NARUC CENTER FOR PARTNERSHIPS & INNOVATION WEBINAR SERIES

THE ELECTRON SUPERHIGHWAY: MODERNIZING U.S. TRANSMISSION INFRASTRUCTURE

MARCH 19, 2020

Moderator:

- **Chairman Sally Talberg,** Michigan Public Service Commission

Speakers:

- **Bruce Tsuchida**, Principal, The Brattle Group
- **Jennie Chen**, Senior Counsel, Federal Energy Policy, Duke University Nicholas Institute for Environmental Policy Solutions
- **Kerinia Cusick**, Co-Founder, Center for Renewables Integration
- **Jon Wellinghoff**, CEO, GridPolicy Inc., and former Chairman, Federal Energy Regulatory Commission

TODAY'S SPEAKERS

Bruce Tsuchida
Principal
The Brattle Group

Jennie Chen
Senior Counsel
Duke University Nicholas Institute

Kerinia Cusick
Co-Founder
Center for Renewables Integration

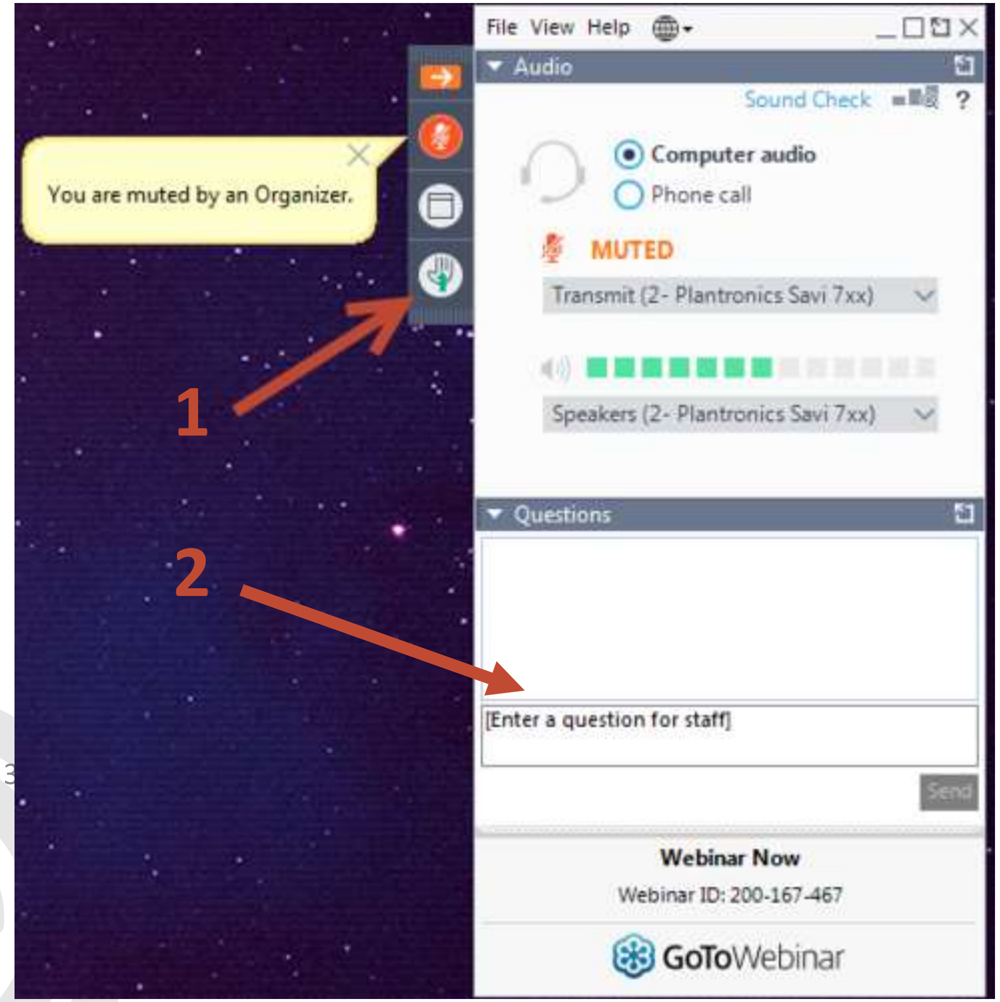
Jon Wellinghoff
CEO
GridPolicy Inc.

QUESTIONS

Submit questions two ways:

1. Raise your hand and the moderator will call on you to unmute your line

2. Type a question into the question box



The Electron Superhighway: Modernizing U.S. Transmission Infrastructure

ADVANCED TRANSMISSION TECHNOLOGIES WEBINAR

FOR

THE NATIONAL ASSOCIATION OF REGULATORY UTILITY COMMISSIONERS (NARUC)

CENTER FOR PARTNERSHIPS & INNOVATION (CPI)

PRESENTED BY

T. Bruce Tsuchida

March 19, 2020

THE Brattle GROUP

Disclaimer

This presentation is intended to assist the discussion for the March 2020 NARUC CPI Webinar "The Electron Superhighway: Modernizing U.S. Transmission Infrastructure." This presentation and associated discussion are not meant or permitted to be a substitute for the exercise of any business judgment. The contents of this presentation may involve the use of assumptions and projections with respect to conditions that may exist or events that may occur in the future. Although The Brattle Group has applied assumptions and projections that are believed to be reasonable, they are subjective and may differ from those that might be used by other economic or industry experts to perform similar analysis. In addition, and equally as important, actual future outcomes are dependent upon future events that are outside The Brattle Group's control. No one can give any assurance that the assumptions, projections, or judgments used will prove to be correct or that actual future outcomes will match the forecasts. The Brattle Group cannot, and does not, accept liability under any theory for losses suffered, whether direct or consequential, arising from any reliance on this presentation, and cannot be held responsible if any conclusions drawn from this presentation should prove to be inaccurate.

Agenda

- Transmission and Transfer Capabilities
- Advanced Transmission Technology
- Potential Benefits
- What is Missing?

Transmission and Transfer Capabilities

Transfer capabilities are largely defined by two factors: the physical capacity of individual lines and network topology.*

Physical capacity of individual overhead lines:

- Primarily defined by the maximum operating temperature to:
  - Maintain minimum electrical clearances (line sagging, etc.).
  - Limit annealing of conductor aluminum.
  - Limit aging of connectors/hardware.
- Increased power flow warms the line (resistive heating).
- Ambient conditions also impact line temperature.

Network topology:

- Key factor defining the distribution of power flows—i.e., how much flows on each line.

Traditional thinking treated transmission as if it is fixed and cannot be operated dynamically.

- Transmission has a fixed capacity, much like roads do (e.g., the number of cars that can go through at any given time).
- Advancements in maps and GPS technology have allowed for easier and more efficient driving on the same roads.
- Are there similar technologies that allow for such innovation in transmission operations?

* Note that the actual operating limits are more often defined by contingencies, rather than by the ratings of a single line.

Advanced Transmission Technology

Advanced Transmission Technologies are largely operation enhancement technologies.

These technology options are relatively new.

- Supported by advancements in power electronics, communication devices, computational processing power, and optimization algorithms.
- These technology options focus on operational improvements and have a much lower cost and faster implementation than traditional transmission technologies.
  - Similar to the comparison between building a road to reduce congestion (long-term investment) and having a good map/GPS system to avoid congested roads (operational improvements).

Largely two technology types:

1. More accurate measurements and projections of transmission operating conditions:
   - Dynamic Line Ratings (DLR)
   - Adoptive Line Ratings (ALR)
2. Flexible and dynamic control of transmission systems to optimize existing assets' operations:
   - Flexible Alternating Current Transmission Systems (FACTS)
   - Phase Shifters
   - Transmission Topology Optimization
   - Storage Technologies

Dynamic Line Ratings

Today's practice is largely based on Static Line Ratings (SLR).

Maximum operating temperature for a given line is pre-determined.

- Uses conservative assumptions, such as low wind, high temperature, high solar irradiance etc., to accommodate most conditions.
- It is similar to setting the speed limit for highways based on a snowy road conditions.

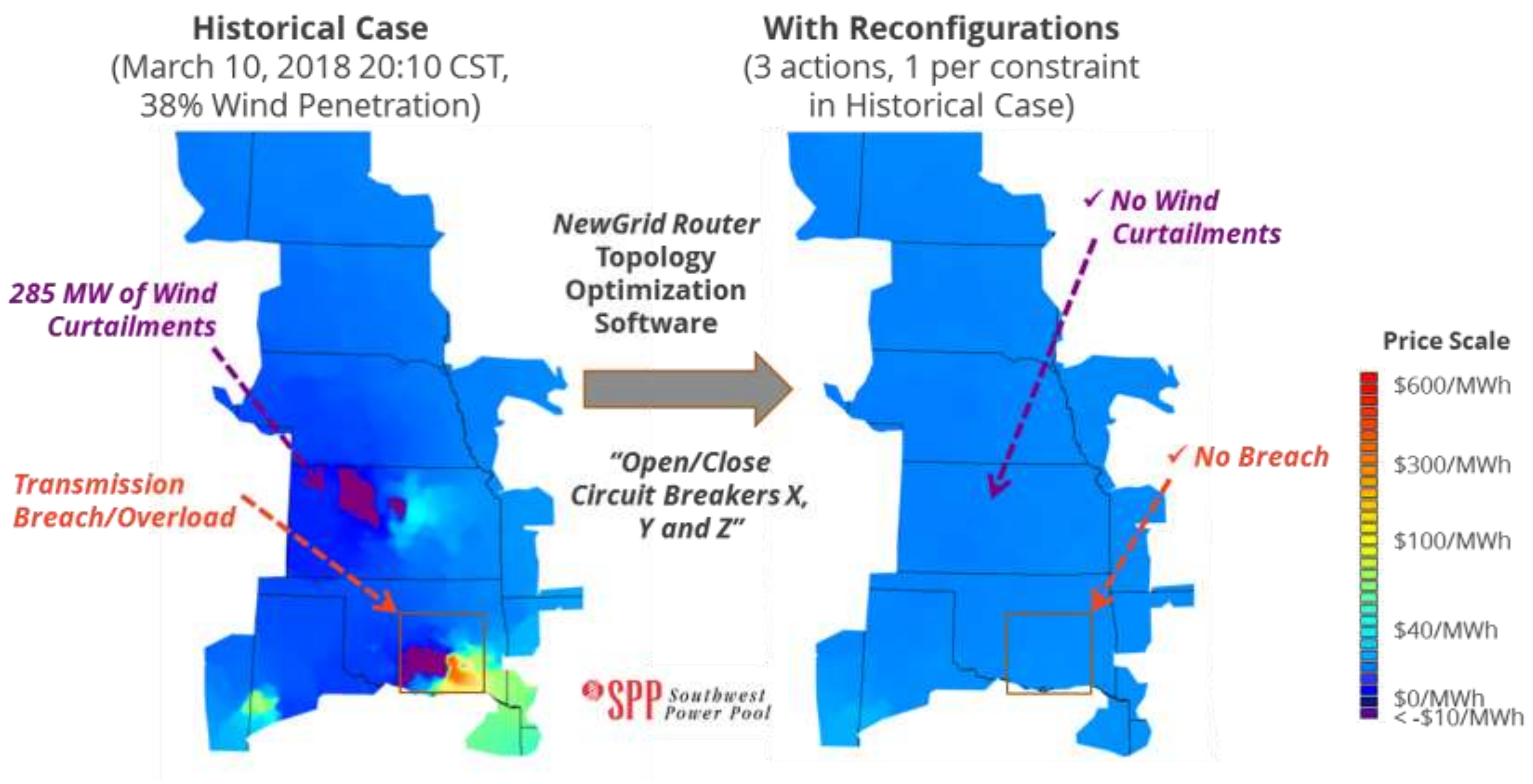
Dynamic Line Ratings (DLR) adjust this limit based on ambient conditions.

- Thermal ratings use real-time measurements at the line location (along line corridor).
  - Line temperature, Line sagging, Ambient conditions (temperature, humidity, solar irradiance, wind, precipitation etc.).
  - DOE/ONCOR study indicates DLR transfer capability to be 5 to 25% higher than SLR.
- Accumulation of real-time data can be used for future calibration.
  - DLR is variable and requires a forecast for operations planning.
- High wind leads to higher cooling and allows for increased flow.
  - High degree of overlap between wind production and DLR-induced allowable flow increase has been observed.
  - European studies indicate DLR contributes to approximately 15% reduction in wind curtailments in some areas.

Advanced Transmission Technology Example 2:

Topology Control

Topology optimization software technology automatically finds reconfigurations to route flow around congested elements (“Waze for the transmission grid”).



Potential Benefits

Various studies indicate significant benefit potentials at relatively low cost.

Benefits are in the *tens to hundreds of million dollars*:

- Similar range to the operational benefits of RTO-/ISO-operated regional markets.
  - PJM estimates benefits of $100 million a year for nodal vs TLR, and $100 million a year reduced needs of Grid services.
- Reduces congestion.
  - DOE/ONCOR Study estimates 10% increase in ratings could eliminate most congestion.
  - Entergy confirms an average of 10+% increase in line capacity (DLR applied primarily in off-peak periods).
  - U.S.-wide annual congestion cost is estimated to be nearly $6 billion.
- Helps with renewable integration.
  - European studies indicate DLR's contribution to reduced wind curtailment (~15%).
  - Quick implementation helps with the fast clean energy transition pace.
  - Relatively lower cost investments helps cash stranded utilities that need to invest to accommodate load growth (which could be triggered even further by electrification, etc.).
- Complements new investments.
  - Enhance underlying system to take full advantage of new investment potential
  - Mitigate the impacts of construction (or maintenance) outages.
  - Bridge the gap until permanent solution can be achieved.
- Others (system awareness, redundancy, resiliency, etc.).

What is Missing?

Are the technologies by themselves understood?

- These operational technologies are relatively new.
  - Enabled through recent technology breakthrough in electronics, communications, computational power, etc.

Are the incentives aligned?

- Congestion costs are passed through to end-consumers.
  - Limited benefits for transmission operators/owners to adopt these technology options.
- Industry rewards maintaining reliability more than improving operational efficiency.
  - Changing operations to improve efficiency can be seen as risk taking.
- Transmission owners who earn sufficient returns on investments may prefer larger investments.
  - These technology options are actually complementary to new investments.
- Should there be a benefit-sharing mechanism?
  - UK or Australian system may provide hints.

https://www.brattle.com/news-and-knowledge/publications/improving-transmission-operation-with-advanced-technologies-a-review-of-deployment-experience-and-analysis-of-incentives

About Brattle

The Brattle Group provides consulting and expert testimony in economics, finance, and regulation to corporations, law firms, and governments around the world. We aim for the highest level of client service and quality in our industry.

OUR SERVICES	OUR PEOPLE	OUR INSIGHTS
Research and Consulting	Renowned Experts	Thoughtful Analysis
Litigation Support	Global Teams	Exceptional Quality
Expert Testimony	Intellectual Rigor	Clear Communication

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- Distributed Energy Resources
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- Electricity Market Modeling & Resource Planning
- Electrification & Growth Opportunities
- Energy Litigation
- Energy Storage
- Environmental Policy, Planning and Compliance
- Finance and Ratemaking
- Gas/Electric Coordination
- Market Design
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The Electron Superhighway: Modernizing U.S. Transmission Infrastructure

NARUC

Jennie Chen

March 19, 2020

Opportunities

- Losses (plant auxiliary loads, T&D, substation consumption) ~ 314,000,000 MWh ~ 7.5%
- Leaky lines: T&D losses ~ 5%
- Underused lines: surveyed usage ~ 20% @ peak
- Electricity injected into grid spills does not necessarily flow in desired direction
- Congestion costs ~ $6 billion annually

SEC. 1223. (a) DEFINITION OF ADVANCED TRANSMISSION TECHNOLOGY.— A technology that increases the capacity, efficiency, or reliability of an existing or new transmission facility, including

- underground cables
- advanced conductor technology
- high-voltage DC technology
- energy storage devices
- controllable load
- distributed generation
- enhanced power device monitoring
- …

Some barriers to wider deployment

- TO cost recovery and incentives
  - Return on capital investments
  - Existing inventory
- Planning processes
  - Modeling capability
  - Need to get TO buy-in to propose as part of planning process
  - Focus on primary congestion zones
- Planner and TO conservatism
- Uncertainty on cost recovery via market as well as rate base

Existing federal regs & policies

- Policy Statement on Incentive Regulation (1992) – Performance targets
- Order 2000 (1999) – efficiency incentives, PBR
- EPAct 2005 – encouraged deployment of ATTs, establish PBR => Order 679 (2006)
- Orders 890, 1000 (2007, 2011) – comparable consideration to all solutions, tech neutral processes
- 2017 Policy Statement – compensating storage for transmission and market services
- 2019 NOI on Improvements to Transmission Incentives Policy
- DOE – one type of T&D technology covered by appliance & equipment efficiency standards

The Electron Superhighway: Modernizing U.S. Transmission Infrastructure

Center for
Renewables
Integration

ATT includes energy storage

Sample Case Studies

- Oakland Clean Energy Initiative (OCEI)
  - Distribution connected assets and upgrades selected in lieu of 115 kV or 250 kV transmission line
  - Utility owned storage included in rate base and operated by utility as transmission, solar is not
- Bonneville Power I-5 500 kV
  - Project cancelled and replaced with peak reduction (DER +) technologies
- Germany plans 900 MW of energy storage for transmission services in 2025
  - Inadequate transmission to move wind energy from north to load in south
  - Batteries will be used to optimize performance of existing grid
- Local capacity projects driven by transmission constraints
  - Moss Landing Reliability Must Run generation facility being replaced by 480 MW / 4 hour battery

Difference Between ATT and NTA

- Can all Non-Transmission Alternatives be considered transmission assets?

  - Non-Transmission Alternative (NTA) = taken into account by ISO in future load projection, not included in transmission plan for cost recovery

  - Advanced Transmission Technology (ATT) = assets that fulfill a transmission need, are controlled by grid operator, and compensated as transmission

FERC Led Solutions: Incentive NOI

- FERC re-examining Order 679's case by case risk and challenges ROE incentive adder[1] approach

- Two technical conferences held:
  - September, 2019: Managing Transmission Line Ratings [2]
  - November, 2019: How are Grid Enhancing Technologies (GETs) currently used?[3]
    - Post workshop questions from FERC include:
      - Do parties support a shared savings approach for compensating GET (vs ROE adder)?
      - Are software upgrades required
      - Should other benefits be considered for GETs (e.g. reliability, flexibility, etc.)

[1] Inquiry Regarding the Commission's Electric Transmission Incentives Policy, FERC Docket No. PL19-3-000. March, 2019
[2] Transmission Line Rating conference: https://www.ferc.gov/CalendarFiles/20190820083804-Supplemental%20Notice.pdf
[3] GET technical conference: https://www.ferc.gov/EventCalendar/EventDetails.aspx?ID=13554&CalType=%20&CalendarID=116&Date=11/05/2019&View=Listview

Disclosure: CRI submitted reply comments in Incentives NOI as part of coalition, CRI partner GridPolicy submitted shared savings proposal in GET technical workshop as part of CRI grant

FERC Led Investigation: MISO SATOA

- MISO submitted tariff changes to FERC to allow storage as a transmission only asset
  - Distinguishes between SATOA projects proposed by incumbent Transmission Owners and everyone else
    - TO projects go through transmission queue, don't pay interconnection upgrades, etc.
- Protests key points:
  - Right of first refusal for Transmission Owners should not be extended to SATOA
  - Allowing TO SATOA to go through generator interconnection ensures only TO projects can be selected in MTEP
- FERC rejected MISO proposal and will hold technical conference. Topics to be examined include:
  - MISO evaluation and selection criteria
  - SATOA market activities and potential impact
  - Rate structure for SATOA
  - Impact of SATOA on interconnection queue

Disclosure: CRI teamed with ELPC to intervene and submit comments on MISO's SATOA proposal

ISO Led Efforts: CAISO’s Storage as a Transmission Asset (SATA)

- Suspended ISO stakeholder process to define rules for storage to participate in markets and receive cost of service rate recovery
  - Year-long stakeholder process in 2018 that was ultimately suspended
  - ISO would release asset to participate in markets when not required as a transmission asset
  - Significant complexity surrounding process of refunding market revenues and/or accounting for those in competitive selection process
  - SATA would go through interconnection queue

ISO Led Efforts: PJM Market Efficiency

- PJM has evaluated multiple ATT solutions in 2017 and 2019 transmission planning cycles
- 2019 cycle narrowed to 2 options for relieve transmission constraint: upgrade existing 115 kV line vs Power Flow device
  - Preliminary B/C for power flow device = 111:1
  - Preliminary B/C for rebuild = 76:1
- Final report recommends rebuild

Criteria	HL_622 Upgrade Solution	HL_469 SmartValve™* Solution
Constructability Risk	Upgrade, no additional property needed	Greenfield, permitting risk related to new property for substation due to location near historically sensitive area
PJM Operations and Markets	No changes needed to real-time operations procedures and practices	At this time, real-time operations would not be able to fully utilize the dynamic capabilities of this device without additional changes
Additional Integration Cost with Operations and Markets	No additional costs	May require updating Day-Ahead, Real-Time, SCADA systems to support full operational range of this type of device
Industry experience	Established well known solution	Limited experience with SmartValve™ device
Additional System Capability/Flexibility	Yes/No	No/Yes

*SmartValve is a Trademark of Smart Wires Inc.

Source: PJM Baseline Market Efficiency Recommendations. Dec, 2019

The Electron Superhighway

Modernizing U.S. Transmission Infrastructure

NARUC Webinar

March 19, 2020

Presented by Jon Wellinghoff

GridPolicy

Transmission Planning/Ops/Costs Out of Your Control?

- Transmission Planning Used to be Simple
  - Gen Tie Interconnects
  - Known Capacity Factors
  - Size to Meet Peak Load

- Now Things Are Complex
  - Generation/Storage/DERs Are Everywhere
  - Capacity Factors Are Variable
  - Peak Hour No Longer Single Data Point
    - Hard to Build 12 Peak Models
  - Grid Balancing Services: Reactive Support & Voltage Control Will Be Needed More

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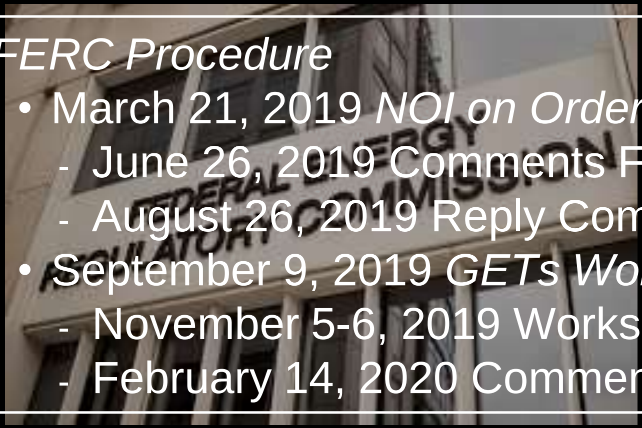
GETs: Grid Enhancing Technologies



FERC Procedure

- March 21, 2019 *NOI on Order 679* Transmission Incentive
  - June 26, 2019 Comments Filed
  - August 26, 2019 Reply Comments Filed
- September 9, 2019 *GETs Workshop* Noticed
  - November 5-6, 2019 Workshop Held
  - February 14, 2020 Comments Filed

GETs:

- Increase Capacity, Efficiency, or Reliability of Transmission Facilities
- Are:
  - Power Flow Control & Transmission Switching Equipment
  - Storage Technologies
  - Advanced Line Rating Management Technologies
- No Incentive to Install
- Performance Based Shared Savings Incentive Filed in GETs Comments

GridPolicy

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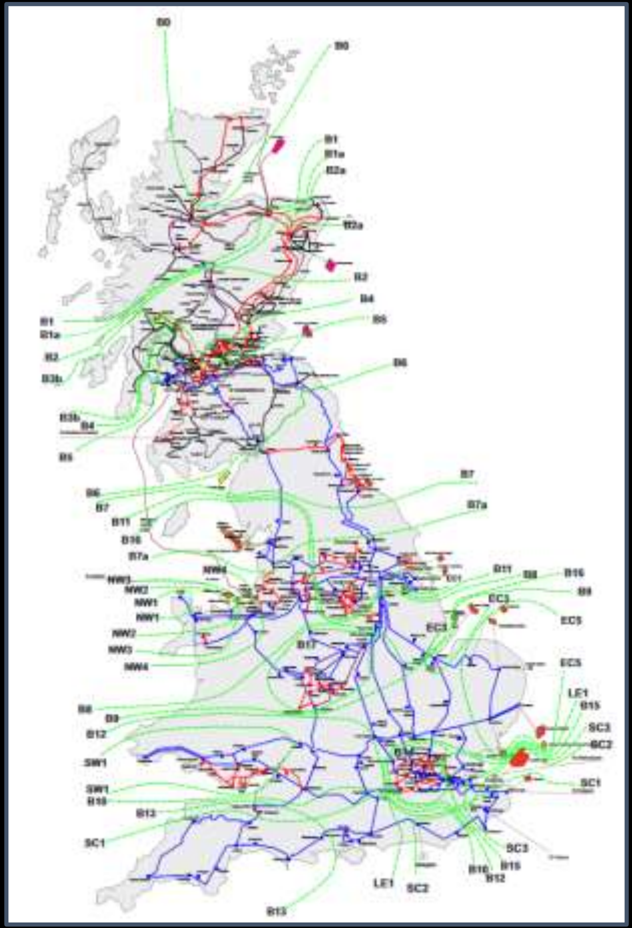
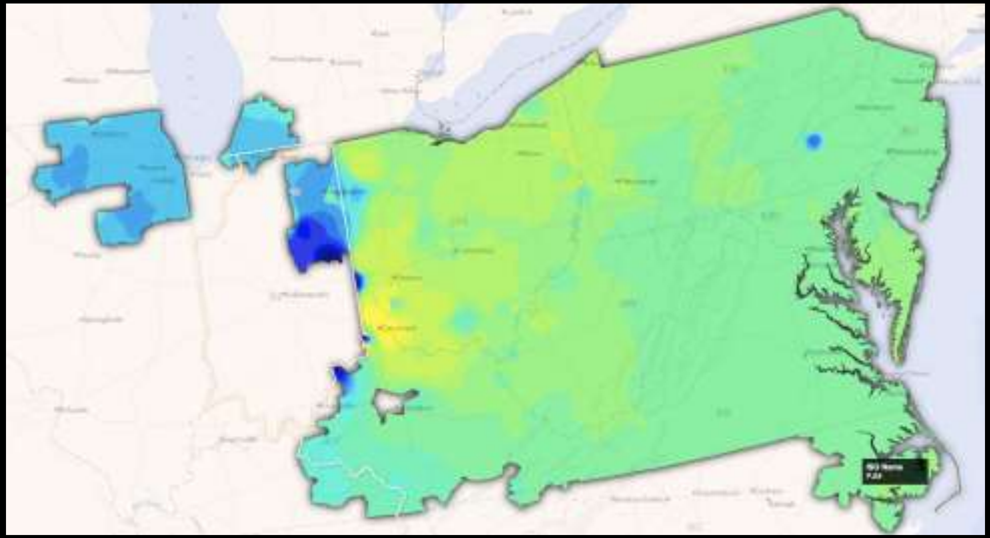
Transmission System Cost Savings Opportunities for State Commissions to Consider



In UK
GETs to Produce:
- 1500 MW -> 4000 MW Incremental Transfer Capability
- $165 M -> $400 M Capital Cost Savings
- $Bs Annual Congestion Savings

In PJM
GETs for 30% Renewable Penetration:
- $4 B becomes $ 2.2 B or <40% Cap Ex to Build
- $623 M Yearly Congestion Costs Saved



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What State Commissions Can Do to Lower Transmission Costs

IRP Filings or Rate Proceedings Require:

- Current Utilization Factors/Rates for T&D Infrastructure
  - Justify Those Factors/Rates
  - Establish Goals & Strategies for Improving Utilization Factors
- Current T&D Congestion Cost Data
  - Establish Goals & Strategies to Reduce T&D Congestion
- Evidence of Incorporation of ATT/GET Review & Analysis in Planning Processes

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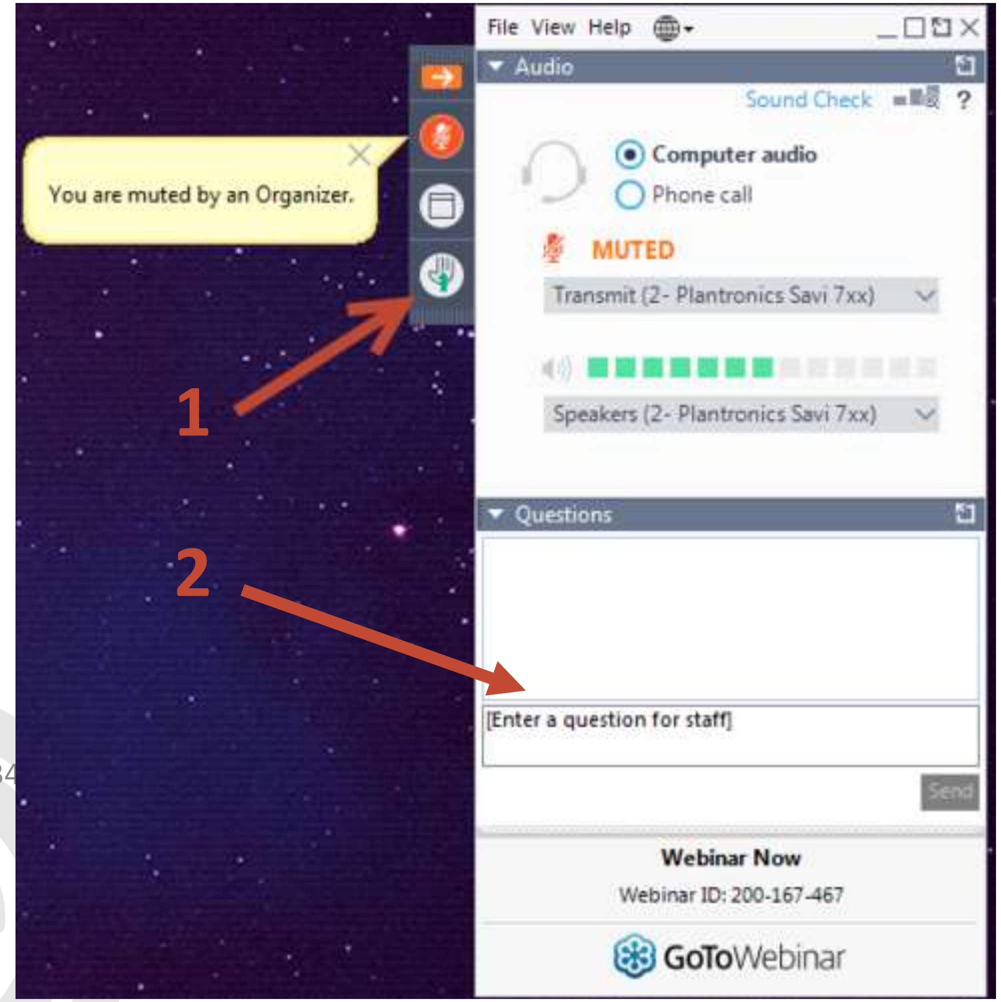

SPEAKER CONTACT INFORMATION

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- Jon Wellinghoff: jon@gridpolicy.com

Next Webinar April 29, 2-3:30pm Eastern Time – Practical Protocols for Utility Pilot Projects

Innovations in public utility products and services are possible sources of disruption in utility business models and in fast-changing relationships between consumers, prosumers, and third party providers. Utility pilot programs are proliferating, addressing both demonstrations of technical capabilities themselves, and proofs of concept for how new technologies might interface with updated rate designs, customer preferences and behavioral changes, utility system planning and operations, and more. This webinar explores the state of the art in pilot program design, management, monitoring, and evaluation, and examines Michigan's effort to consider standards that could be applied to future pilot program proposals.

Moderator: **Hon. Tremaine Phillips**, Commissioner, Michigan Public Service Commission

- **Peter Cappers**, Research Scientist and Strategic Advisor to the Electricity Markets and Policy Group at the Lawrence Berkeley National Laboratory. Peter is working with other LBNL staff on a report about best practices in pilot program design, management, monitoring, and evaluation. He will present the findings to date.
- **Joy Wang, Ph.D.**, of the Michigan PSC Staff, will present a summary of information gathered in a review of Michigan utility pilot programs instituted from 2008 to the present, and will report about the initial findings from the *MI Power Grid* stakeholder working group on new technologies and pilots.
- Other presenter TBD.

UPCOMING NARUC INNOVATION WEBINARS

Resilience and Recovery: Puerto Rico

April 16, 2020 | 3 – 4 pm EDT

Two and a half years after the devastation of Hurricane Maria, many things have changed in Puerto Rico's energy sector. NARUC and NRRI have been assisting the Puerto Rico Energy Bureau in their efforts on energy regulation and resilience. Join for an update on progress and see how you can help.

Register here

Carbon Pricing in Utility Regulation

May 21, 2020 | 3 – 4 pm EDT

States around the country are pricing carbon emissions from electricity generation. How can a carbon price be incorporated into commission decisions from performance-based ratemaking to cost-benefit analyses? Learn from states and experts that are tackling the integration.

Register here

Measuring Energy Efficiency Savings in Real Time

June 18, 2020 | 3 – 4 pm EDT

Administering energy efficiency incentive programs and calculating actual energy savings have historically been separate, but advances in real-time consumption tracking are rapidly changing that. Learn about the developments enabling the measurement of savings in near real-time.

Register here