



# Grid Enhancing Technologies in Transmission Operations and Planning: Challenges and Opportunities

ESIC-AGI FA25 Power Seminar Series



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UNIVERSITY



# Agenda



**What are GETs?**



**Why GETs and Why now?**



**Understanding the Technology**



**Research Opportunities**

# Transmission Planning vs Operations

- Transmission planning is the long-term process of designing and expanding the transmission network to meet future electricity demand reliably and economically.
- Transmission operations involve the **real-time** or **near-term** management of the transmission system to ensure safe, reliable, and efficient delivery of electricity.

Aspect	Transmission Planning	Transmission Operations
Time Frame	Long-term (years)	Short-term to real-time
Focus	Future system needs	Current system performance
Decision Type	Strategic (infrastructure investment)	Tactical (real-time control actions)
Data Used	Forecasted demand, generation, scenarios	Real-time measurements, forecasts
Outcome	Expansion plans, reliability studies	System stability, reliability, efficiency



**What are GETs?**

# 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



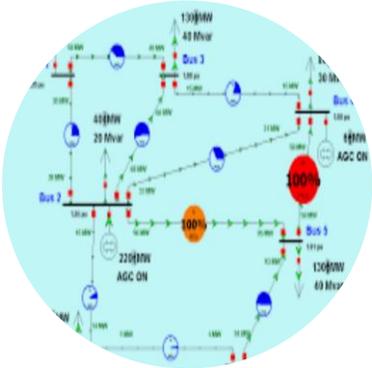
Updates thermal ratings of lines in real time

## Power Flow Controllers



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

## Topology Optimization

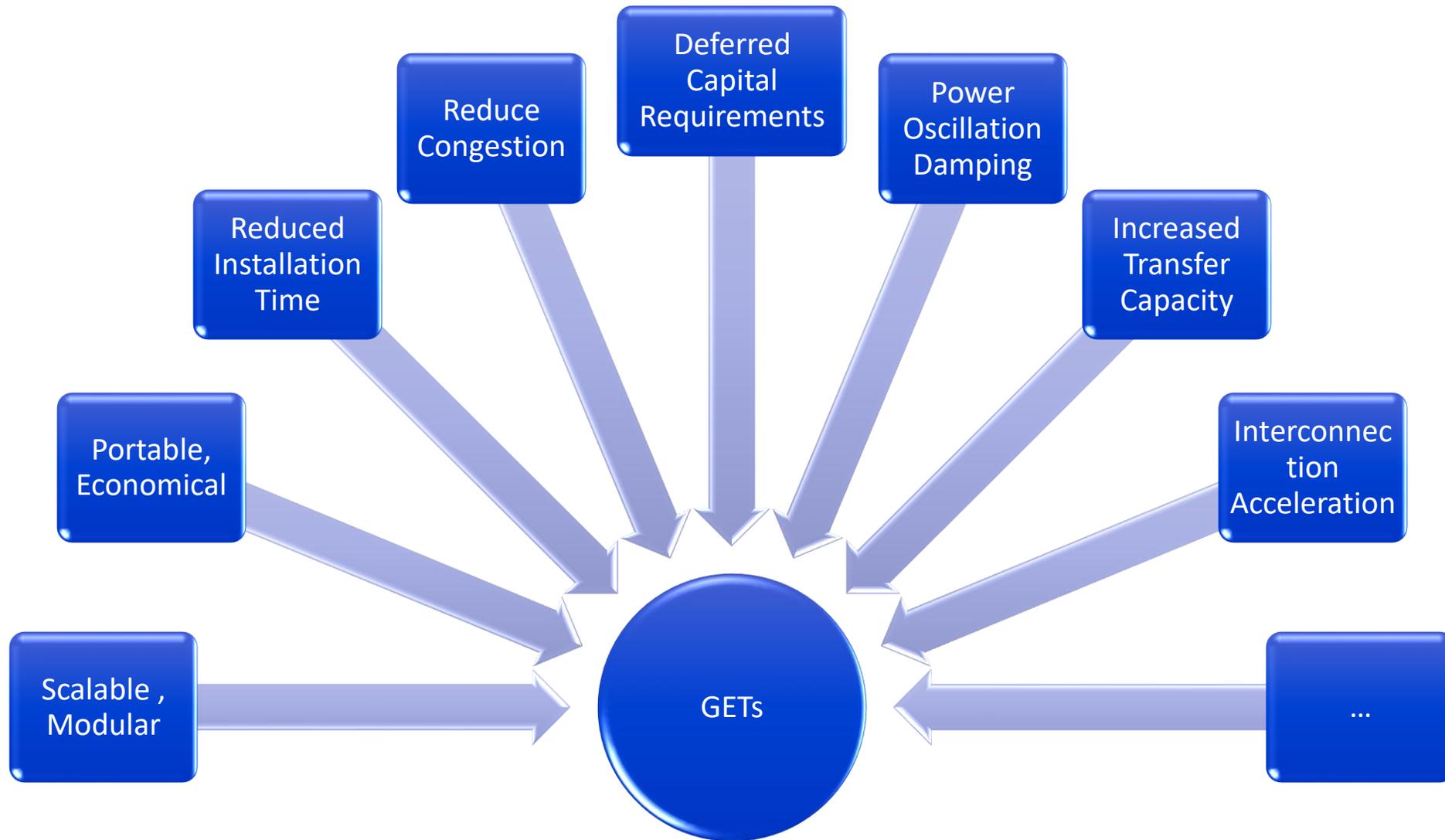


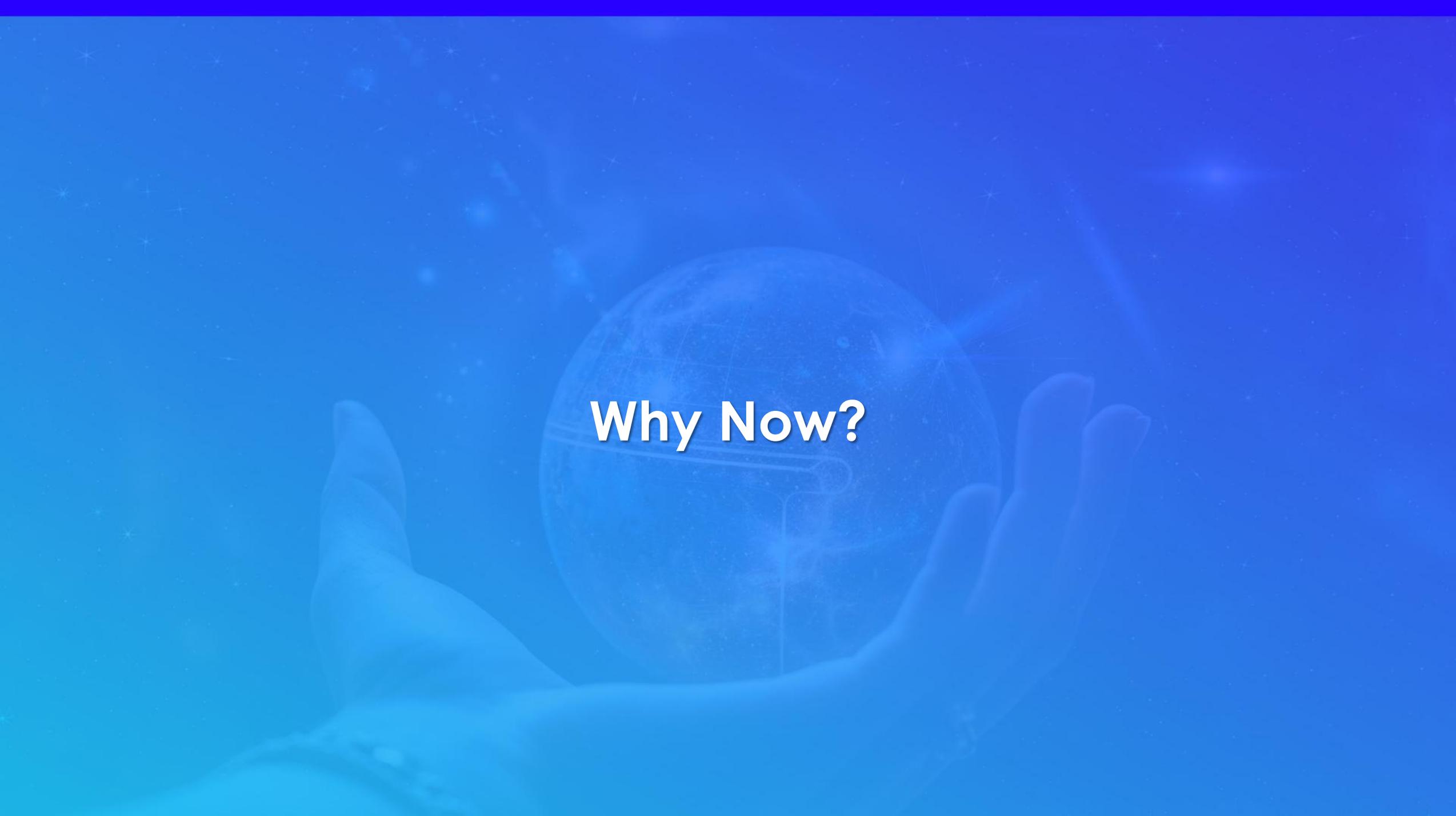
Redirects power to avoid congested or overloaded lines



**Why GETs?**

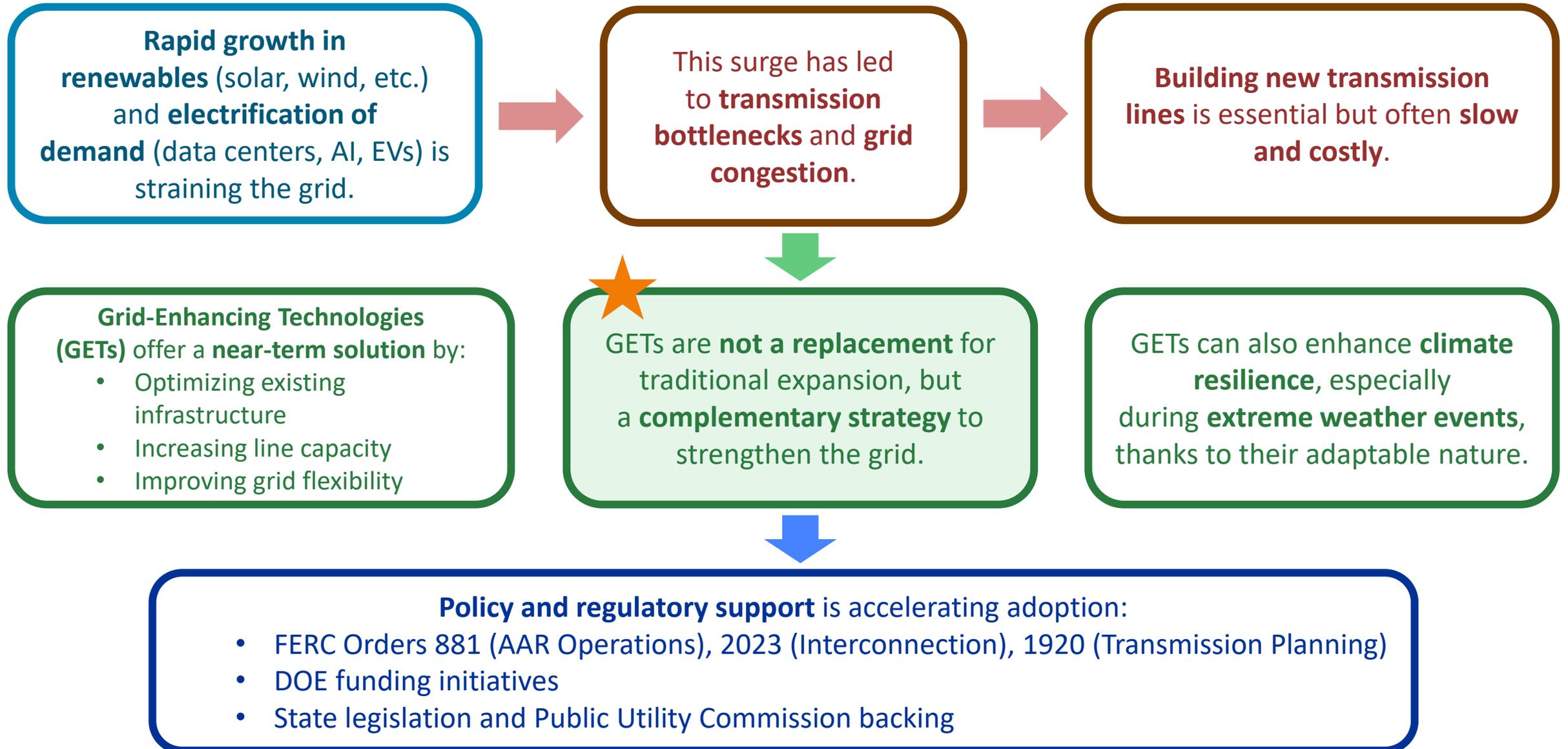
# Why GETs





**Why Now?**

# Grid Challenges & Role of GETs



# Order No. 1920: One of the Final Ruling

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

- **1198.** We adopt the NOPR proposal, with modification, to require transmission providers in each transmission planning region to consider, in Long-Term Regional Transmission Planning and existing Order No. 1000 regional transmission planning processes, dynamic line ratings and advanced power flow control devices for each identified transmission need. We modify the NOPR proposal to require that, in addition to dynamic line ratings and advanced power flow control devices, transmission providers
- must consider in Long-Term Regional Transmission Planning and existing Order No. 1000 regional transmission planning processes advanced conductors and transmission switching. Thus, under this modification, **transmission providers must consider: (1) dynamic line ratings (2) advanced power flow control devices; (3) advanced conductors; and (4) transmission switching.** We clarify that transmission providers
- must consider each of these enumerated technologies when evaluating new regional transmission facilities, as well as upgrades to existing transmission facilities.

Only a segment of the ruling is listed here. For full details, please check [FO1920](#)



Effective date of  
Order 1920

August 12, 2024

EPRI Presentation and  
Webcast Video

[Click here](#)

(Check Attachments Tab)

# Order No. 2023 Reforms: One of the Final Ruling

- **1578.** We adopt, with modifications, the proposed revisions to section 7.3 of the *pro forma* LGIP, and sections 3.3.6 and 3.4.10 of the *pro forma* SGIP. We modify the NOPR proposal to require transmission providers to evaluate the following enumerated list of alternative transmission technologies: static synchronous compensators, static VAR compensators, advanced power flow control devices, transmission switching, synchronous condensers, voltage source converters, advanced conductors, and tower lifting. We modify proposed *pro forma* LGIP section 7.3 to require transmission providers to evaluate the list of alternative transmission technologies enumerated in this final rule during the cluster study, including any restudies, of the generator interconnection process in all instances (i.e., for all interconnection customers in a cluster), without the need for a request from an interconnection customer. We require transmission providers to evaluate each alternative transmission technology listed in *pro forma* LGIP section 7.3 and to determine, in the transmission provider's sole discretion, whether it should be used, consistent with good utility practice, applicable reliability standards, and other applicable regulatory requirements. Finally, we require transmission providers to include in the *pro forma* LGIP cluster study report, an explanation of the results of the evaluation of the enumerated alternative transmission technologies for feasibility, cost, and time savings as an alternative to a traditional network upgrade.

Only a segment of the ruling is listed here. For full details, please check [FO2023](#)

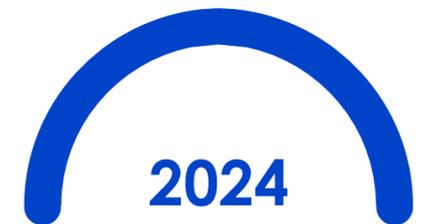


2023



November 6,  
2023

The ruling was published in the [federal register](#) (Order 2023) on September 6, 2023. This ruling became effective on November 6, 2023



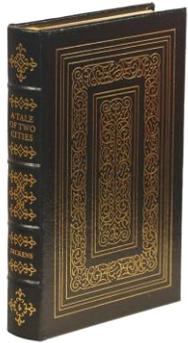
2024



April 3,  
2024

Transmission providers to propose how they will operate in compliance with the final rule by proposing changes to their tariffs.

# There's a lot to unpack...



**A Tale  
of Two Cities**  
428 pages

**Harry  
Potter Series  
(average)**

~700 pages



**Holy Bible**  
1,200 pages



**Lord of the  
Rings**  
1,200 pages



**FERC Order  
No. 1920**  
1,363 pages



**FERC Order  
No. 2023**  
1,481 pages

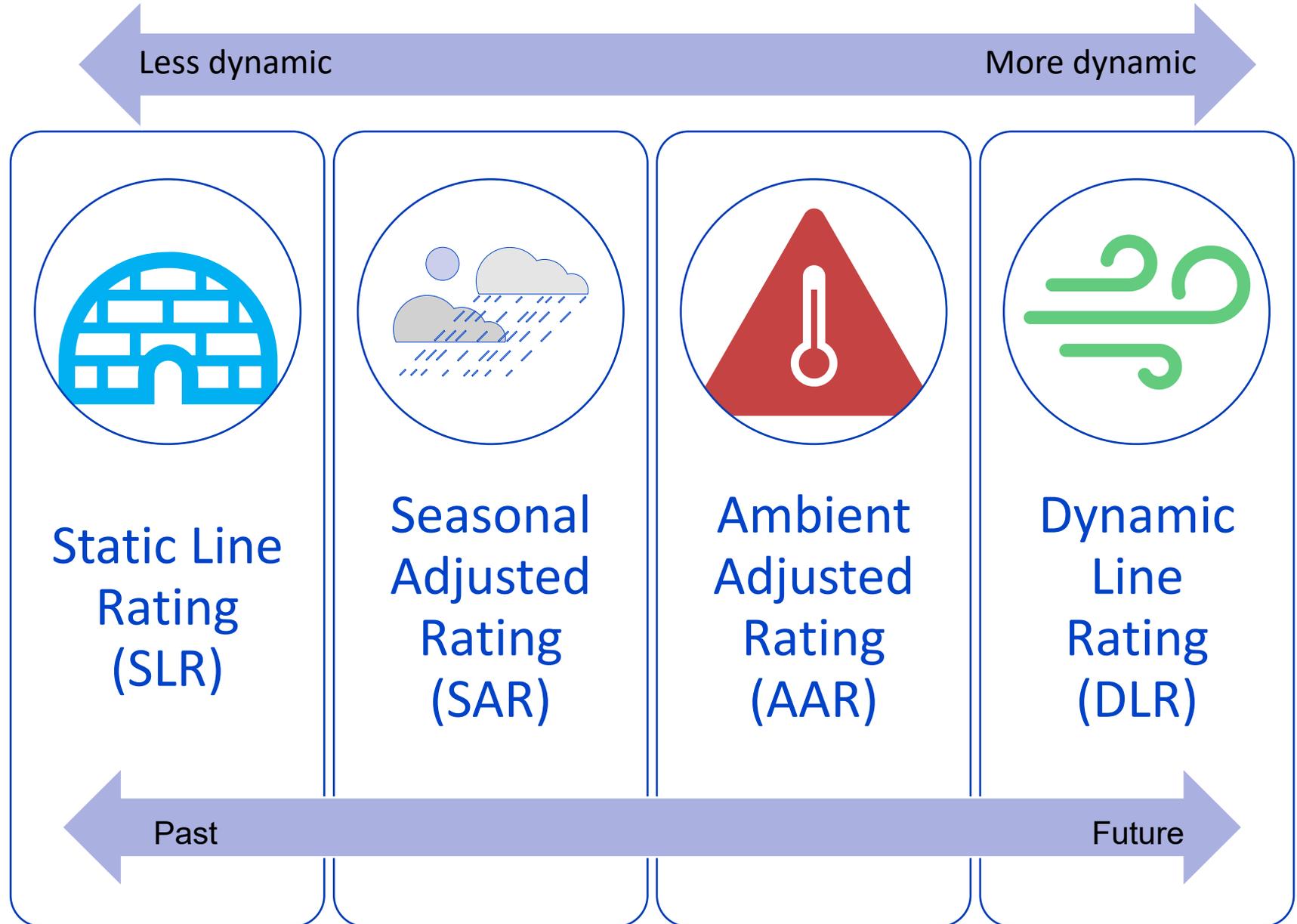




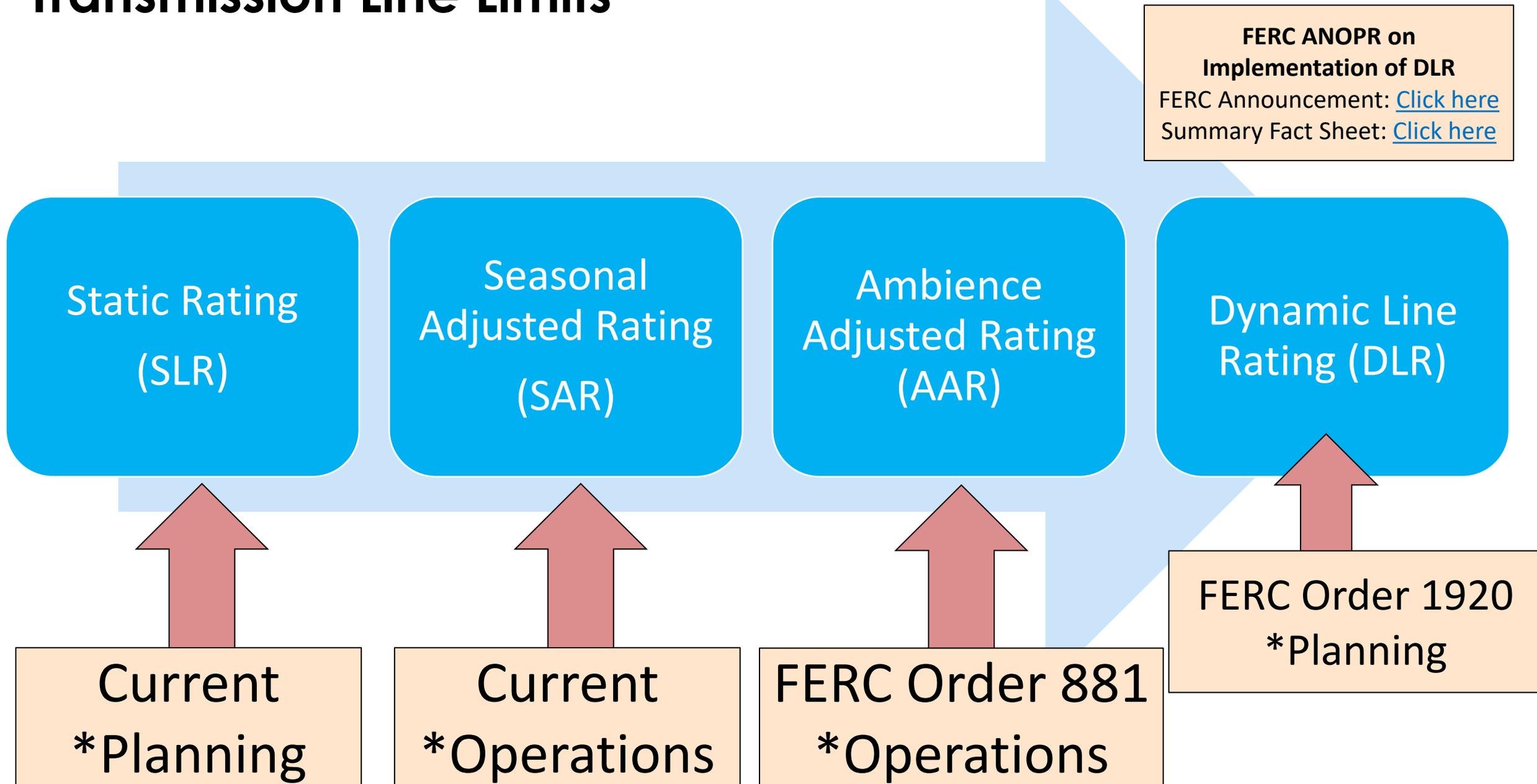
# Transmission Line Ratings

# Transmission Line Limits

- There are four categories of transmission line limit calculations.
- The SLR is the most conservative to DLR, being the most dynamic or flexible.



# Transmission Line Limits





# Advanced Conductors

# Traditional Conductors

Initially, bare, stranded copper was utilized as an overhead transmission conductor due to its high conductivity and good tensile strength. The aluminum 1350-H19 replaced copper as the main conductive material due to its lower cost and lower density.



**All Aluminum  
Conductor  
(AAC)**



**Aluminum  
Conductor  
Alloy  
Reinforced  
(ACAR)**



**All Aluminum  
Alloy  
Conductor  
(AAAC)**



**Aluminum  
Conductor  
Steel  
Reinforced  
(ACSR)**

# Advanced Conductors



**ACSS**

Aluminum Conductor Steel Supported



**ACFR**

Aluminum Conductor Fiber Reinforced



**ACCR**

Aluminum Conductor Composite Reinforced



**ACCM**

Aluminum Conductor Composite Multistrand



**ACCS**

Aluminum Conductor Composite Supported



**HVCRC**

High Voltage Composite Reinforced Conductor



**LSCC**

Low Sag Composite-core Conductor



**TS**

Total Solutions



**ACCC**

Aluminum Conductor Composite Core

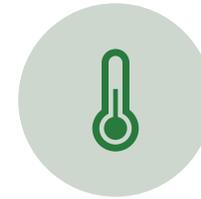
# Advanced Conductors vs Traditional Conductors



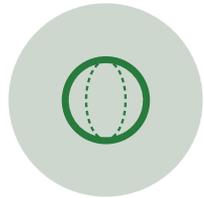
Lower unit weight



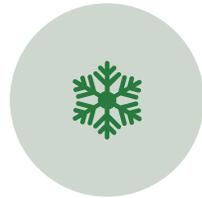
Higher core strength



Sags less at high temperatures



More aluminum for same diameter



Sags more under ice loading



More care needed when handling and installing



No core inspection tools (non-steel core)



Higher cost



No long-term operational experience

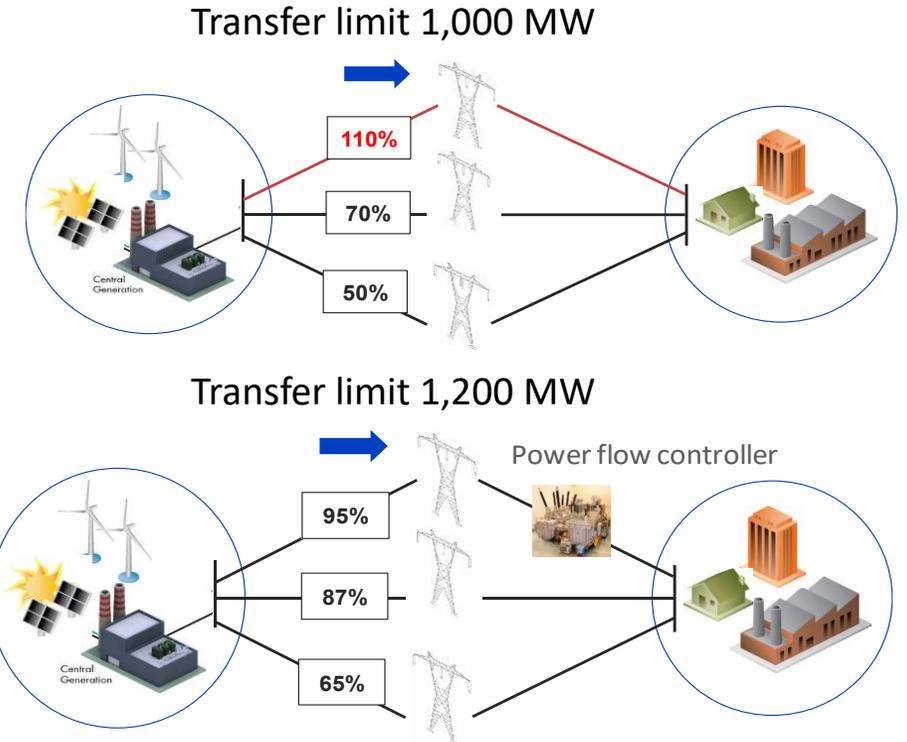
**Key Takeaway: Higher Currents Possible => Increased Transmission Line Capacity**



# Advanced Power Flow Control

# Power Flow Controllers

- Power Flow Control:
  - Ability to change the way that power flows through the grid by actuating on high voltage devices connected in series
- Advanced Power Flow Controllers (APFC):
  - Power electronic based
  - Modular and scalable, more responsive, faster deployment



**Power Flow Control devices allow better utilization of existing transmission assets by balancing flows**

# How does APFC do it?



Transgrid, Australia



ISA, Colombia



National Grid, UK (X5)

**Technical:** Modular Static Synchronous Series Compensators (m-SSSC), a type of FACTS device, inject a controllable voltage in quadrature (i.e.,  $90^\circ$  phase shift) with the line current.

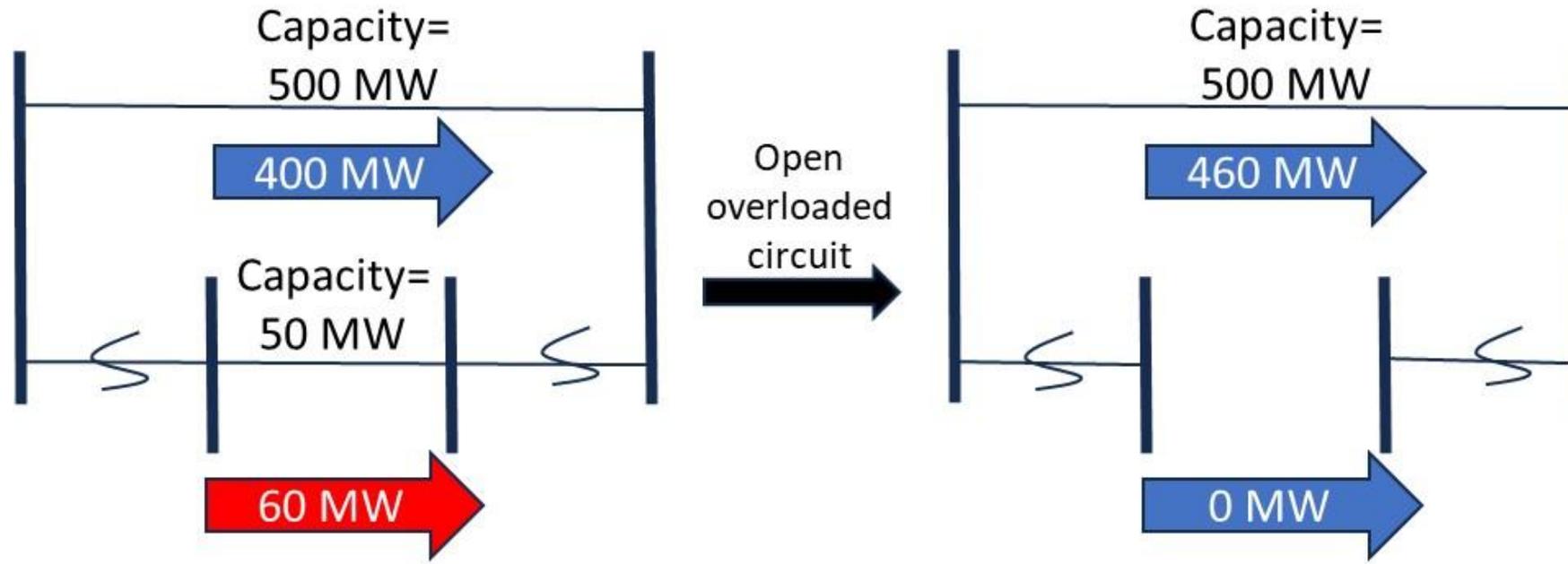
**Indirect Effect:** The quadrature voltage injection alters the apparent impedance of the line, allowing operators to redistribute power flows without physically modifying the grid.

**Simplified:** Push power away from overloaded lines or pull power toward underutilized lines, enhancing grid flexibility, reliability, and efficiency.



# Topology Optimization

# Topology Reconfiguration



Identifying best configuration that alleviates congestion and increase transfer capacity by redirecting the flows

## Opportunities:

1. Congestion Relief
2. Improved Operations & Planning
3. Does not require new hardware

## Challenges:

1. Computational Complexity
2. Impact on Existing Markets
3. Increased Circuit Breaker Operations
4. Potential Impacts on Stability
5. Increased Complexity for Operators



# RESEARCH OPPORTUNITIES

# Identify Priority Gaps for Broader Deployment



Advanced Conductors



Dynamic Line Ratings



Power Flow Controllers



Topology Optimization



## GETs Characteristic Technical Bases



Technology Evaluation



Planning Models/tools



Operations Models/procedures



Acquisition & Maintenance



Incentives & Markets

# DLR – Dynamic Line Rating: Opportunities

- ❖ What are use cases or applications where AAR/DLR could be potentially beneficial or applied?  
(e.g., To update the Seasonal Ratings)  
(e.g., the percentage of times the static rating is higher than the DLR)  
(e.g., outage coordination)
- ❖ What risks are involved in using AAR/DLR in Short Term Planning or Long-Term Planning (LTP)?
  - ❖ How much investment planning can be saved?  
(i.e., Over-investment or Stranded Units that will not be used)
- ❖ Should one decide to use AAR/DLR in Planning, what rated value to be used?
- ❖ What would be impact on markets if DLR is considered in Operations?



# APFC – Advanced Power Flow Control: Opportunities

## Establishing Standards & Specifications

- Define performance benchmarks, testing protocols, and validation procedures for new technologies.

## Advanced Modeling & Simulation

- Develop models for steady-state, dynamic, stability, EMTP, and protection studies to support system analysis.
- Tackle issues related to modularity, portability, and varying time horizons.

## System Coordination & Integration

- Design coordination methods and processes for seamless operation of multiple devices.
- Design regulatory policies.

## Market Impact & Cost-Benefit Analysis

- Evaluate economic implications and formulate strategies for value-driven deployment.

# What EPRI is doing to address the roadblocks?

## Reference guides:

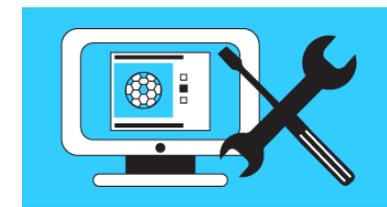
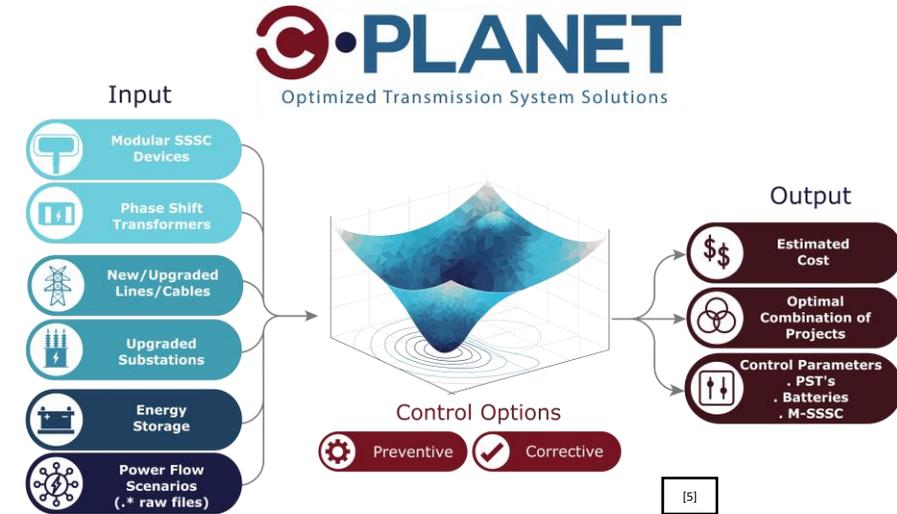
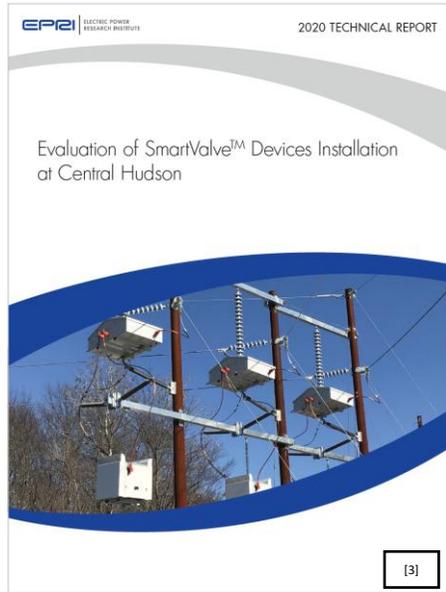
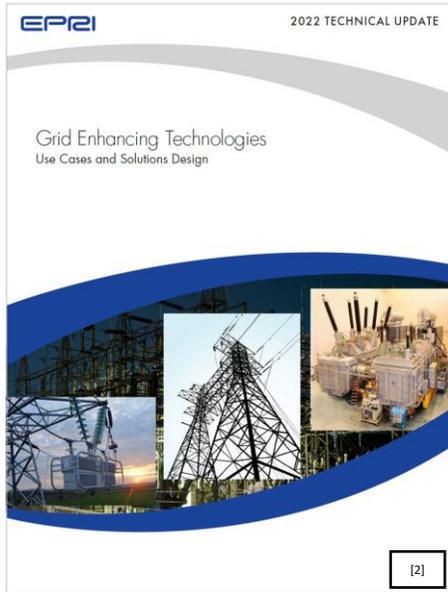
- To increase knowledge of alternative choices
- Evaluation of Technologies

## Full-scale testing with utilities

## Exploring Excellence:

- Cost/Benefit Framework
- Comprehensive Case Studies
- Collaborative R & D

## Innovative analytical tools to analyze and evaluate these technologies



# Conclusion and Future Directions



- GETs offer scalable, cost-effective solutions to reduce congestion and maximize transmission capacity.
- Regulatory frameworks encourage adoption and evaluation of GETs.
- Several research opportunities to overcome technical and operational challenges.
- Continued innovation essential for a resilient, modern electric grid.
- How to combine these technologies in an efficient way? What tools and methods are necessary?

# Additional Links

- EPRI's GET SET Initiative
  - <https://interactive.epri.com/get-set/p/1>
- <https://watt-transmission.org/>
- <https://inl.gov/national-security/grid-enhancing-technologies/>



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