Accelerating and Scaling Up GETs

ESIG Webinar

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Grid Enhancing Technologies (GETs) are technologies that maximize electricity delivery through transmission lines

Advanced Conductors

Operates at higher temperatures, allowing more power to flow

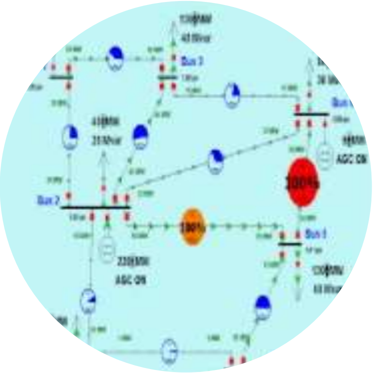
Dynamic Line Ratings

Updates thermal ratings of lines in real time

Power Flow Controllers

Reroutes power to lines with available capacity by adjusting impedance on lines

Topology Optimization

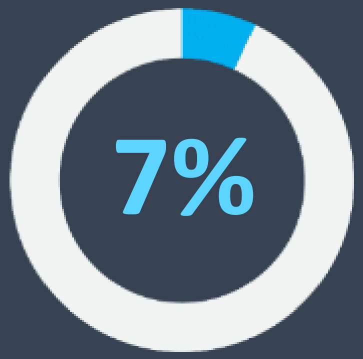


Redirects power to avoid congested or overloaded lines

Global initiative to learn and plan for wide-scale deployment of GETs to increase transmission capacity

Today's Transmission Investments

Transmission

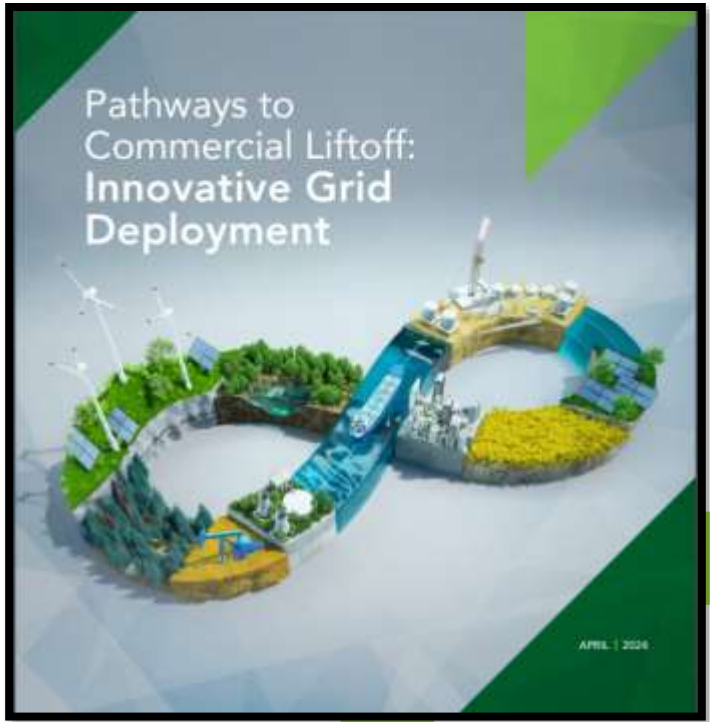


Advanced Technologies

Source: EEI Business Analytics 2022 surveys.

Advanced technologies will have a much greater portion of tomorrow's transmission investments

GETting Mainstream…



187 FERC ¶ 61,068
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

18 CFR Part 35

[Docket No. RM21-17-000; Order No. 1920]

Building for the Future Through Electric
Regional Transmission Planning and Cost Allocation

(Issued May 13, 2024)

AGENCY: Federal Energy Regulatory Commission.

ACTION: Final rule.

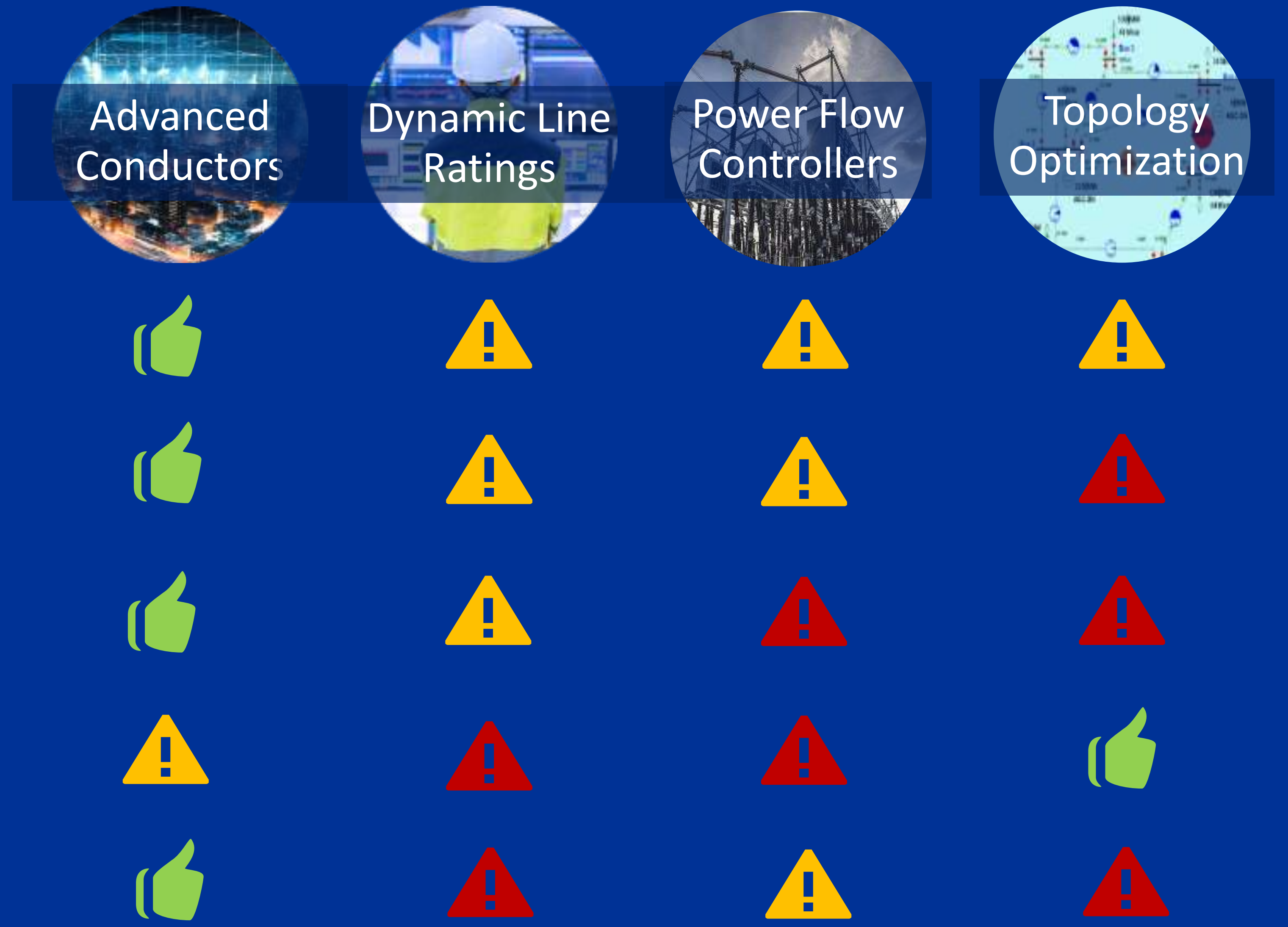
The New York Times

The U.S. Urgently Needs a Bigger Grid. Here's a Fast Solution.

A rarely used technique to upgrade old power lines could play a big role in fixing one of the largest obstacles facing clean energy, two reports found.

Replacing existing power lines with cables made from state-of-the-art materials could roughly double the capacity of the electric grid in many parts of the country. Jim Wilson/The New York Times

Ways to Encourage Greater Broader Deployment



GETs Characteristic Technical Bases

- Technology Evaluation
- Planning Models/tools
- Operations Models/procedures
- Acquisition & Maintenance
- Incentives & Markets

Research Activities to Accelerate Deployment

Advanced Conductors

1. Conduct long term thermal-mechanical aging of advanced conductors.
2. Evaluate the effects of high temperature conductors on energized maintenance.
3. Identify and implement inspection technologies.
4. Undertake long term monitoring of advanced conductor installations

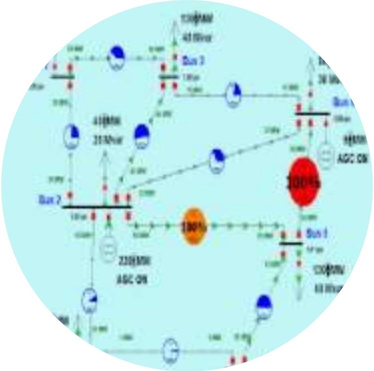
Dynamic Line Ratings

1. Conduct full scale field trials
2. Develop DLR specification and lab evaluations
3. Assess critical span identification and coverage area

Power Flow Controllers

1. Develop a planning framework to design APFC-based transmission solutions
2. Develop guidelines for the operation/control of multiple APFCs
3. Characterize performance /reliability
4. Develop planning and EMS models
5. Develop best practices for the operation of APFC in day-ahead and real-time markets
6. Develop specifications, maintenance, inspection practices

Topology Optimization



1. Technology Evaluation
2. Tools for supporting implementations (stability analysis, grid strength, short circuit levels)
3. Understand impacts on markets and existing resources
4. Evolve planning models

GET SET Spring Workshop

Join us as we share learnings from research, demos, and deployments of GETs

Thursday June 20 – Friday June 21
Georgia Power Corporate HQ, Atlanta, GA

For More Information or to register, contact:
GETSET@epri.com

Session Topics

- **Experiences with Advanced Conductors**
- **Lessons Learned and the Road Ahead for Dynamic Line Ratings**
- **Markets, Incentives, and Regulatory Considerations to Scale Up**
- **Deployments of Advanced Power Flow Controllers**
- **Technology Provider Fair**

Enhancing the Grid with DLR

Types of Ratings and Their Purpose

Seasonal ratings (summer and winter)

The same every year known years in advance

Ambient adjusted ratings (AAR)

Go up and down hourly based on air temperature

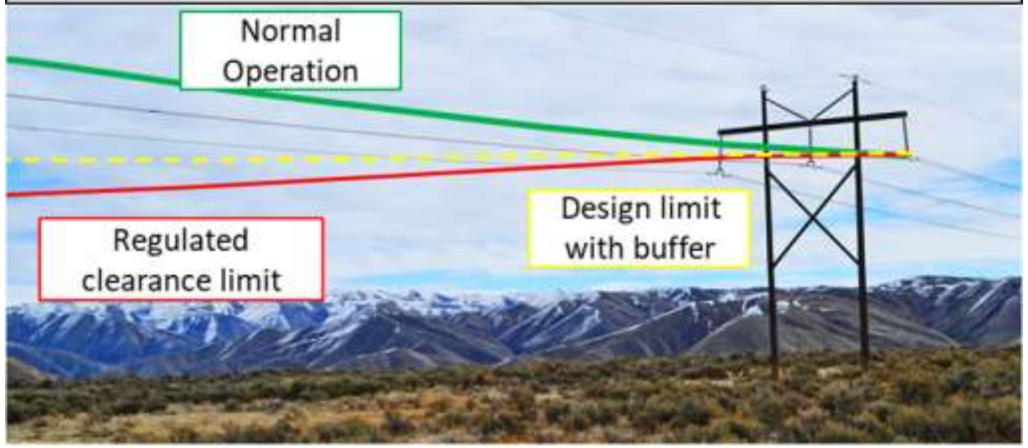
Few models accurately predict (small errors in forecasts can have big effects)

Dynamic line ratings (DLR)

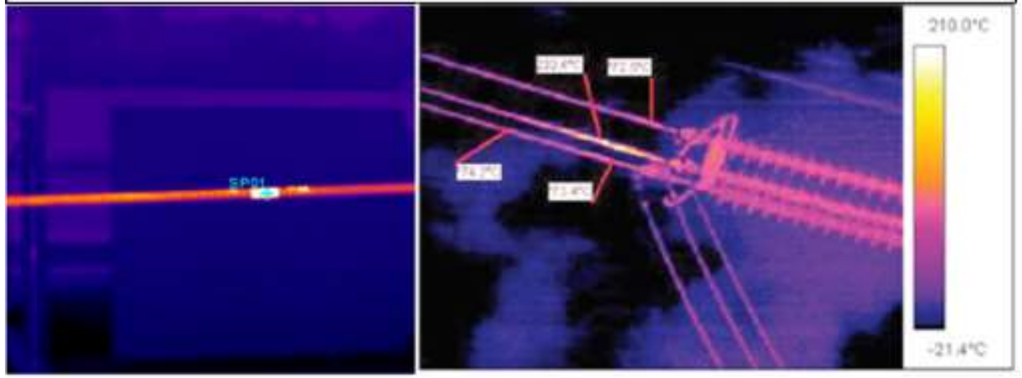
Change every 15-30 minutes based on wind speeds

Very difficult to predict beyond a few hours

Prevents clearance issues and flashovers



Prevents failures due to loss of strength (annealing)



Increases transmission capacity on existing circuits without physical changes

Can increase capacity during favorable weather

There are many technology providers available

Adopting AAR makes later adoption of DLR easier

DLR technologies can provide insight into other system conditions

Capacity gains typically align with peak demand and peak renewable generation

On lines with no clearance buffer, aged conductors, SIL limits, voltage drop limits, limiting substation ratings – to safely apply DLR costly upgrades are needed

Ratings may go down as often as 30-40% of the time

Accuracy, reliability, and cost vary complicating finding best-fit solutions

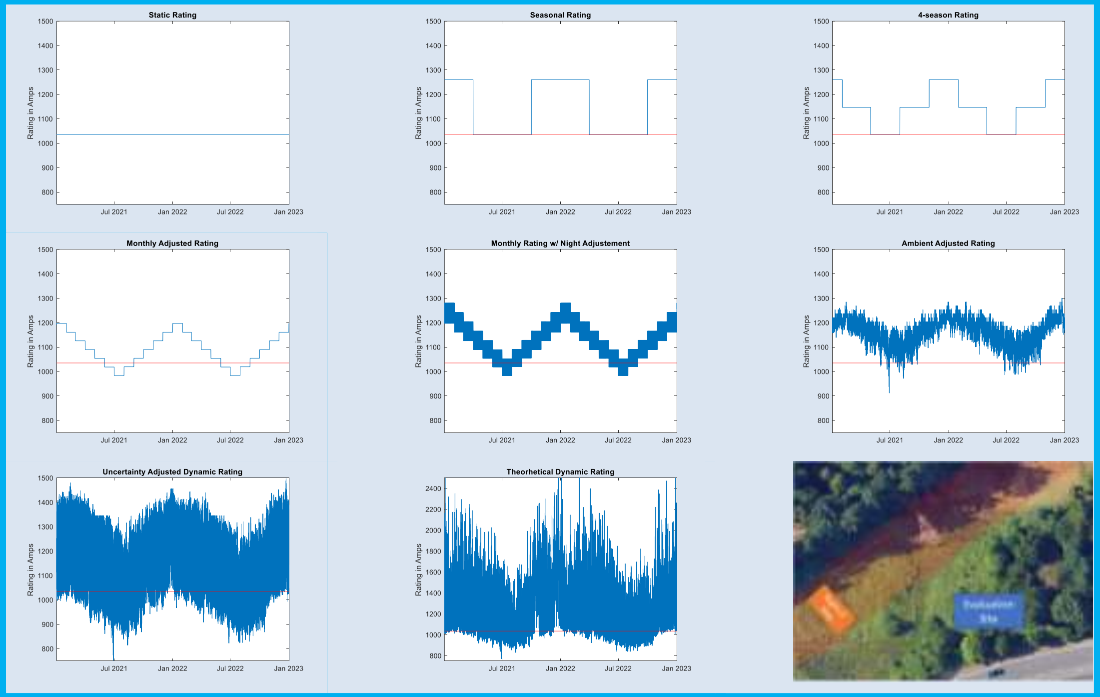
Adopting AAR reduces the ROI of adopting DLR

There are presently no industry standards for specifying or validating DLR systems

Gains may not be there when needed, and vary rapidly over time

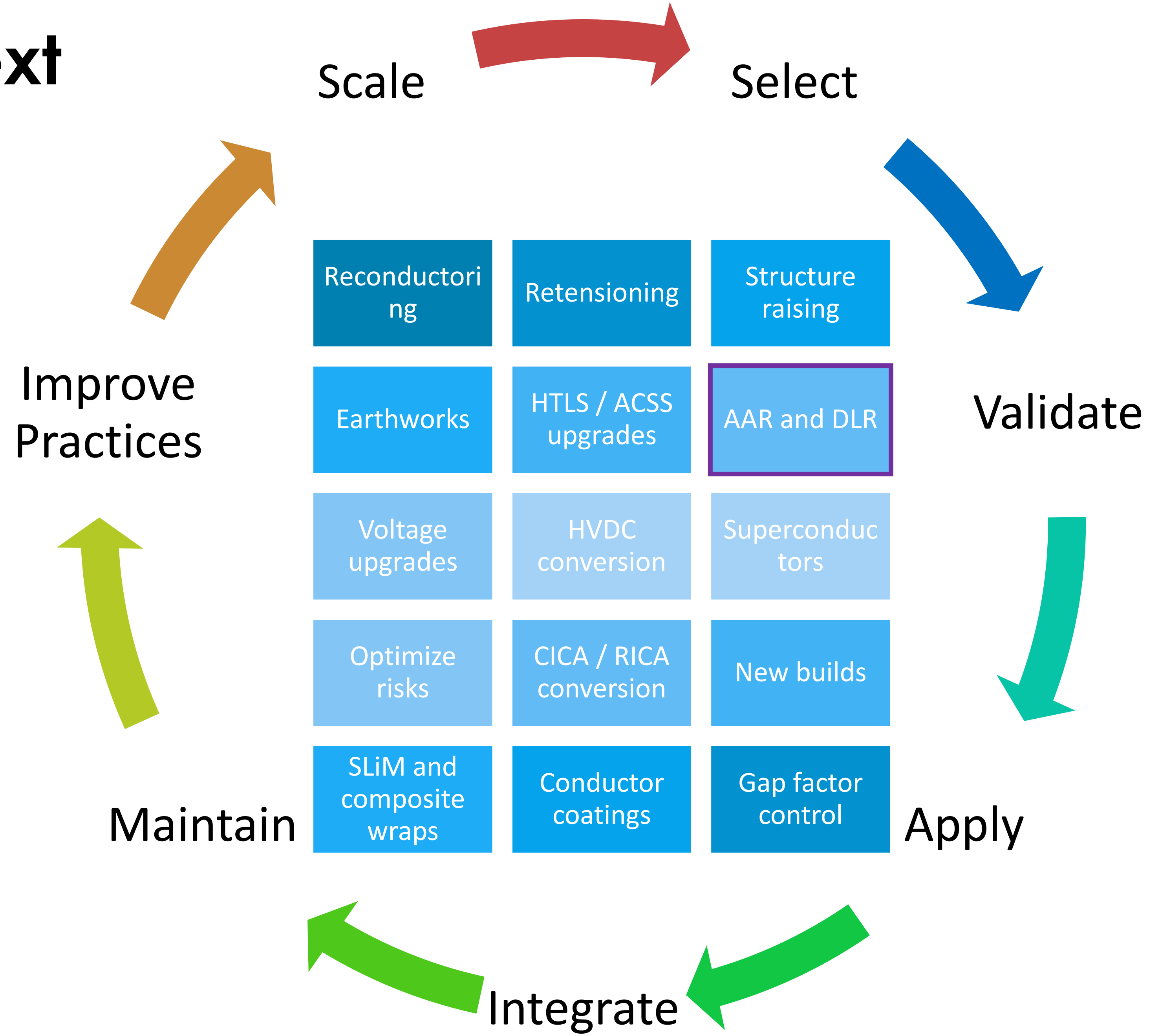
How DLR Differs From Other Ratings

Simplified Examples of Rating Types



Keeping DLR in Context

- DLR can be a very useful "tool in the toolbox"
- To leverage DLR capabilities, we need to understand the full life cycle performance and costs
- We also need to know how DLR compares to traditional upgrades and emerging technologies so we can "Right size" solutions
- In some cases, DLR can be applied in tandem with other upgrades to get improved capacity / ROI



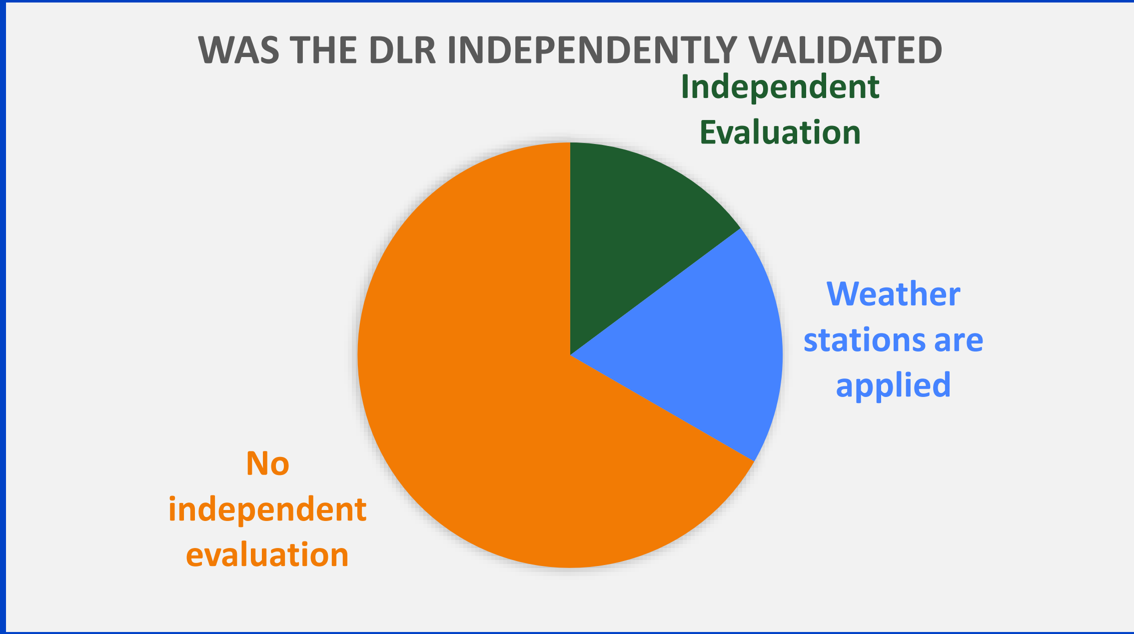
The Range of DLR Technologies Available

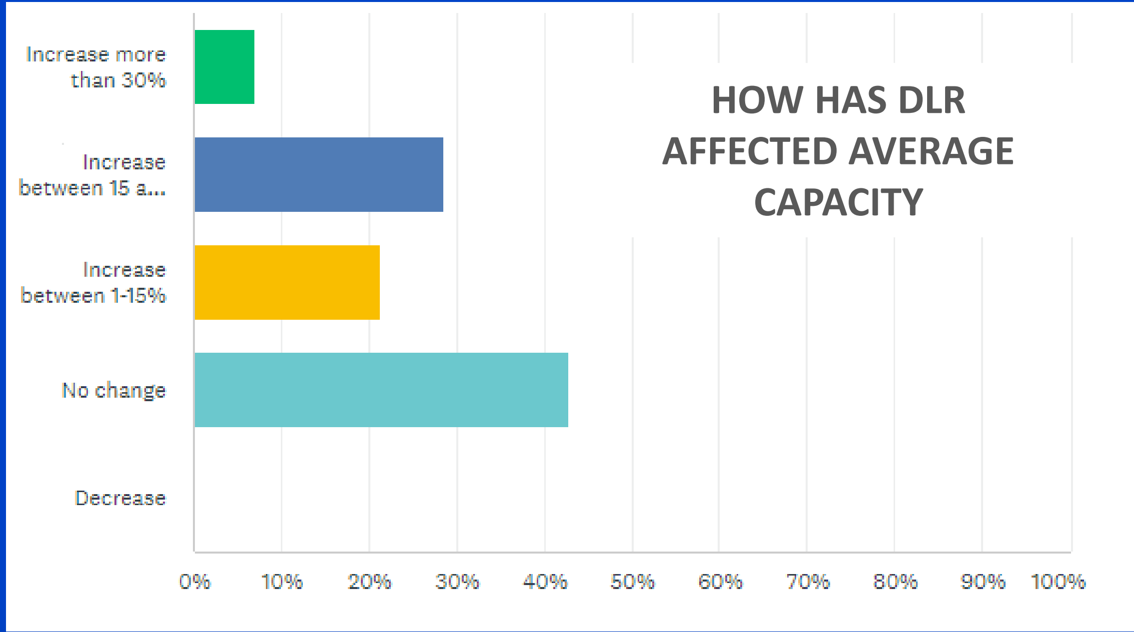
Ampacimon	Awesense	Bandweaver	Cat-1	Commercial Weather Models (>10)	DeAngeli OPGW	DeAngeli Smart	DOL	EGM – MSU
EMO (Micca)	Enline	GE Digi-DLR	GridGuard DLR	Grid Pulse	Grid Raven	Gridwell	Infravision	LakiPower
Line IQ	Lindsey	Line Ranger	LineVision	Luna - LIOS	Neara	NEC SpectralWave	Neuron	PitchAero-DLR
PMU method	Power Donut	Praetorian	Prisma Photonics	Prysmian OPGWatch	Public Weather Models (>13)	Public Weather Networks (>80)	Ritherm	Sagometer
SentriSense	Smartwires SUMO	Splight AI	Sumitomo DLR	ThermalRate	TopoloNet	Utility Weather Stations	WindSim	

Key: Software based | Hardware based | OPGW / FO connection

Current State of the Science for DLR

- DLR technology providers have different methods to establish the wind speed used for ratings calculations
  - This influences cost, reliability, risk, accuracy, maintenance, cyber requirements etc.
- Utilities have many tradeoffs to find right size and no-lose scenarios
  - Weather-based DLR can be used as a baseline for cost and performance that commercial DLR should improve upon to merit adoption
- Compared to GETs like advanced conductors, DLR has not been as rigorously evaluated and has fewer standards/ industry guides for best practices





Adoption Barriers Reported by Utilities / Challenges Observed in Field Trials

Accuracy concerns	Lack of error / risk management	Complete failure in under a year	Communication dropouts	Poor calibration methods / high maintenance	Battery explosions
Corona and audible noise issues	Failed or missing weather seals	Differences in performance when hardware and software updates are performed	Physical attachment issues	Accuracy drop off due to line maintenance	Accuracy drop off due to structure movement (wood poles)
Capacity reduced significant portion of time	Improper installation issues / damage	Damage from improper maintenance	Copper theft (of ground leads)	Dropouts during low solar or line load conditions	Capacity limited by other factors (DLR gains not actionable)

Knowledge Gaps

Acquisition

- Understanding accuracy & uncertainty of ALL available technologies
- Requirements for specifications and validation
- Life cycle costing (CapEx + O&M)
- Performance ranked against alternative upgrades

Planning & Operations

- Defining then managing uncertainty/risk of rating and forecast
- Automatic 'bad data' management
- Models/processes for decisions
- Industry-wide practices and tools
- Training

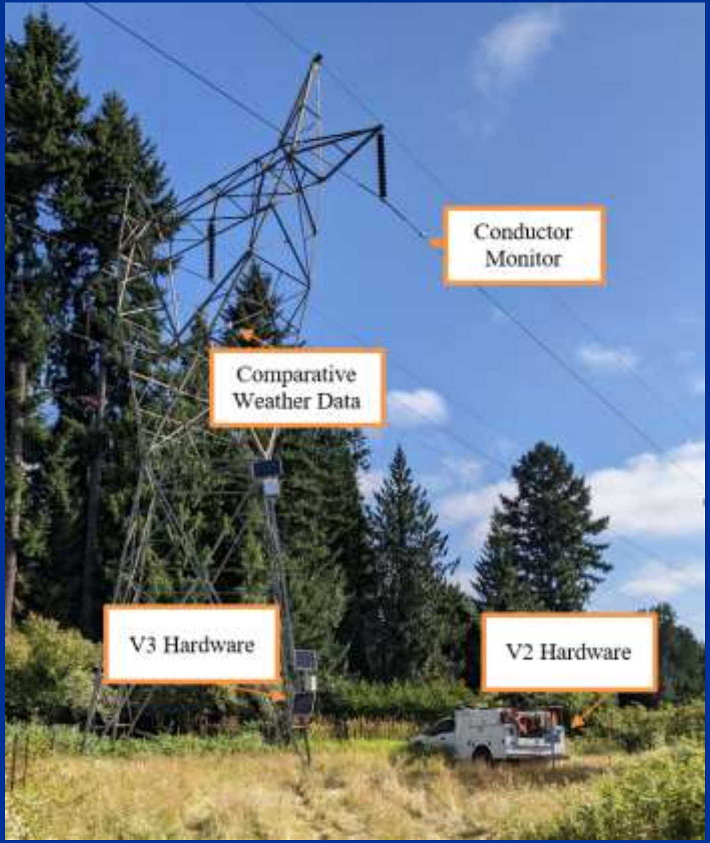
Maintenance

- Expected failure / outage rate
- Failover procedures and spares strategy
- Quantity & skills of resources needed
- Degradation & failure modes
- Life expectancy
- Disposal / end of life treatment

Existing Pathways to Address & Accelerate DLR Solutions

- **Full Scale Field Trials**

Compare against known reference



- **DLR Specification and Lab Evaluations**

MEASUREMENT ACCURACY

ELECTRIC & MAGNETIC FIELDS WITHSTAND

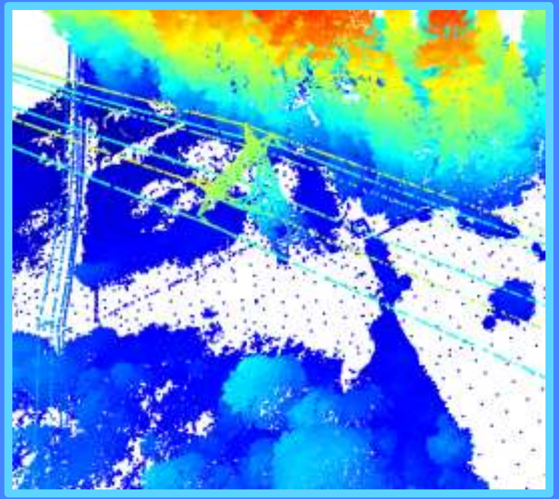
POWER CYCLING

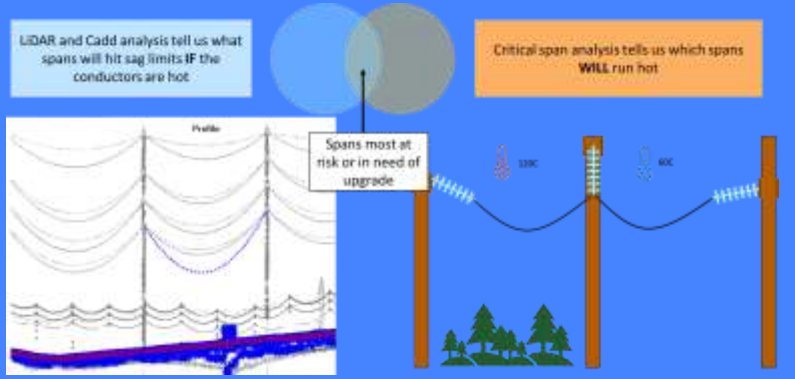
ATTACHMENT SLIP / VIBRATION

ENVIRONMENTAL EXPOSURE

SWITCHING AND LIGHTNING

- **Critical Span Identification and Coverage Area**





Incentives for Efficient Investment and Operation

Can our Transmission system GET a little relief?

Estimated Congestion Costs ($M)

ISO/RTO	2016	2017	2018	2019	2020	2021	2022
ERCOT	497	976	1,260	1,260	1,400	2,100	2,800
ISO-NE	39	41	65	33	29	50	51
MISO	1,402	1,518	1,409	934	1,181	2,849	3,700
NYISO	529	481	596	433	297	551	1,000
PJM	1,024	698	1,310	583	529	995	2,500
SPP	280	500	450	457	442	1,200	2,000
National Estimate	6,501	7,266	8,776	6,379	6,686	13,353	20,777

Grid Strategies, "Transmission congestion costs rise again in U.S. RTOs," July 2023. Available: https://gridstrategiesllc.com/wp-content/uploads/2023/07/GS_Transmission-Congestion-Costs-in-the-U.S.-RTOs1.pdf

How much relief can we GET?

PJM Example

Total Transmission Congestion Costs (USD millions) for RTOs from 2016 - 2022

RTO	2016	2017	2018	2019	2020	2021	2022	2023 (*)
PJM	1024	698	1310	583	529	995	2500	1069

Source: Grid Strategies, Transmission Congestion Costs Rise Again in the U.S. RTOs, July 2023

(*) Source: 2023 Annual State of the Market Report for PJM

Benefits and Value of New Power Flow Controllers, EPRI, Palo Alto, CA: 2018. 3002013930. Available: https://www.epri.com/research/products/000000003002013930

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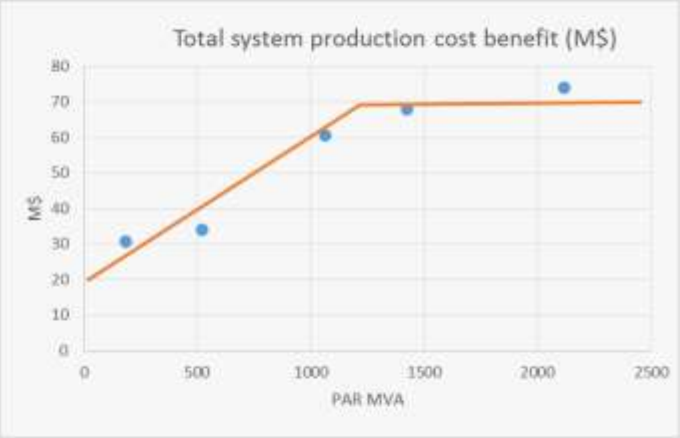

Benefits and Value of New Power Flow Controllers, EPRI, Palo Alto, CA: 2018. 3002013930. Available: https://www.epri.com/research/products/000000003002013930

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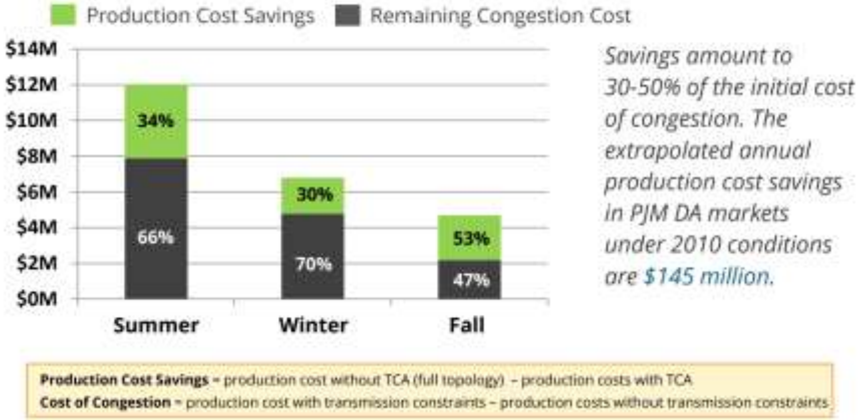

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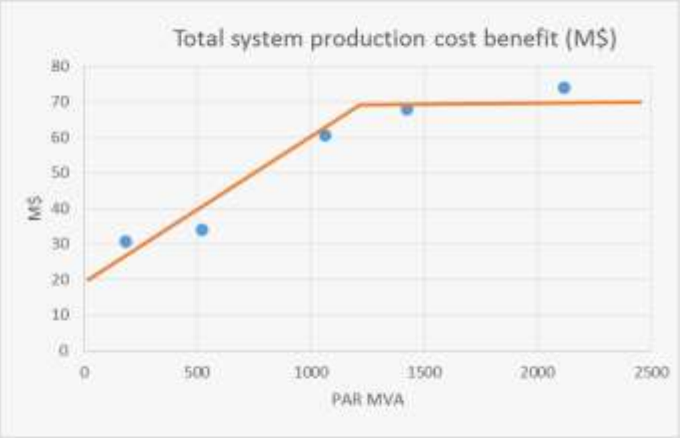

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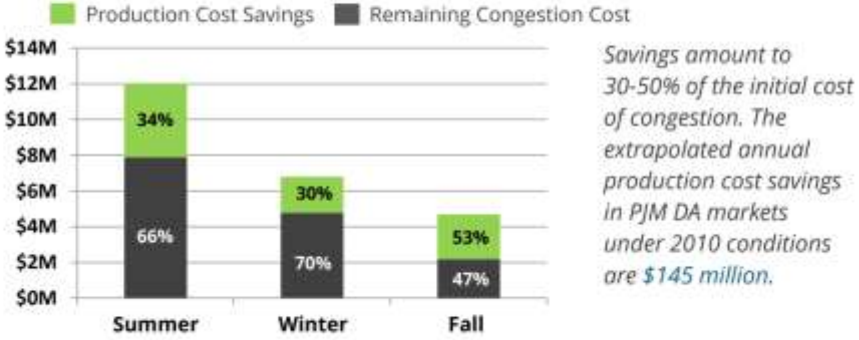
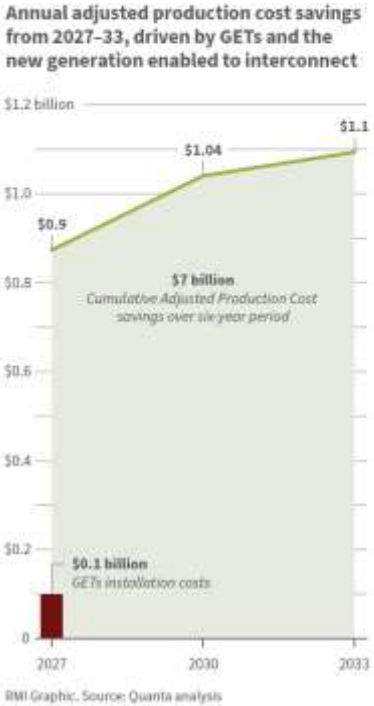
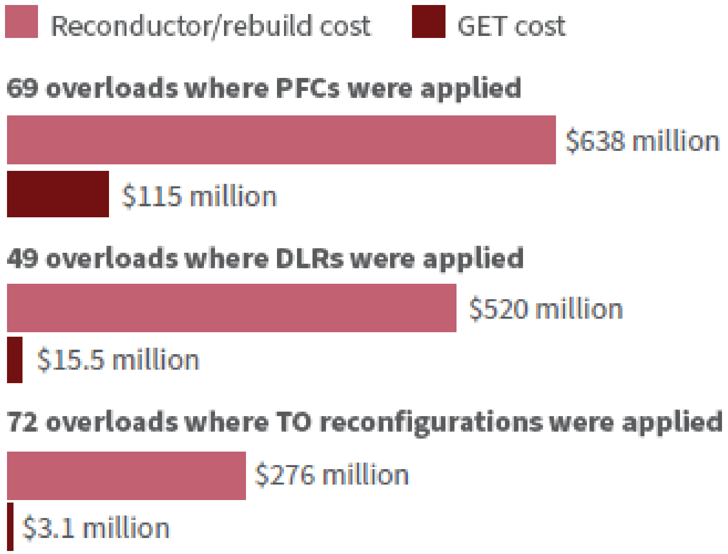


Production Cost Savings = production cost without TCA (full topology) – production costs with TCA
Cost of Congestion = production cost with transmission constraints – production costs without transmission constraints



Comparison of the typical network upgrade costs vs the cost of the GET alternatives



Katie Siegner, Sarah Toth, Chaz Teplin, and Katie Mulvaney, *GETting Interconnected in PJM: Grid-Enhancing Technologies (GETs) Can Increase the Speed and Scale of New Entry from PJM's Queue*, RMI, 2024, **https:// rmi.org/insight/analyzing-gets-as-a-tool-for-increasing-interconnection-throughput-from-pjms-queue/**.

What are the important issues to GET addressed?

Julia Selker, WATT Coalition (Linkedin)
Polls from 2023 ESIG Fall Technical Workshop

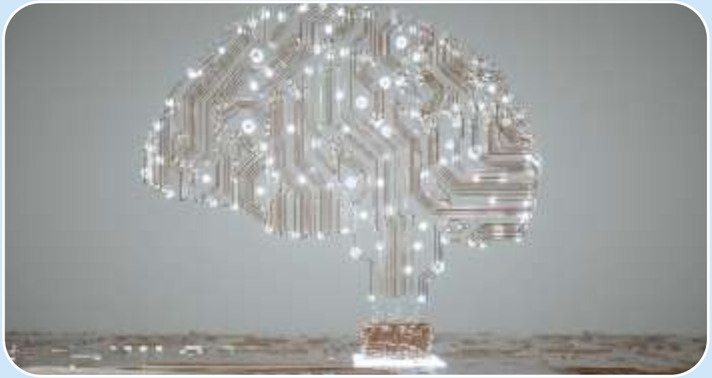
How did we GET here?

- 2005 FERC Order 679
- Mar. 2020 RM20-10 *Electric Transmission Incentives*
- Sept. 2021 FERC Workshop on Performance-based Ratemaking Approaches
- Dec. 2021 Order 881 *Managing Transmission Line Ratings (Ambient Adjusted Ratings)*
- Feb. 2022 AD22-5 Notice of Inquiry: *Implementation of Dynamic Line Ratings (DLR)*
- Jul. 2023 Order 2023 Improvements to Generator Interconnection Procedures and Agreements
- May 2024 Order 1920 Building for the Future through Electric Regional Transmission Planning and Cost Allocation

What do well designed incentives GET us?

Efficient **investment**; cost-effective infrastructure and energy suppliers

Efficient **operation**; Truthful participation and behavior that supports a reliable system operation



Innovation; and new technologies that can do things better and cheaper than what exists

What types of incentive will GET important?

Innovate

- Is there a means for new technologies to enter and compete?

Invest

- If it is a better alternative, is there an incentive for buyer/user to install?

Hedge

- If efficiency causes uncertainty, can participants hedge?

Operate

- Is there incentive to operate the facility in the most efficient manner possible?

GETting Investments Right

Benefits to Consumers

Return on Equity

Risks and Challenges

- Planned Benefit vs. Actual Benefit
- Congestion Revenue Allocation
- Shared Incentives

EPRI

Things can GET challenging

	Current Practice	Operator Confidence	Cost	Market Model and Computation	Congestion Hedging / Revenue Adequacy
DLR	Use of AAR in some regions; planned in all FERC ISOs; DLR pilots	Moderate	Low	Easy	Moderate
Advanced Power Flow Controller	PST in Day-ahead in few markets; no others in US	More	Moderate	Moderate	Easier
Topology Optimization (for economics)	Not for economics	Low	Low	Challenging	Challenging
Internal HVDC	NYISO, Soon SPP	High	High	Moderate	Easy

Between Long Island and New York City, the day-ahead scheduling of the PAR-controlled lines (i.e., the 901 and 903 lines) was highly inefficient with power scheduled in the inefficient direction in 97 to 98 percent of hours in 2014, which was comparable to the results in recent years. The use of these lines *increased* DAM production costs by an estimated $14 million in 2014 because prices on Long Island were typically higher than those in New York City where the 901 and 903 lines connect.

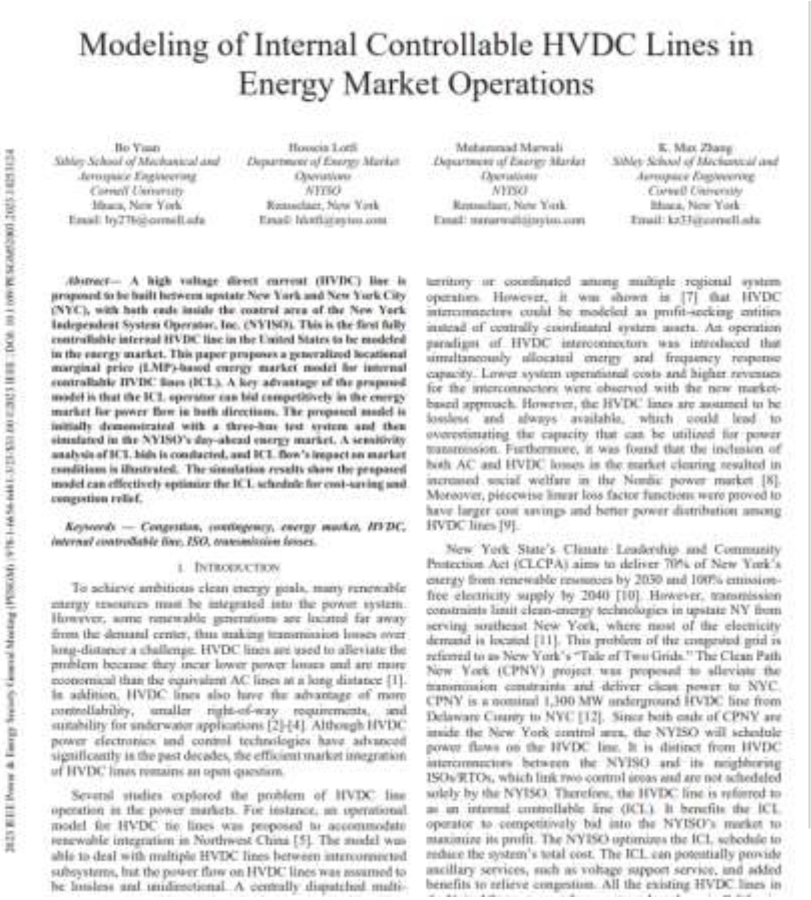
-Potomac Economics, NYISO State of the Market Report, 2014.

Research on incentive solutions is GETting us there

IEEE TRANSACTIONS ON POWER SYSTEMS, VOL. 32, NO. 3, MAY 2017

Computationally Efficient Adjustment of FACTS Set Points in DC Optimal Power Flow With Shift Factor Structure

Mostafa Sahraei-Ardakani, *Member, IEEE*, and Kory W. Hedman, *Member, IEEE*



Modeling of Internal Controllable HVDC Lines in Energy Market Operations

Bo Yuan, Sibley School of Mechanical and Aerospace Engineering, Cornell University, Ithaca, New York

Hossein Lotfi, Department of Energy Market Operations, NYISO, Rensselaer, New York

Mohammad Marwali, Department of Energy Market Operations, NYISO, Rensselaer, New York

K. Max Zhang, Sibley School of Mechanical and Aerospace Engineering, Cornell University, Ithaca, New York

2016 49th Hawaii International Conference on System Sciences

Financial Transmission Rights in Changing Power Networks

Aleksandr M. Rudkevich, Newton Energy Group

Michael C. Caramanis, Boston University

Evgeniy A. Goldis, Newton Energy Group

Xiaoguang Li, Boston University

Pablo A. Ruiz, Boston University

Richard D. Tabors, Tabors Caramanis Rudkevich

Abstract

Nomenclature

Research Gaps that need to GET addressed

Efficient incentive design to incentivize technologies that provide significant benefit/cost value over their life

Computationally efficient operational designs to represent GETs

Participation Models and Incentives to develop and operate GETs

Mechanisms to better hedge congestion with GETs in forward auctions

Improved confidence in GETs: demonstrations, forecast assessments, backup options

The GET Pun

Upcoming Incentives Panel Discussion at EPRI-ESIG-NERC-NATF workshop

GET SET
Grid-Enhancing Technologies for a Smart Energy Transition

- U.S. Department of Energy Lift Off Report
- Potomac Economics take on incentives for GETs in operation
- Portland General Electric utility perspective

Exploring the Regulatory landscape | Incentivizing technologies when they provide value

Participate in our Initiative

Mailing List

Contact GETSET@epri.com to join our forthcoming GETs mailing list

GET SET Workshop

June 20-21

Fill the DLR Status Survey

https://www.surveymonkey.com/r/YDZ3789

Updates, deliverables and additional information will also be shared on a dedicated webpage to be launched in June

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