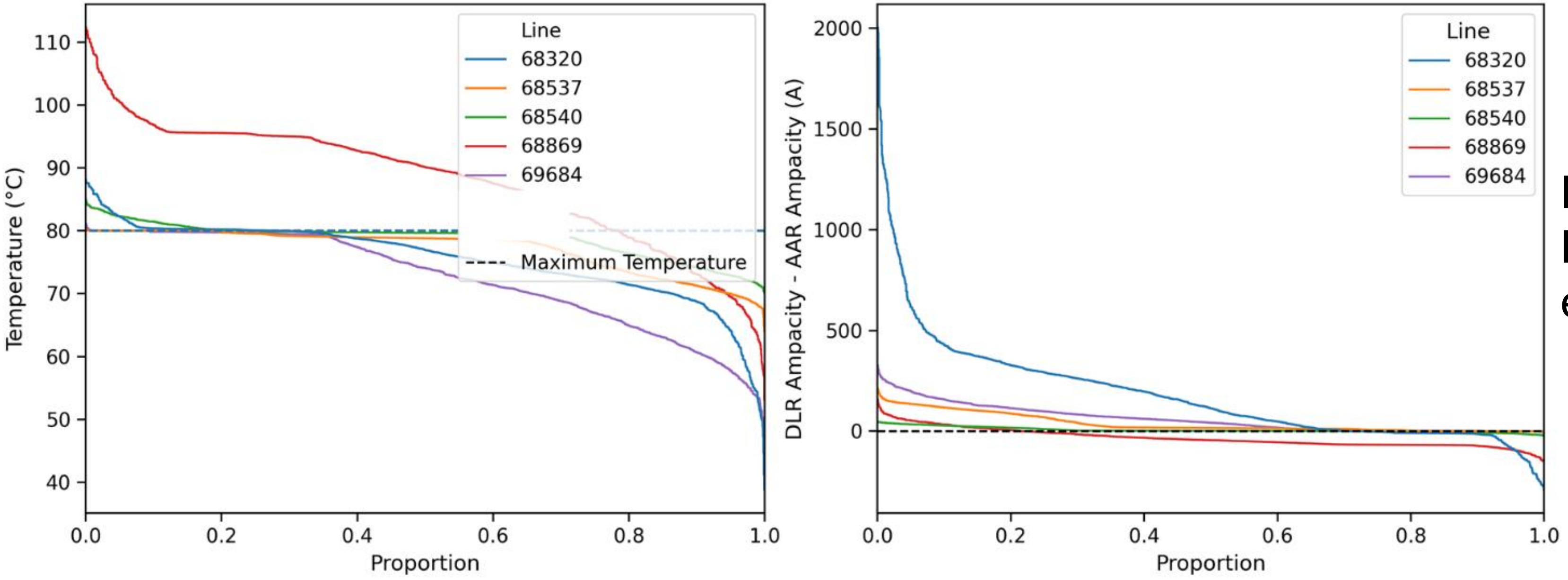
State	County	Transmission Line Density (circuit miles/sq. miles)	Wind Farm
OR	Sherman	0.487 (Percentile Rank: 87.8)	Biglow Canyon
			Hay Canyon
			Klondike 2
			Klondike 3-1
			Patu
			Star Point
OR	Gilliam	0.235 (Percentile Rank: 56.9)	Wheat Field
WA	Klickitat	0.362 (Percentile Rank: 77.9)	Dooley/Maryhill
			Goodnoe Hills
			Goodnoe Hills 2
			Linden
			White Creek

DLR Versus AAR for BPA Wind Farms



Reflects high temperature, low wind conditions

Pacific Northwest (coastal)

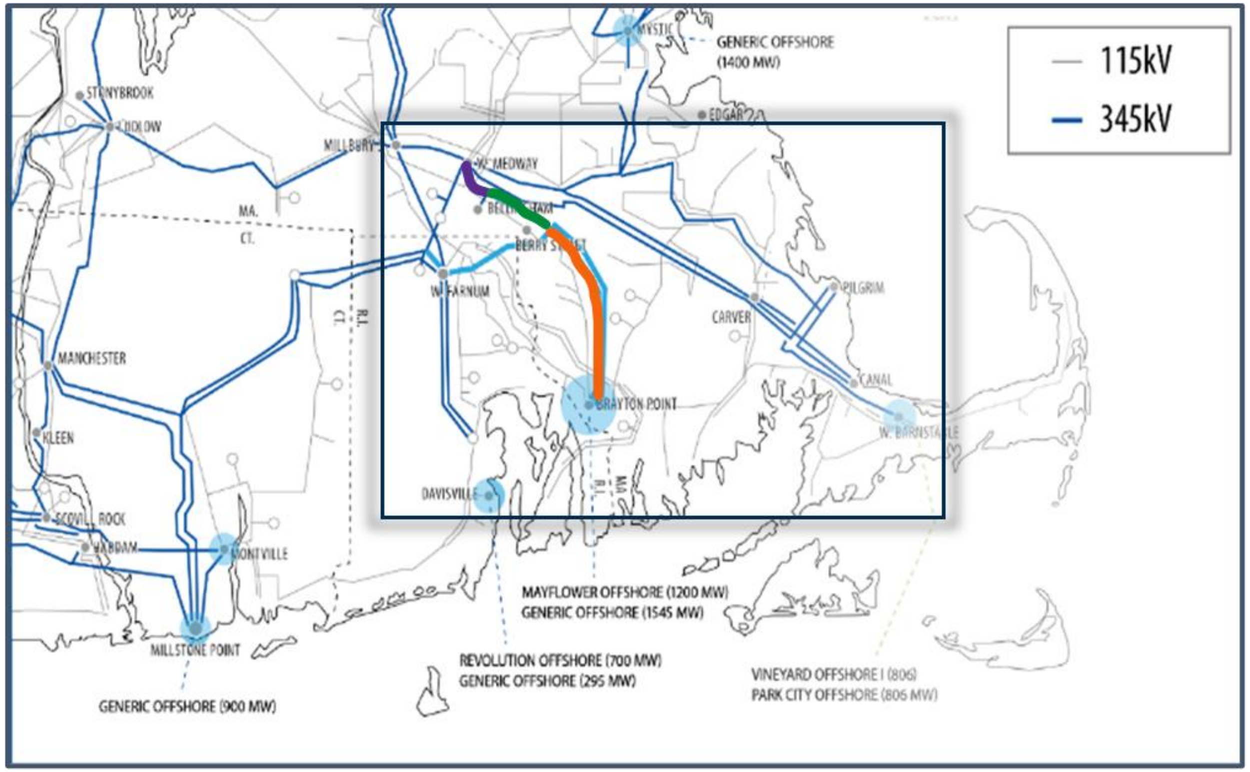


NAERM Project: CA-OR Border during a wildfire event.

DLR Versus AAR Statistics

Region	DLR % time above static	DLR % time above AAR	Conductor time % above max	Conductor time % above max (summer)
Boise IPCo	99.7 [0.4]	89.4 [4.3]	8.2 [6.3]	8.5 [6.5]
Boise NOAA	99.6	74.3	15.3	17.0
Columbia River Gorge Wind Farms	97.6 [3.4]	75.5 [22.9]	25.6 [23.9]	23.9 [27.8]
Columbia River Gorge	99.7	78.1	19.0	18.6
Hells Canyon	83.5	39.2	60.2	68.1
IF Region	98.3	77.2	21.8	31.2
INL Loop	95.6	75.5	29.3	33.4
California Bay Area	84.5 [17.7]	52.4 [30.6]	36.6 [34.3]	-
California-Oregon Border	98.4 [2]	67.7 [24.1]	-	29.9 [26]
RTS GMLC	99.3	81.1	4.4	2.6
Southeast Massachusetts	91.3 [14.9]	42.6 [26.6]	56.8 [26.7]	74.8 [20.6]
Average	**93.4**	**70.0**	**26.3**	**29.5**
Minimum	**71.5**	**39.2**	**4.4**	**2.6**
Maximum	**99.7**	**89.4**	**60.2**	**68.1**

Transmission Line Ranking for PFC Implementation

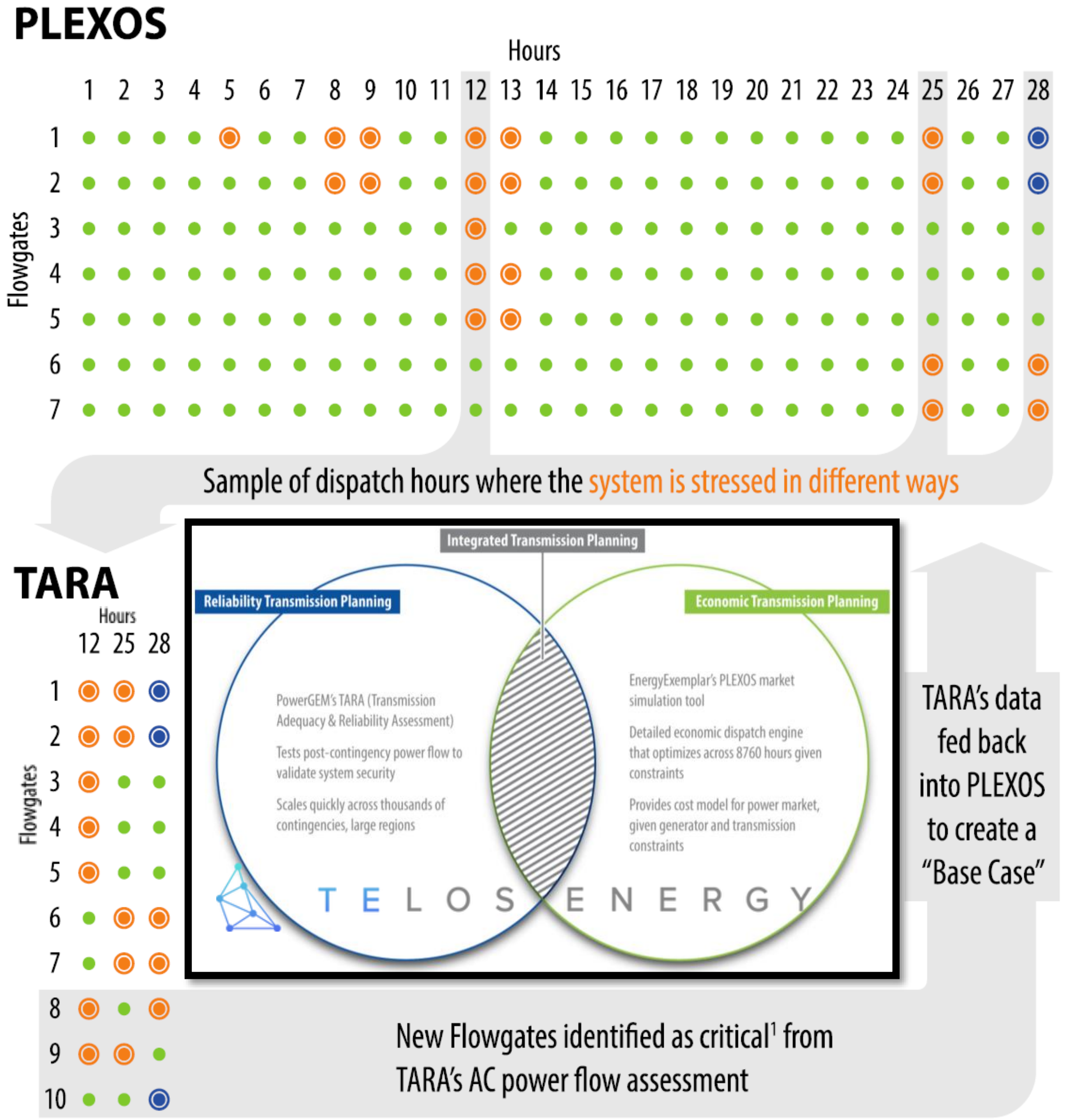


Mapped PFC Locations

PLEXOS Production Cost Impact of Each PFC Location

PFC Location	Ranking	Congestion Rent Improvement ($M)	Production Cost Improvement ($M)	Total Curtailment Improvement (GWh)
Berry St – Brayton Point	1	10.4	4.3	181.8
Medway – Bellingham	2	8.0	3.1	146.2
Berry St – Bellingham	3	8.7	3.1	143.5

https://cigre-usnc.org/wp-content/uploads/2024/06/Optimized-Power-Flow-Control-Device-Siting-with-Coupled-Production-Cost-AC-Powerflow-Modeling-Presentation1.pdf



PLEXOS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	🟢	🟢	🟢	🟢	🟠	🟢	🟢	🟠	🟠	🟢	🟢	🟠	🟠	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟠	🟢	🟢	🔵
2	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟠	🟠	🟢	🟢	🟠	🟠	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟠	🟢	🟢	🔵
3	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟠	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
4	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟠	🟠	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
5	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟠	🟠	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
6	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟠	🟢	🟢	🟠
7	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟠	🟢	🟢	🟠

Sample of dispatch hours where the system is stressed in different ways

TARA

	12	25	28
1	🟠	🟠	🔵
2	🟠	🟠	🔵
3	🟠	🟢	🟢
4	🟠	🟢	🟢
5	🟠	🟢	🟢
6	🟢	🟠	🟠
7	🟢	🟠	🟠
8	🟠	🟢	🟠
9	🟠	🟠	🟢
10	🟢	🟢	🔵

PowerGEM's TARA (Transmission Adequacy & Reliability Assessment)

Tests post-contingency power flow to validate system security

Scales quickly across thousands of contingencies, large regions

EnergyExemplar's PLEXOS market simulation tool

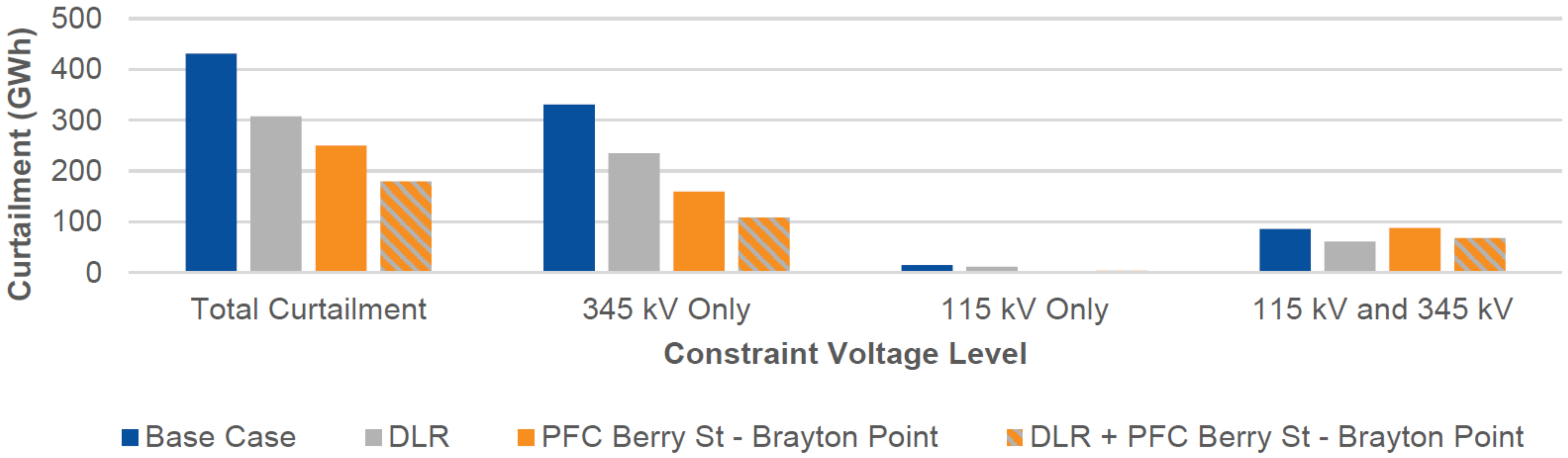
Detailed economic dispatch engine that optimizes across 8760 hours given constraints

Provides cost model for power market, given generator and transmission constraints

TARA's data fed back into PLEXOS to create a "Base Case"

New Flowgates identified as critical[1] from TARA's AC power flow assessment

The GETs Case with PFC and DLR



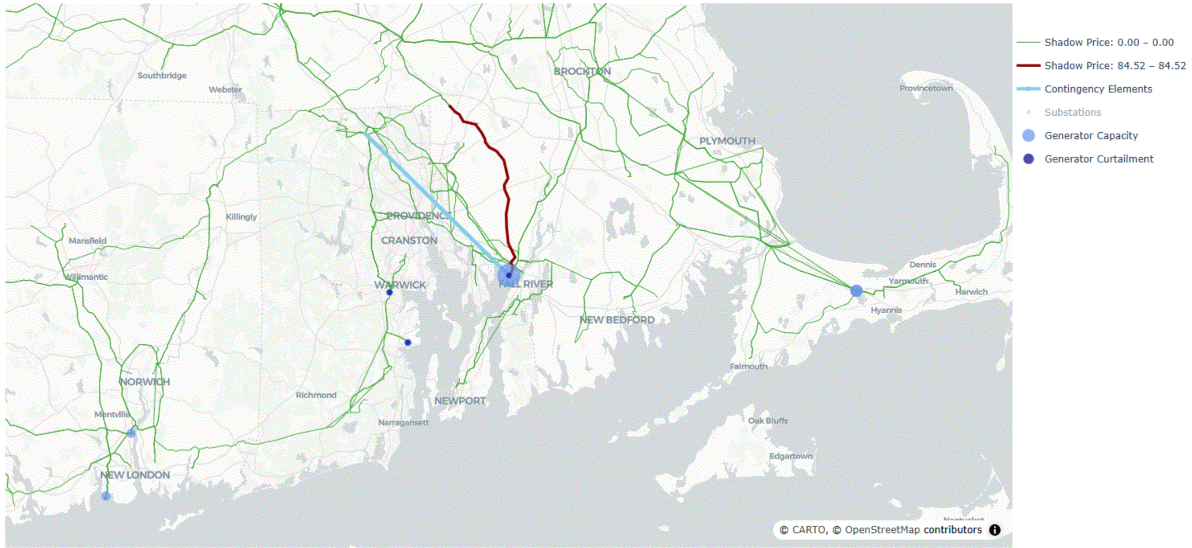
Device Type	All Export Paths Congested	Some Export Paths Congested	Devices Interactive Effects
DLR	DLR can add additional transmission capacity to congested export paths.	DLR can increase transmission capacity on average if placed on congested export paths.	N/A
PFC	PFC cannot alter power flow to mitigate congestion.	PFC can alter power flow away from congested export paths.	N/A
PFC+ DLR	DLR can add additional transmission capacity to congested export paths.	PFC can alter power flow away from congested export paths.	Adding a PFC can be helpful when DLR (1) Shifts congested hours from the bucket of “All Export Paths Congested” to “Some Export Paths Congested” (2) Does not fully alleviate congestion, particularly in the “Some Export Paths” case.

High Stress Day, ISO-NE, 22nd December, 2030

→Loss of 345 kV BraytonPt > WestFarnum

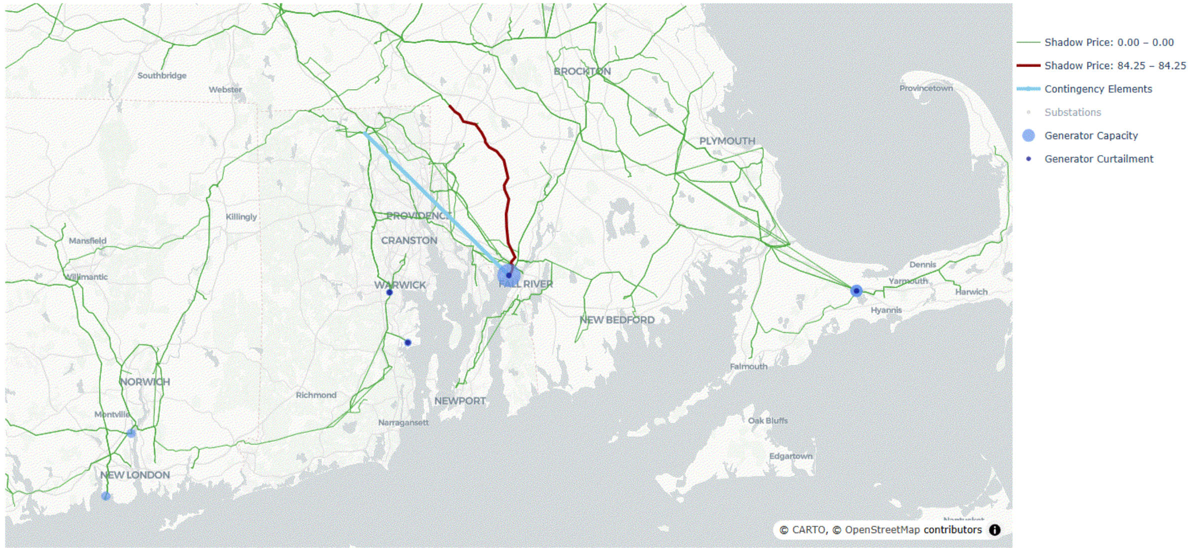
BASE CASE

Hour: 1/24

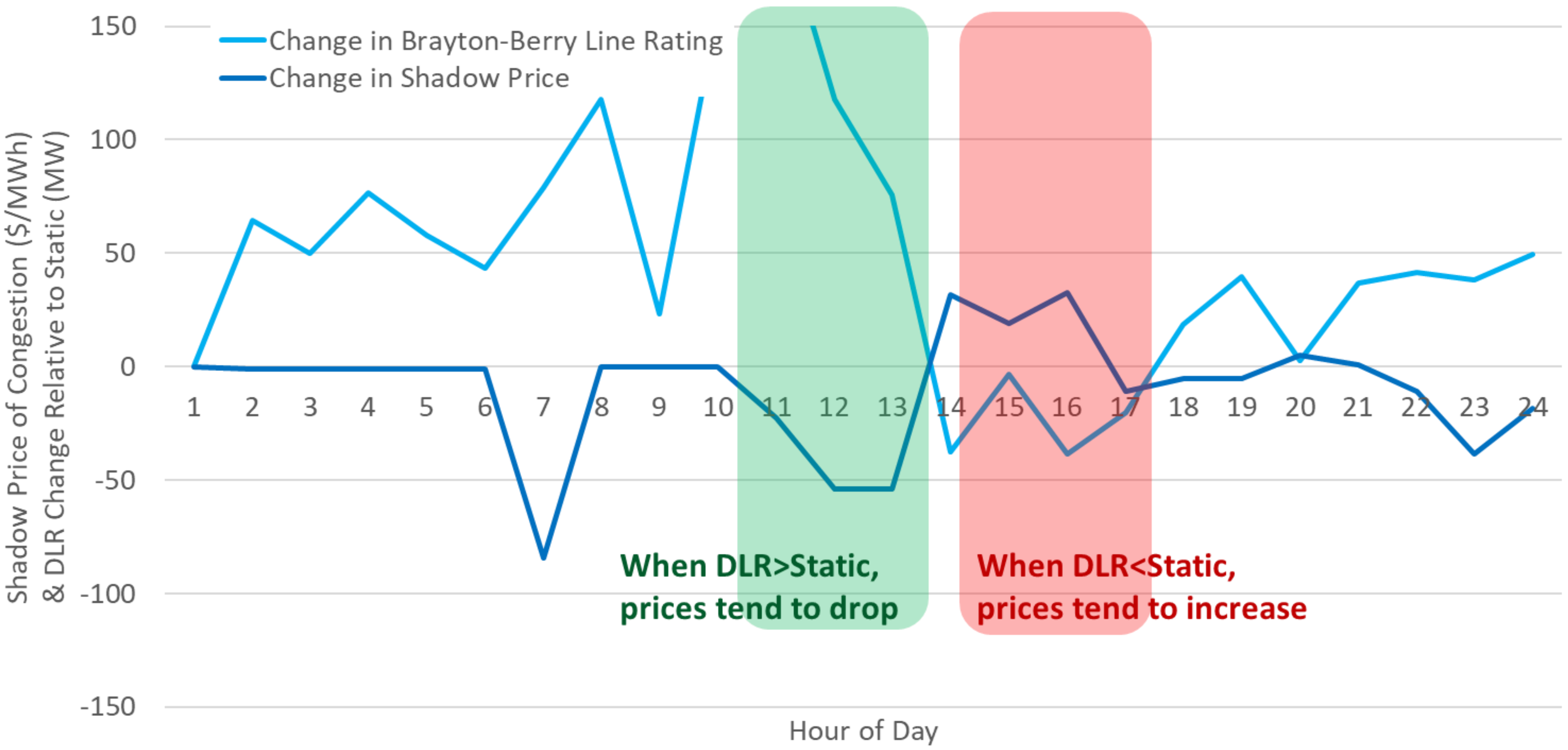


DLR + PFC Case

Hour: 1/24

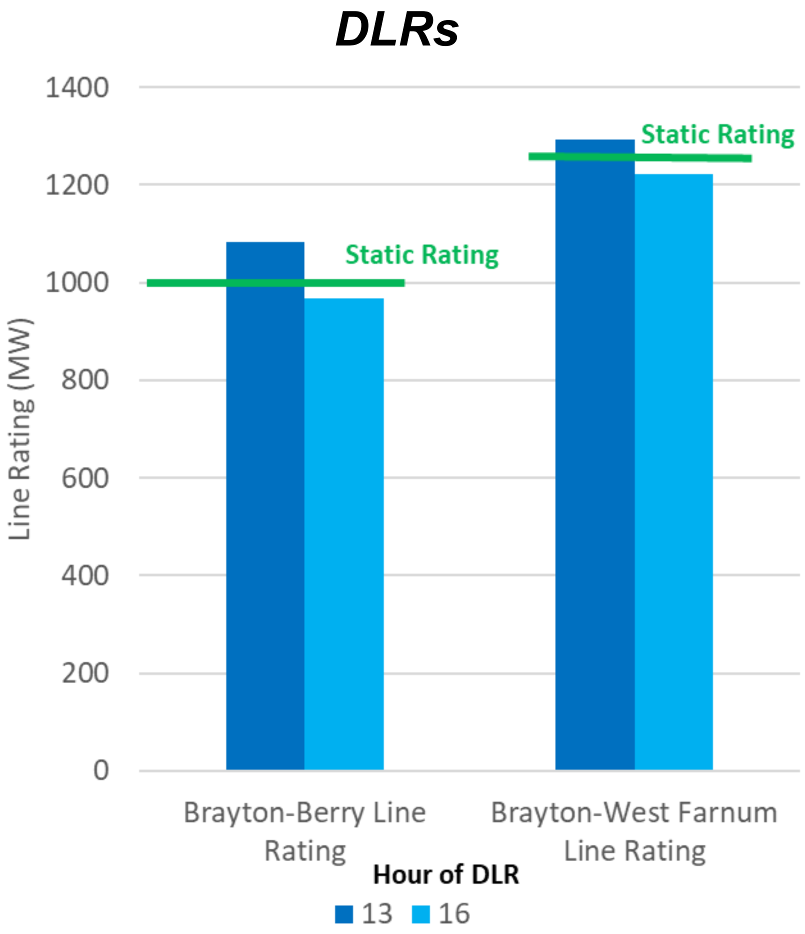


High Stress Day – DLR's Impact on Shadow Price



Shadow Price: The cost of the Transmission constraint in terms of system re-dispatch.

High Stress Day – 1300 and 1600 Hrs

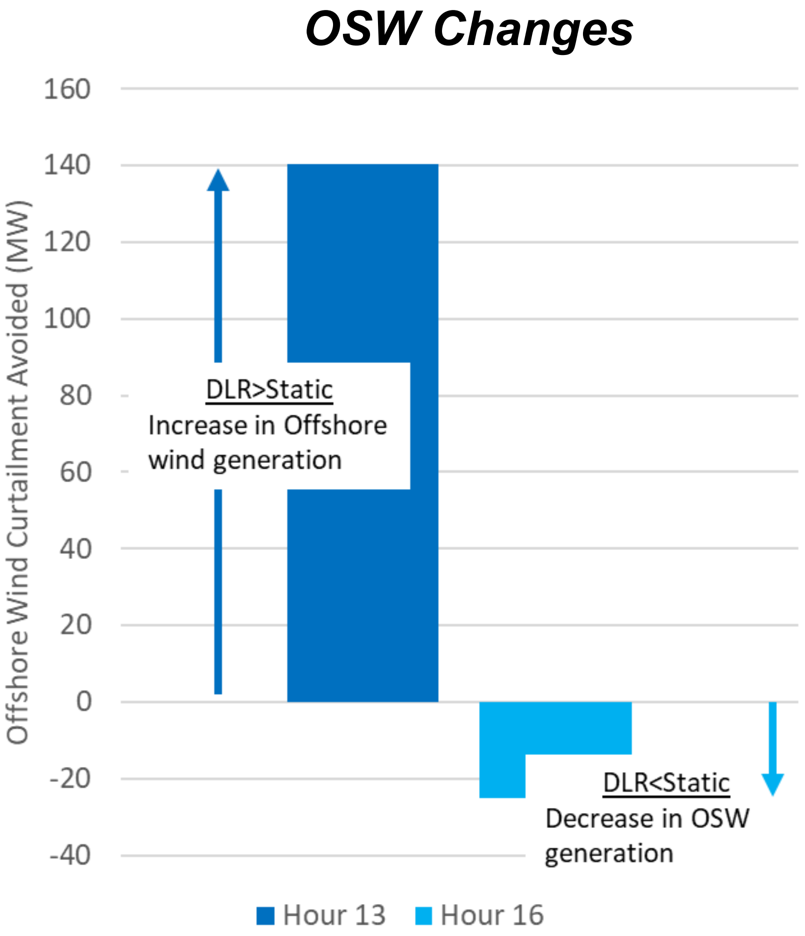


DLR Performance:

1. In hour 13, the DLR on both lines exceeding the static
2. In hour 16, the DLR revealed lower transfer capability than static assumptions

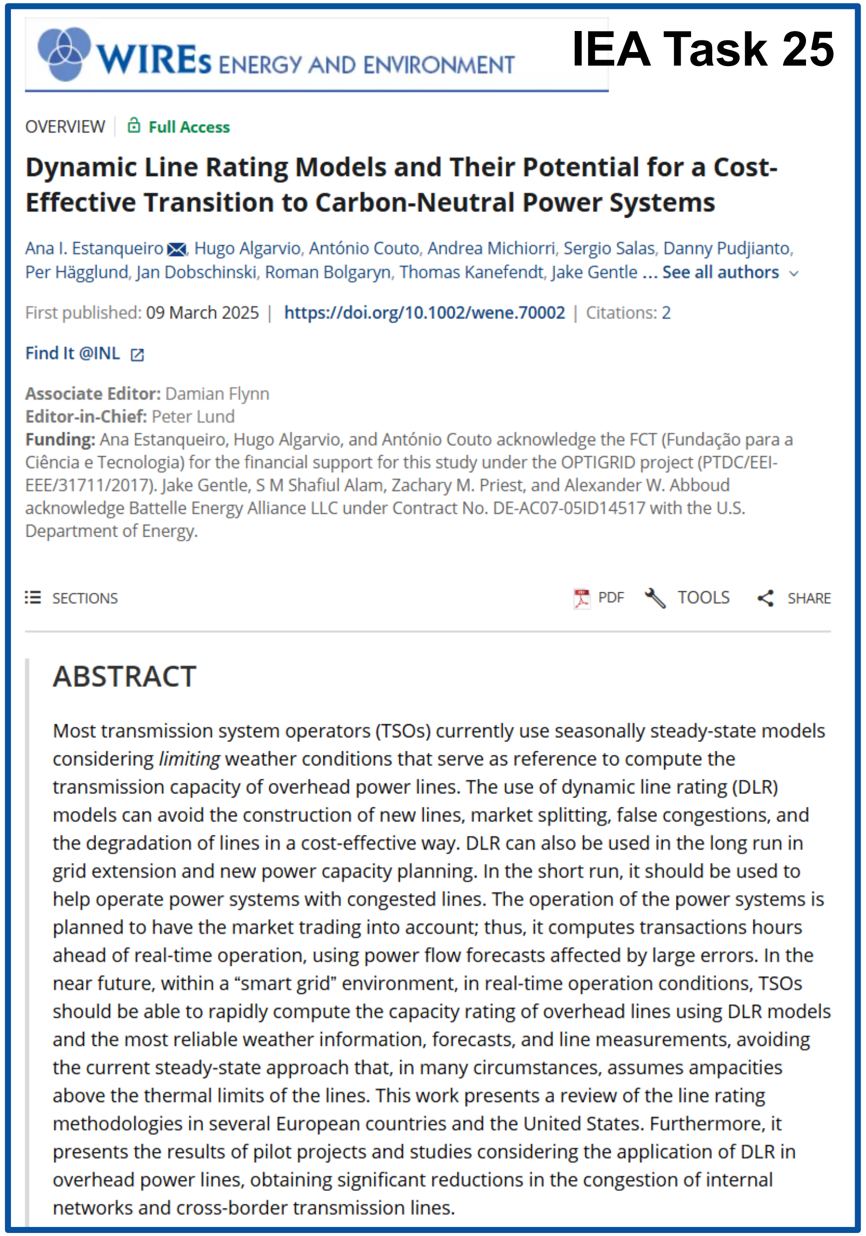
PFC Performance:

1. PFC settings modified to minimize cost across system.



High Impact Disseminations

IEA Task 25



WIREs ENERGY AND ENVIRONMENT

OVERVIEW | Full Access

Dynamic Line Rating Models and Their Potential for a Cost-Effective Transition to Carbon-Neutral Power Systems

Ana I. Estanqueiro, Hugo Algarvio, António Couto, Andrea Michiorri, Sergio Salas, Danny Pudjianto, Per Hägglund, Jan Dobschinski, Roman Bolgaryn, Thomas Kanefendt, Jake Gentle ... See all authors

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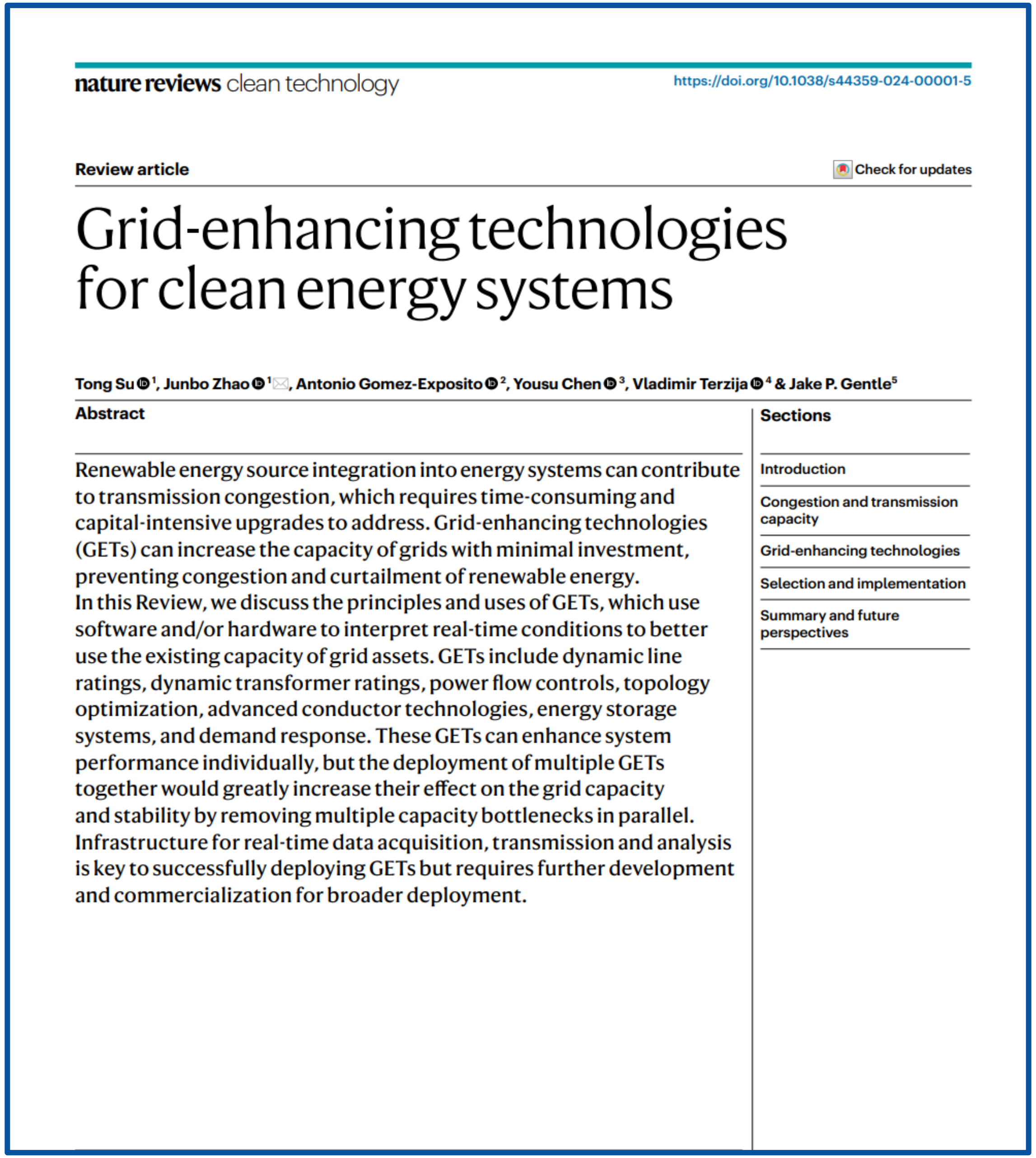
ABSTRACT

Most transmission system operators (TSOs) currently use seasonally steady-state models considering *limiting* weather conditions that serve as reference to compute the transmission capacity of overhead power lines. The use of dynamic line rating (DLR) models can avoid the construction of new lines, market splitting, false congestions, and the degradation of lines in a cost-effective way. DLR can also be used in the long run in grid extension and new power capacity planning. In the short run, it should be used to help operate power systems with congested lines. The operation of the power systems is planned to have the market trading into account; thus, it computes transactions hours ahead of real-time operation, using power flow forecasts affected by large errors. In the near future, within a "smart grid" environment, in real-time operation conditions, TSOs should be able to rapidly compute the capacity rating of overhead lines using DLR models and the most reliable weather information, forecasts, and line measurements, avoiding the current steady-state approach that, in many circumstances, assumes ampacities above the thermal limits of the lines. This work presents a review of the line rating methodologies in several European countries and the United States. Furthermore, it presents the results of pilot projects and studies considering the application of DLR in overhead power lines, obtaining significant reductions in the congestion of internal networks and cross-border transmission lines.



nature reviews clean technology
https://doi.org/10.1038/s44359-024-00001-5

Review article

Check for updates

Grid-enhancing technologies for clean energy systems

Tong Su[1], Junbo Zhao[1], Antonio Gomez-Exposito[2], Yousu Chen[3], Vladimir Terzija[4] & Jake P. Gentle[5]

Abstract

Renewable energy source integration into energy systems can contribute to transmission congestion, which requires time-consuming and capital-intensive upgrades to address. Grid-enhancing technologies (GETs) can increase the capacity of grids with minimal investment, preventing congestion and curtailment of renewable energy. In this Review, we discuss the principles and uses of GETs, which use software and/or hardware to interpret real-time conditions to better use the existing capacity of grid assets. GETs include dynamic line ratings, dynamic transformer ratings, power flow controls, topology optimization, advanced conductor technologies, energy storage systems, and demand response. These GETs can enhance system performance individually, but the deployment of multiple GETs together would greatly increase their effect on the grid capacity and stability by removing multiple capacity bottlenecks in parallel. Infrastructure for real-time data acquisition, transmission and analysis is key to successfully deploying GETs but requires further development and commercialization for broader deployment.

Sections

Options for Increasing Line Capacity

Dale Douglass, DPC

Buck Fife, Power Engineers, Inc

Dale Douglass, DPC

Change the Methodology

- Adjust Static Rating Parameters
- Apply Other Ratings
  - Seasonal
  - Ambient Adjusted
  - Dynamic Line Ratings (Real-time and Forecasted)

Change the Physical Rating

- Use Clearance Margin (if available)
- Allow Higher Temperature

Fix Clearance Limits

- Remove Obstacle
- Adjust Tension
- Modify Insulators
- Modify Structures
- Inset Structures

Reconductor

- TW Conductor
- Larger Conductor
- HTLS conductors

Increase the Voltage

- Structure/insulator modification

Rebuild the Line

- New conductor
- More circuits
- Larger voltage

Reconductoring with Advanced Conductors

Image Source: Pivotal Role: Reconductoring key to strengthening the transmission system - Power Line Magazine

Just replace the old wires with new ones…

Advantages:

- Simple
- Inexpensive
- Fast
- Low environmental impact
- More capacity (50-150%)
- Better efficiency

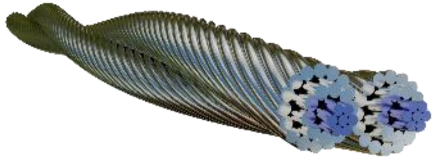
Traditional & Advanced Conductors

Traditional

Stranded copper (legacy technology)

All aluminum alloy conductors

Aluminum conductor steel reinforced (most used today)



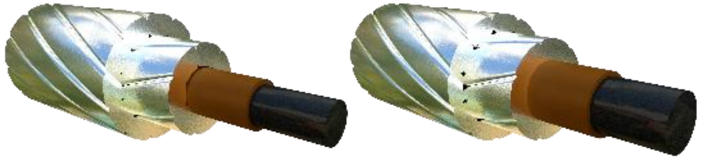
Twisted pair (used in areas with high wind).

Advanced

ACSS Conductor

ACCR Conductor

ACCC Conductor



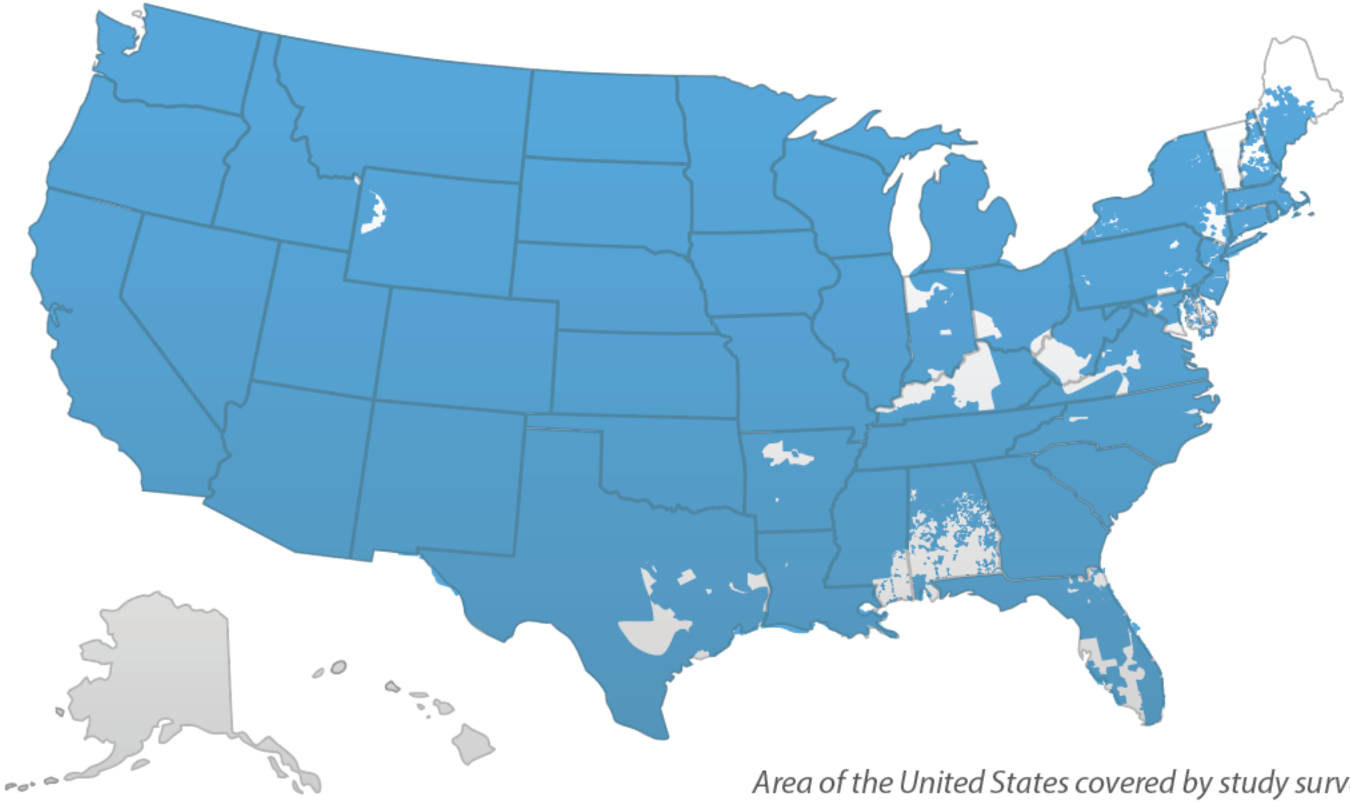
ACCC AZR (left) and ULS-AZR Conductor (right)

TS Conductor

C7 Conductor

E3X coating on ACSS Cable

Advanced Conductor Scan Report

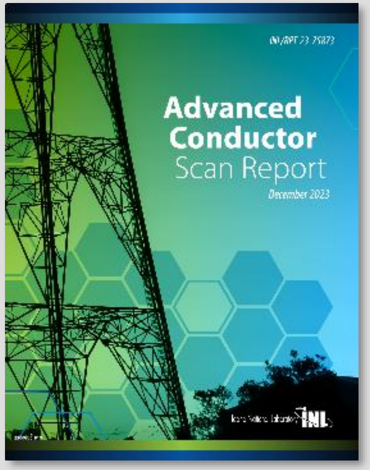


Area of the United States covered by study survey.

44 ELECTRIC TRANSMISSION UTILITIES SURVEYED

Over 70% have deployed advanced conductors

117,510 MILES
OF EXISTING TRANSMISSION LINES WOULD BENEFIT FROM RECONDUCTORING WITH ADVANCED CONDUCTORS



Advanced Conductor Scan Report
December 2023

https://inl.gov/content/uploads/2024/02/23-50856_R8_-AdvConductorszScan-Report.pdf

Deployment example in the PNW

Bonneville Power Administration

(ACSS, ACCR)

Utility Profile

The Bonneville Power Administration (BPA) delivers hydropower produced in the Columbia River Basin to communities across the Northwest. The BPA service area is illustrated in Figure A-20.

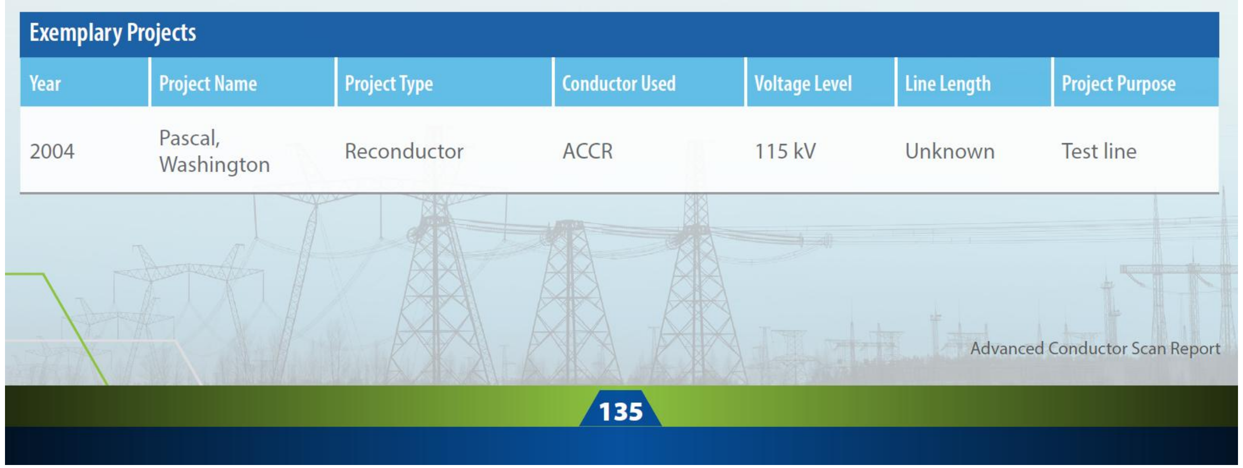
Figure A-20. BPA region.

Conductor Application Successes

BPA has installed ACSS, ACCR (Figures A-21 and A-22) for test and new construction, recognizing the importance of the application and the resulting benefits.

ure A-21. ACSS conductor.

Figure A-22. ACCR conductor.



Exemplary Projects

Year	Project Name	Project Type	Conductor Used	Voltage Level	Line Length	Project Purpose
2004	Pascal, Washington	Reconductor	ACCR	115 kV	Unknown	Test line

Advanced Conductor Scan Report

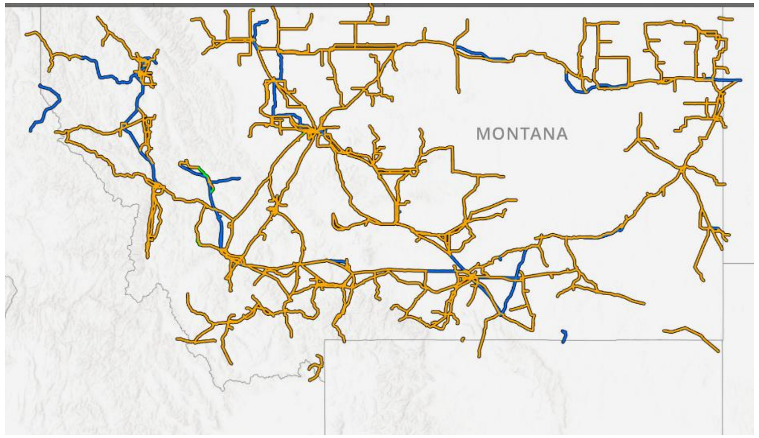
135

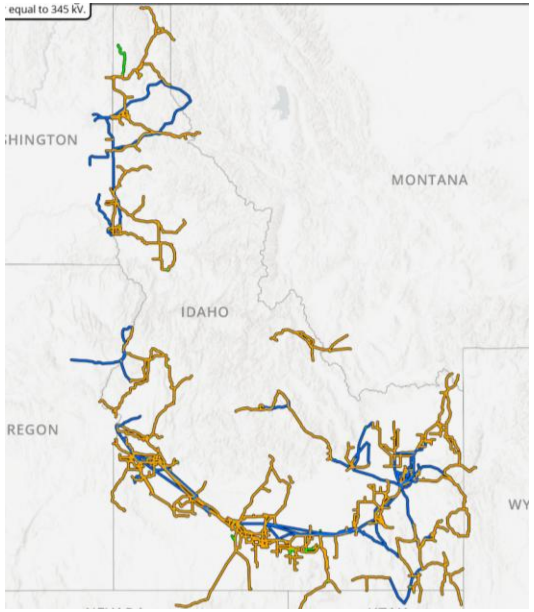
Advanced Conductor Deployment in the PNW

Utility	States	Year	Project Name	Project Type	Project Purpose
Avista	ID, WA	2022	Benton – Othello	Rebuild	Capacity
		Ongoing	Ninth & Central – Sunset	Rebuild	Capacity
BPA	WA	2004		Reconductor	Test line
IPCo					
Montana Dakota Utility	MT	2021	Bismark – Napolean	Reconductor	Renewable energy
NorthWestern Energy	MT	2021	Great Falls – Two Dot	Rebuild	Capacity and reliability
PacifiCorp	ID, WA, OR	2009	Populus Terminal	New construction	Capacity
		2020	Aeolus Shirley Basin	New construction	Capacity
Portland General Electric	OR	2019	Orenco-Sunset	Reconductor	Thermal overloads

Reconductoring Potential in the PNW

- *Shorter line segments with transmission voltage upto 345 kV are thermally limited. These are more likely candidates for reconductoring with advanced conductors.*

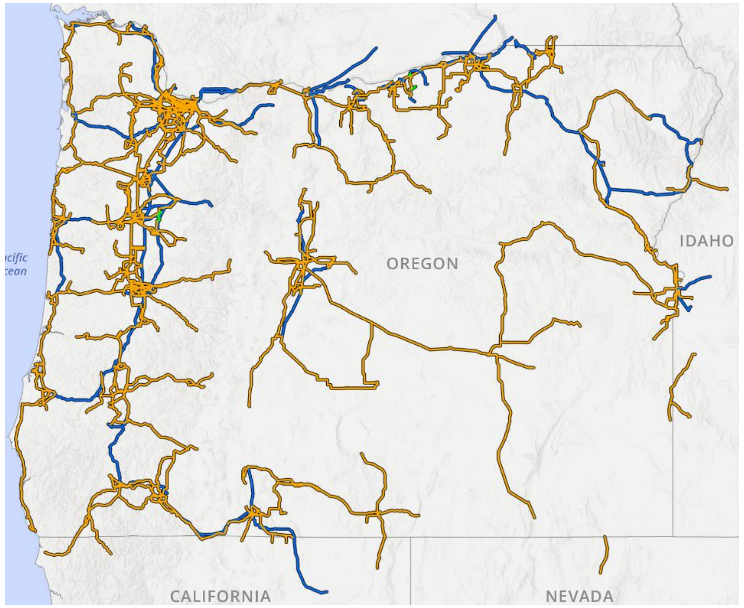




🟩 Distribution (34.5kV or less)

🟧 Subtransmission (35kV - 138kV)

🟦 Transmission (139kV - 345kV)



INL: Advanced Conductor Testing

Overview and Objectives

- Develop and implement testing protocols and plans for advanced conductor technologies
- Assess and demonstrate physical performance under varying operational conditions
  - Emphasize wildfire exposure performance & fire tests
  - Testing to drive installation improvements for minimizing defects/damage

Sponsors:

U.S. DEPARTMENT OF ENERGY
OFFICE OF ELECTRICITY

U.S. DEPARTMENT OF ENERGY
Office of Cybersecurity, Energy Security, and Emergency Response

Partners:

EPRI

GT NEETRAC
National Electric Energy Testing, Research, and Applications Center

FireLab

Conductors Under Test

Utility Donors	Conductor Donation	Conductor Diameter (in)	Length (ft)
LCRA ENERGY • WATER • COMMUNITY SERVICES	Southwire 995 kcmil ACSS/TW/C7-TP	1.108	5,344
Western Area Power Administration	3M 824 kcmil Drake ACCR	1.108	700
Utility 3	Prysmian 1431 kcmil Plover ACSS/TW/MA3/E3X	1.128	2,500
TVA TENNESSEE VALLEY AUTHORITY	TS 1098 kcmil Jackson (Ruddy)	1.131	3,000
Utility 5	CTC 1026 kcmil Drake ACCC/TW	1.465	100 ft, + another 2,000

Roles & Responsibilities

Material Tests		Wildfire Tests		Other Tests	
🟠	Room Temperature Stress Strain	⬢	Conductor Fire	🟩	Qualification Testing (500 cycles)
🟠	Room Temp Ultimate Tensile Strength (UTS)	⬢	Conductor Oven	⬢	Ice Loading Performance Testing (several tests)
🟠	Control Strand UTS	⬢	Conductor Fire Under Tension	🟩	Long-term Thermal Mechanical Aging
🟠	Control Core UTS	⬢	Conductor Oven Under Tension	🟠	Current Cycle Testing on Multiple Series Connector Loops
🟠	Creep Testing	⬢ 🟠	Transmission and Distribution Covered Conductor Fire	🟠	Expanded performance testing of insulation piercing connectors under operational environment conditions
🟩	Self-Dampening Vibration Laboratory Testing	⬢ 🟠	Thermal model development for de-rating fire damaged underground and pole risers	🟩 ▲	Klondike 600' Installation Test
🟩	Fatigue Testing			⬢	Full Scale Installation Test
🟠	Radial Crush Test EIA/TIA 455-41				
⬢ 🟩	Standard Bend Testing				

⬢ INL
🟩 EPRI
🟠 NEETRAC
▲ Georgia Power

⬜ Existing test
🟦 Innovative test

INL: Wildfire Conductor Testing Table

Test Table

Capacity for 5’ or 6’ samples

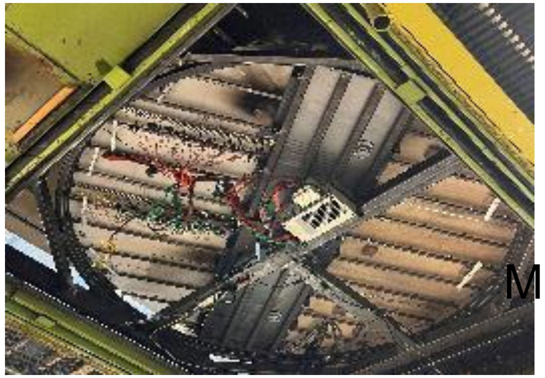
2' x 4' burn section

Mounting frame allows for samples to be raise/lowered to control exposure temperature

Thermocouples mounted along frame will collect/monitor temperature that samples are exposed to

Propane gas delivery system

Opportunity for future/expanded work
Missoula Fire Sciences Lab



Thermocouple wiring beneath burn table

Missoula Fire Sciences Lab

Propane gas delivery to burn table

“Big Sandy” - large tilting burn table

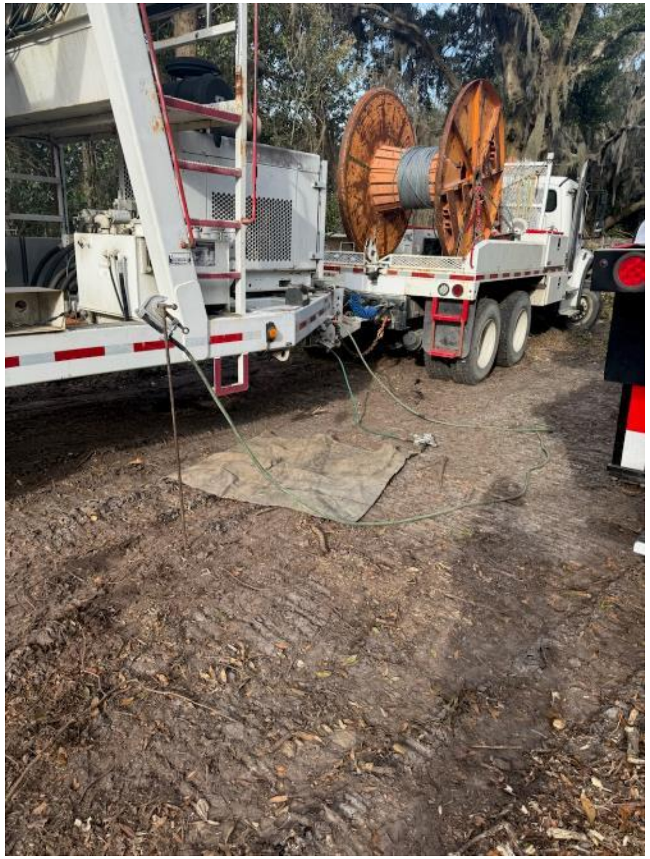
“Pyro Silo” – Grain Bin Ventilation Controlled Combustion Facility

Grain bin chamber interior

Cable run in middle section

Cable Beginning of the day setup Receiving End

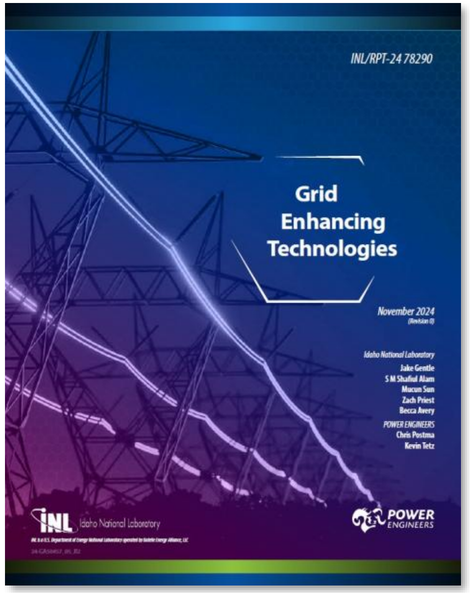
V-Groove Puller, located approximately 60-80 feet from power pole



Equipment on Ground grounded within 10 feet (Green Cable)

Industry Driven Literature on GETs Integration and Control

The Basics



INL/RPT-24 78290

Grid Enhancing Technologies

November 2024
(Revision 0)

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POWER ENGINEERS
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The Control

INL/RPT-24-78148

Implementation and Operation of Power Flow Control Solutions for Transmission Systems

November 2024
(Revision 0)

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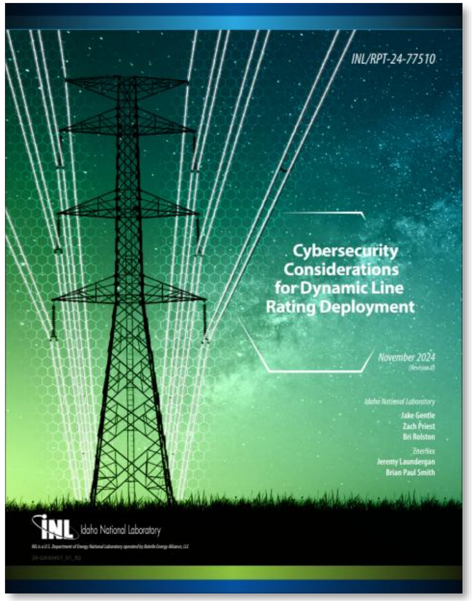
Cybersecurity



INL/RPT-24-77510

Cybersecurity Considerations for Dynamic Line Rating Deployment

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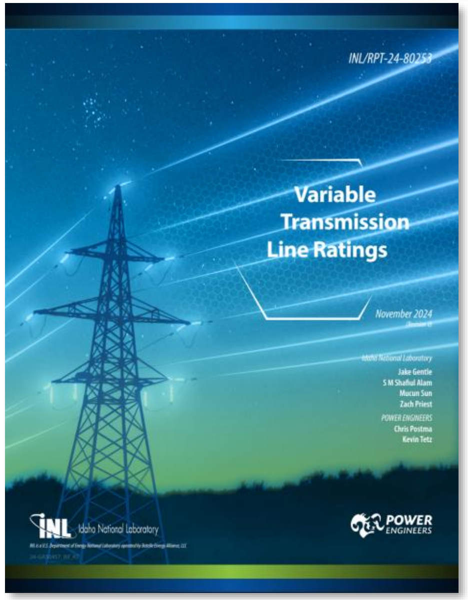

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Variable Transmission Line Ratings

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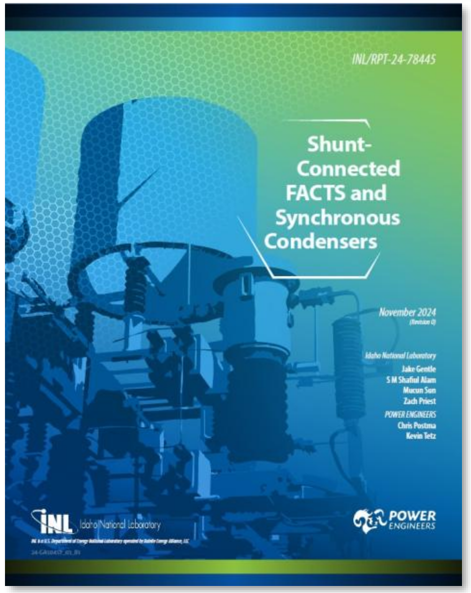

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Shunt-Connected FACTS and Synchronous Condensers

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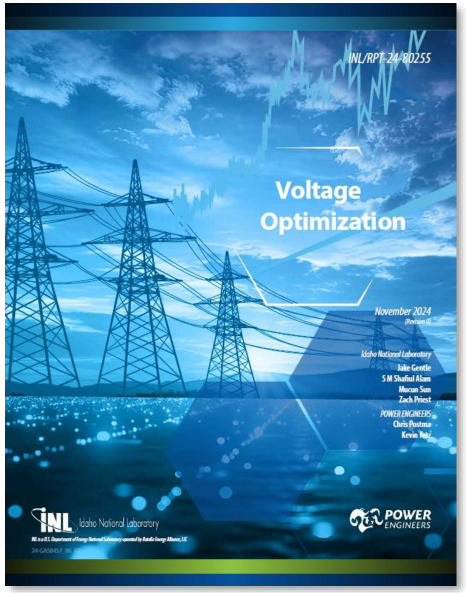

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Voltage Optimization

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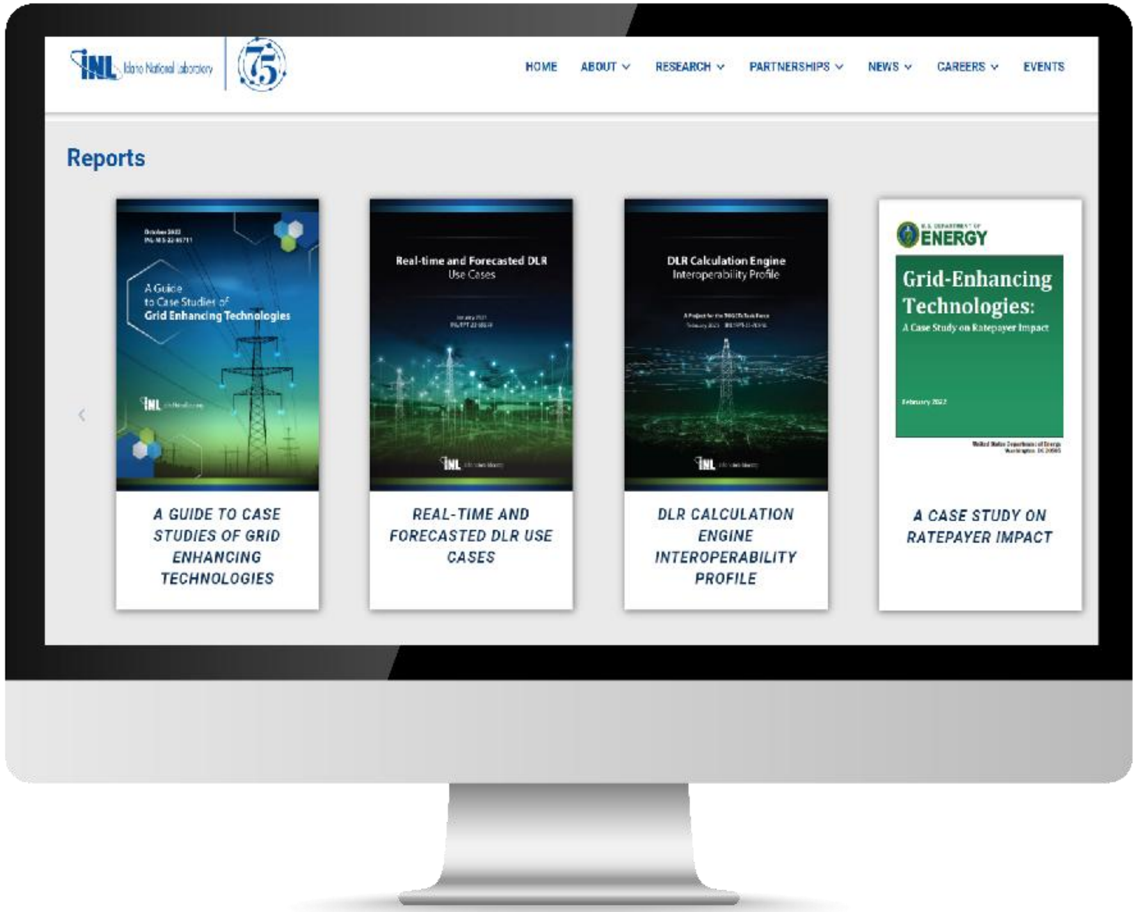
Endless amounts of resources and expertise at INL



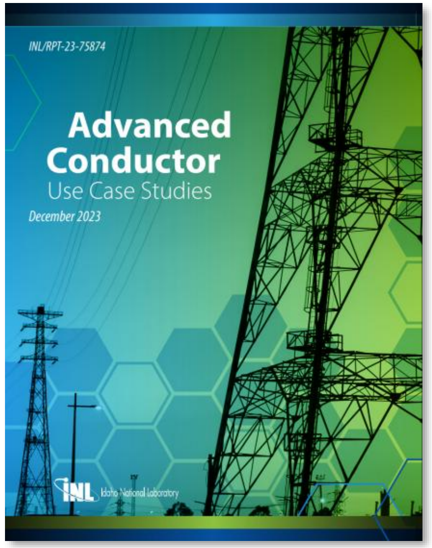
Reports

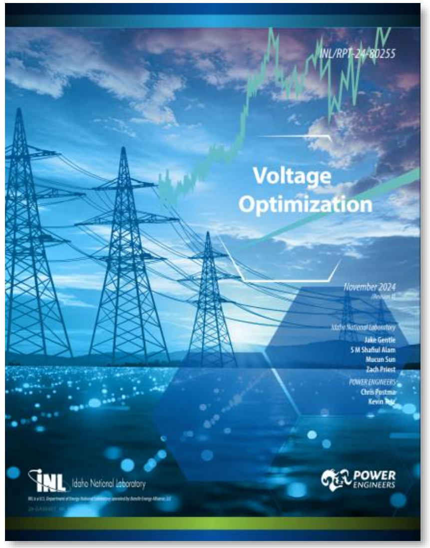
A GUIDE TO CASE STUDIES OF GRID ENHANCING TECHNOLOGIES

REAL-TIME AND FORECASTED DLR USE CASES

DLR CALCULATION ENGINE INTEROPERABILITY PROFILE

A CASE STUDY ON RATEPAYER IMPACT





Email us with your questions!
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Idaho Power Grid Enhancing Technologies Project

Idaho Power Company
Erik Schellenberg Engineering Leader, System Planning
Phil Anderson Engineering Contractor, System Planning

Our Service Area

More than
650,000
customers

Dedicated to Safety

Focused on Reliability

WE KEEP THE LIGHTS ON

99.9%

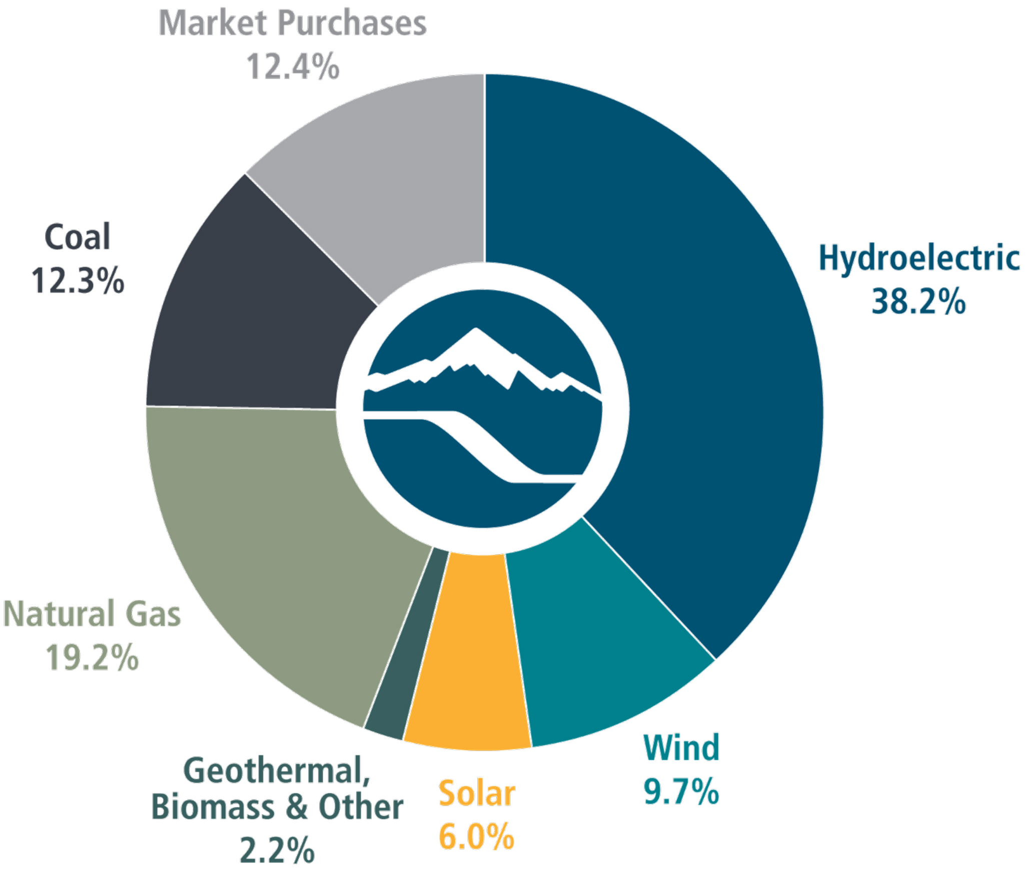
OF THE TIME

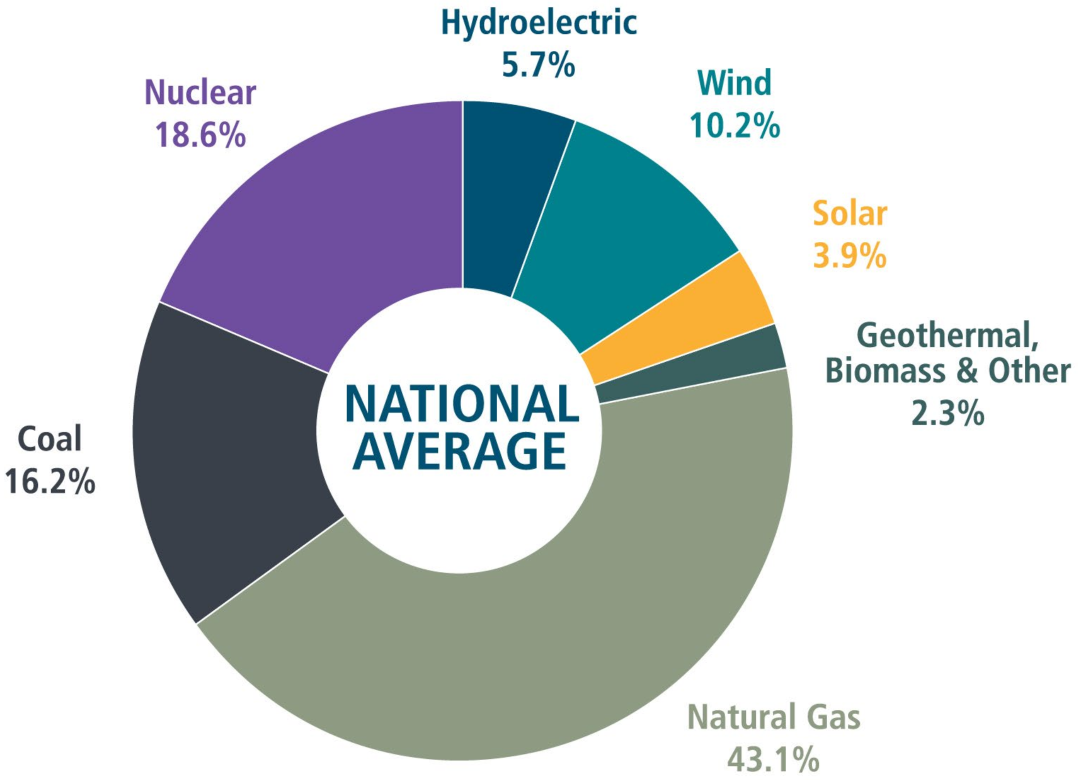
Committed to Affordability

We are **COMMITTED TO AFFORDABILITY**
and working hard to keep our prices
20% BELOW
the national average.

2024 Energy Mix

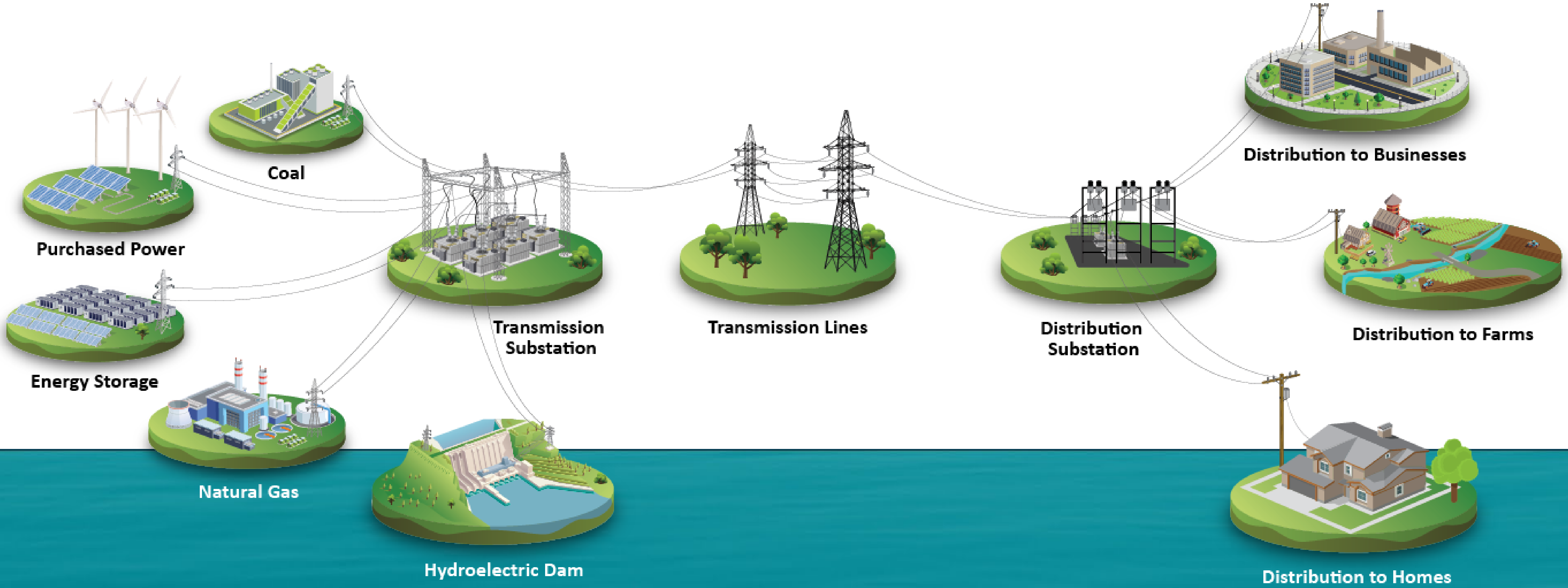
- Energy we generate from company-owned resources, and
- Energy we buy through Market Purchases and long-term contracts with renewables and small-scale hydro generators.



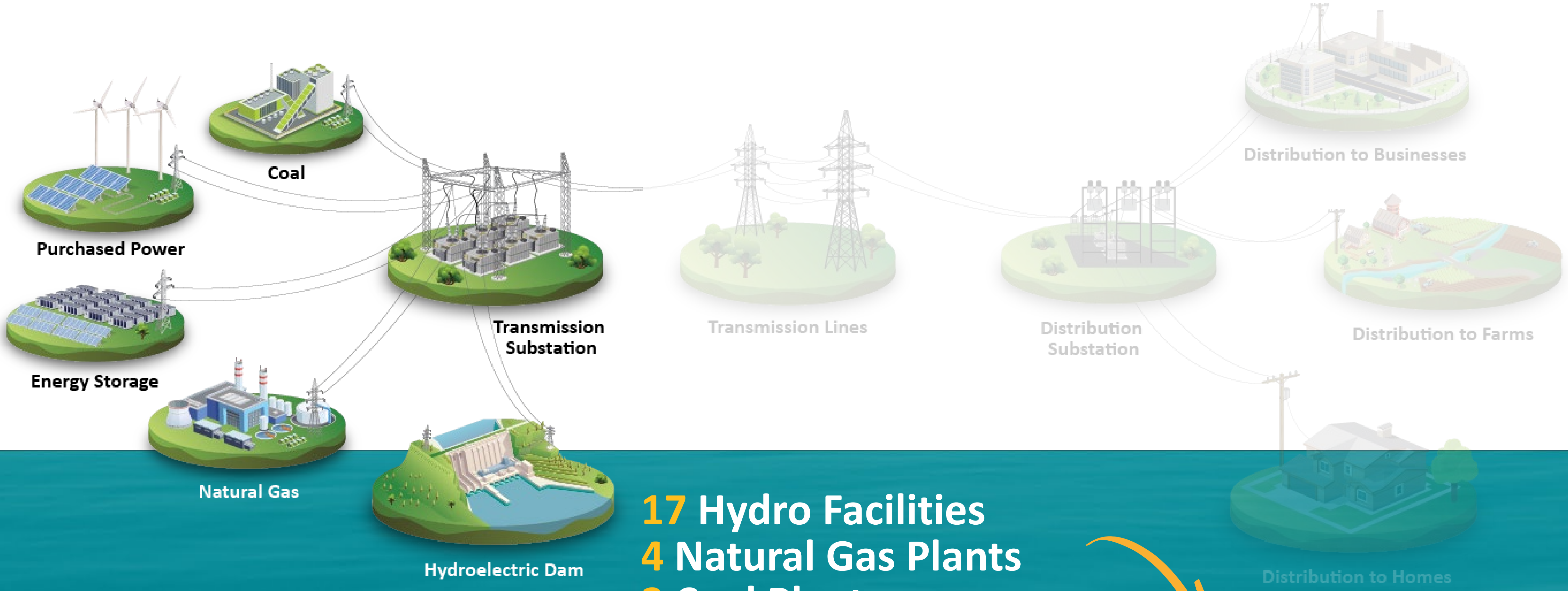


Data Source: U.S. Energy Information Administration.
Totals may not equal 100% due to rounding.

Serving Customers



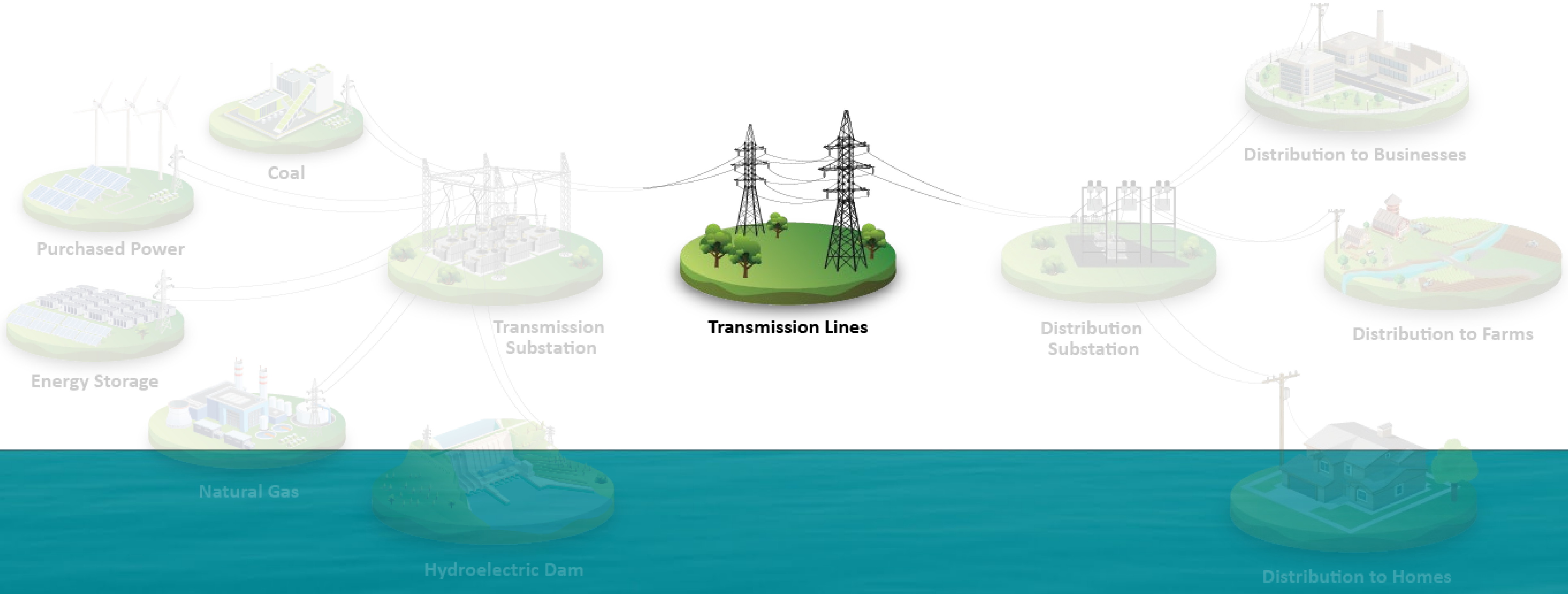
Serving Customers



17 Hydro Facilities
4 Natural Gas Plants
2 Coal Plants
5 Energy Storage Facilities
1 Diesel Facility

Over 3,900 MW

Serving Customers



Over **4,500** Miles of High-Voltage Transmission Lines

Serving Customers

More than **650,000** Customers

Approx. **30,000** Miles of Distribution Lines

More than **260** Substations

Overview

- Definition of Grid Enhancing Technologies (GETs)
- Idaho Power’s experience with Dynamic Line Rating (DLR)
- Idaho Power’s present GET DOE grant project
  - Goal is to implement a working DLR system that can be utilized by Operations and Planning
    - Relieve congestion
    - Offer contingency relief
    - Grow and change as needed

Grid Enhancing Technologies

- Grid Enhancing Technologies (GETs) maximize the electricity transmission across the existing system through a family of technologies that includes sensors, power flow control devices, and analytical tools.
  - Dynamic Line Rating (DLR)
  - Power-Flow Control Devices
  - Analytical Tools

Past Projects

- Partnered with Idaho National Laboratory (INL) on weather augmented Dynamic Line Rating
  - Installed 47 weather stations
  - INL generated a Computational Fluid Dynamics (CFD) model
  - Translated the real time weather station data to all spans of selected transmission lines and calculated real-time line ratings
  - Utilized DLR calculating and visualization software developed by INL

Present Project

- DOE's Office of Electricity invests in GETs research at national labs and with U.S. industry and academia.
  - **Pitch Aeronautics Inc., Boise, ID** – for *Demonstration of Rapid Deployment of Overhead Monitoring Sensors in Combination with Weather-Based DLR System*

Present Project

- Demonstration of Rapid Deployment of Overhead Monitoring Sensors in Combination with Weather-Based Dynamic Line Ratings System

Prime Contractor

Infrastructure Owner

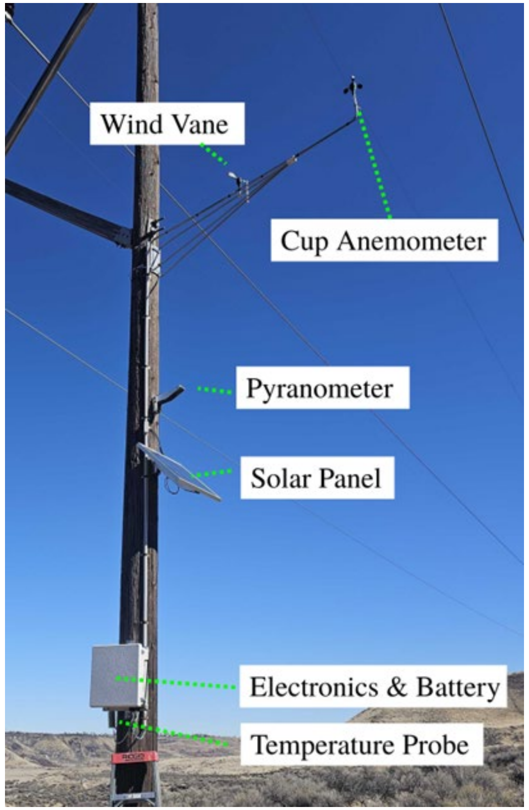
Project Objective

- Implement and test a weather-based DLR system

1. Implement, test, and integrate a DLR system to evaluate the transmission capacity, grid reliability, and transmission dispatch impacts.
2. Assess the influence of DLR on the integration of renewable energy and congestion reduction.
3. Develop a Cost-Benefit Analysis (CBA) framework for evaluating the economic benefits of the DLR system.
4. Demonstrate repeatable drone installation, and operation performance of an integrated low-cost dynamic line rating sensor system. Compare this sensor solution to existing systems in at-scale field trials.
5. Demonstrate secure integration of sensors, software, and transmission dispatch into a cohesive dynamic line rating system.
6. Demonstrate transmission line dynamic line rating operation by weather-based measurements, modeling, and forecasting in a diverse western geography.

Project R&D Tasks

- Existing Weather Station Inspections and Refurbishment

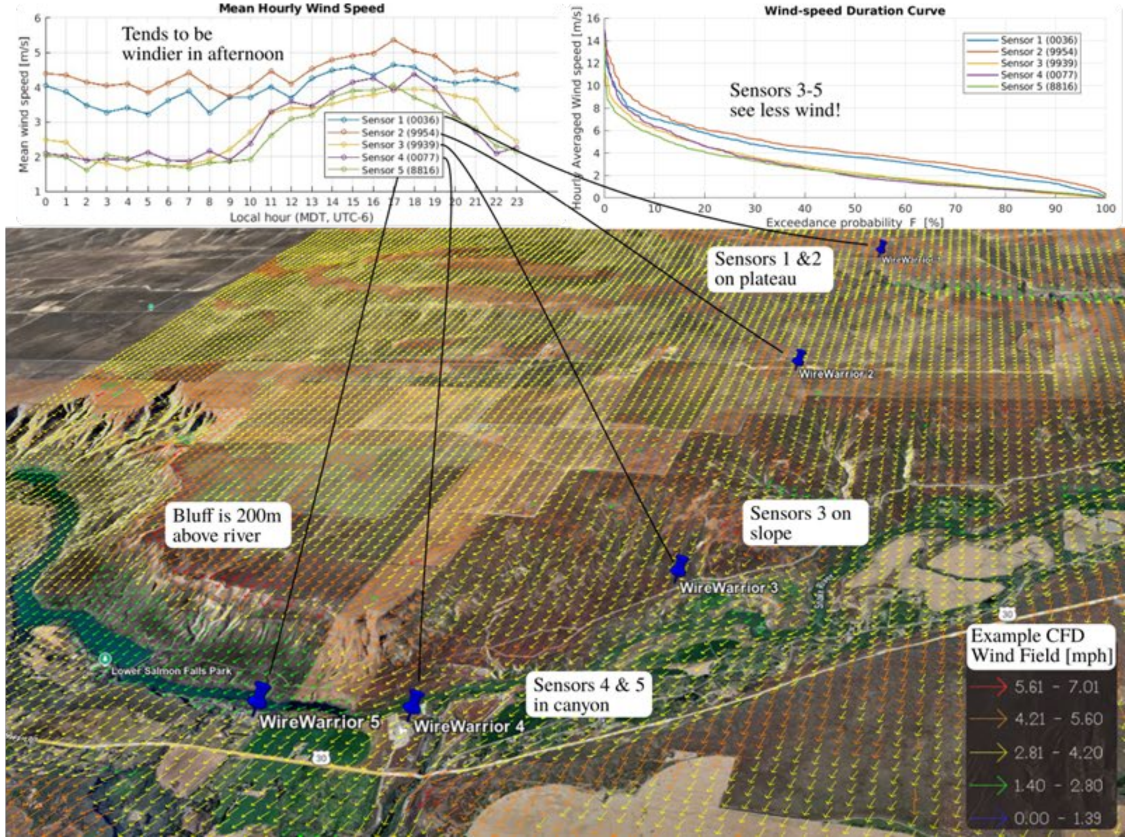


Project R&D Tasks

- Small Scale Site Selection

Small-Scale site selected:

- 2x 138 transmission lines in series totaling 10.5 miles (17km)
- Terrain includes canyon and plateau which influences localized winds.
- Line experiences contingency congestion causing periodic curtailment of wind generators.



Project R&D Tasks

- Sensor Installs

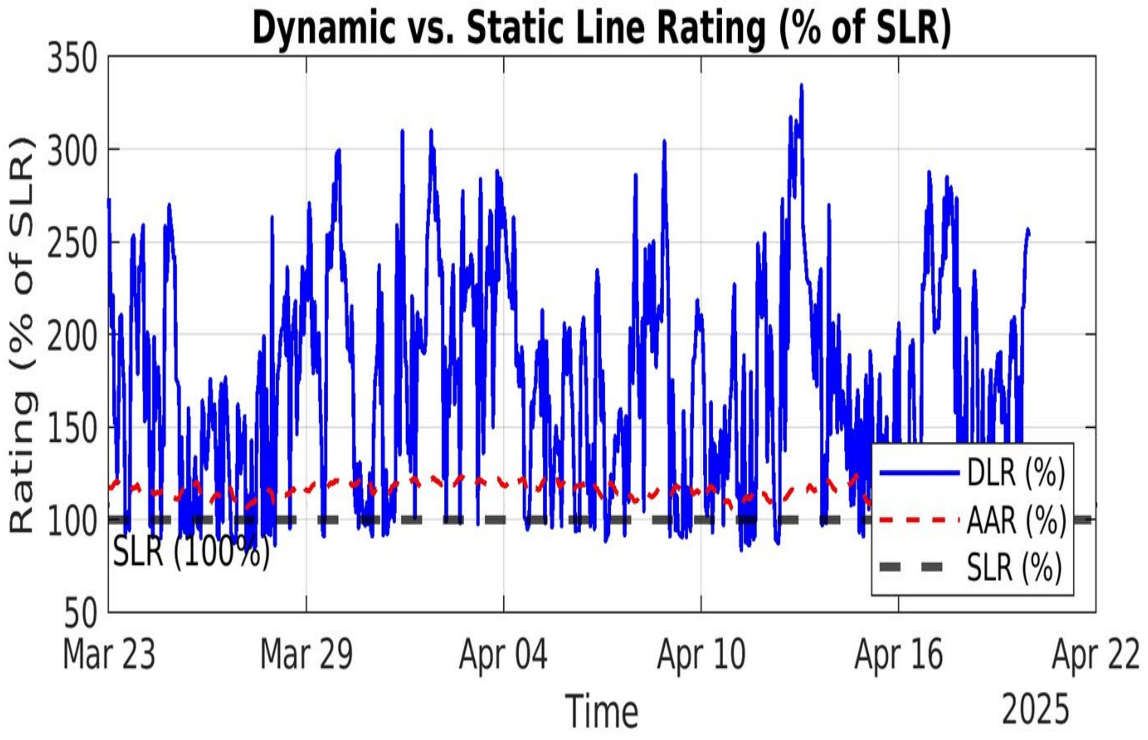
Pitch Aeronautics used their Astria drone to install five WireWarrior sensors on selected small-scale site line.

WireWarrior Sensors

Sensor Install Video

Project R&D Tasks

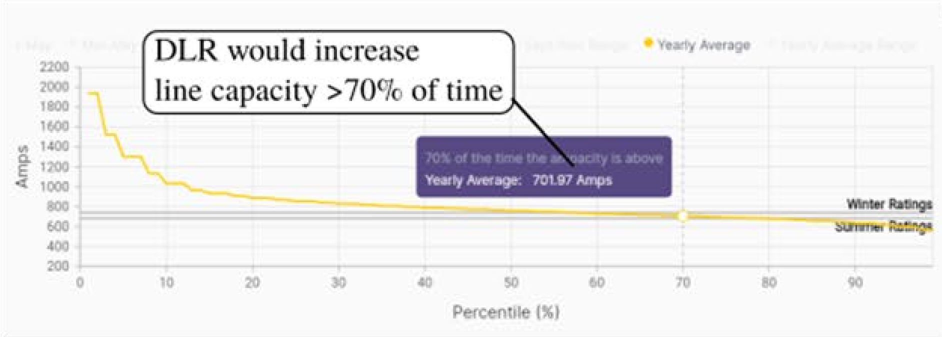
- Initial Sensor Insights



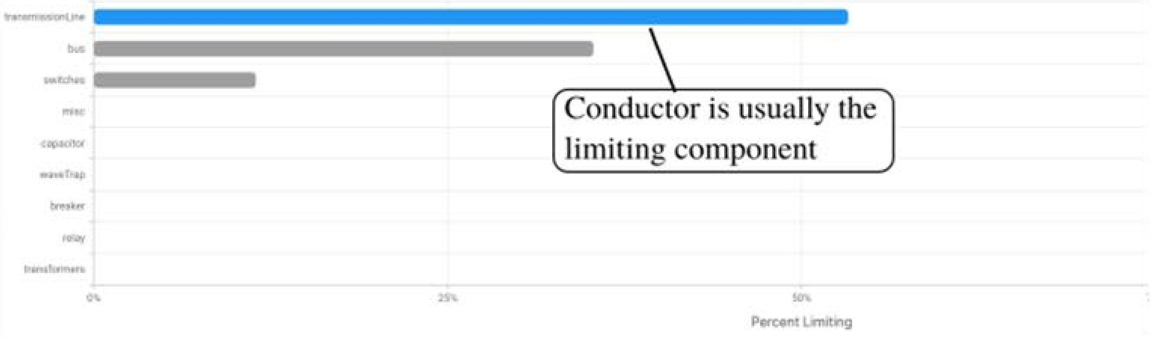
- The dynamic line ratings are higher but much more variable than the ambient and static rating for a large portion of the Spring.
- DLR<SLR during periods of calm wind, (Summer, early mornings?).
- The line consistently has a much higher rating in the late afternoon and evening.

Project R&D Tasks

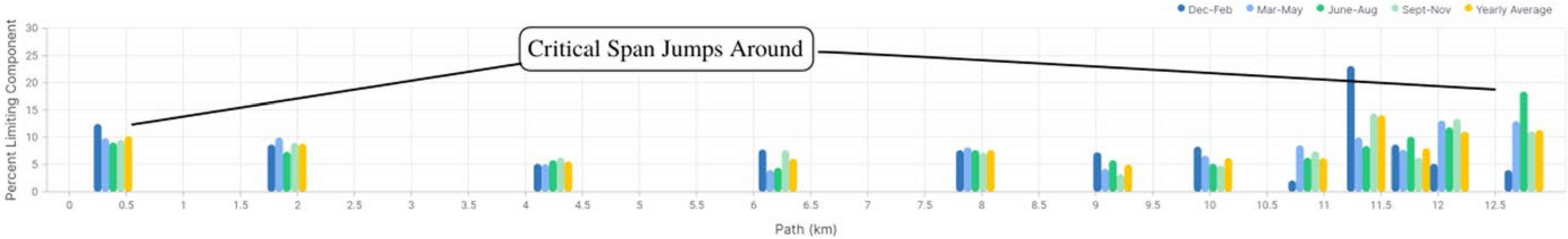
- WireWeather Analytics



DLR would increase line capacity >70% of time



Conductor is usually the limiting component



Critical Span Jumps Around

WireWeather runs DLR computations on three years of historical weather data to characterize how local climate influences DLR on every circuit.

Project Demonstration Phase

- Additional Sensor Installations (30 sensors)
- Communications and Network
- Sensor to DLR Software Verification
- Assessment of Risks and Operating Limitations
- Use of Data for Transmission Operations
- Project Costs and Benefits