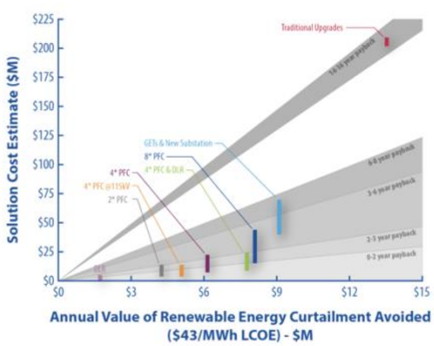
Case Studies and Modeling on the Value of Grid Enhancing Technologies – January 2024

Map of Grid Enhancing Technology Deployments
The WATT Coalition collected member case studies of Dynamic Line Ratings, Advanced Power Flow Control and Topology Optimization from around the world.

June 1, 2023 - Assessing the Value of Grid Enhancing Technologies: Modeling, Analysis, and Business Justification
Idaho National Laboratory – Jake Gentle, Alex Abboud, Megan Culler, Chris Sticht, and Telos Energy - Sean Morash, Andrew Siler, Leonard Kapiloff, Derek Stenclik, Matthew Richwine
This report studies a key offshore wind interconnection point in southeast Massachusetts. It identifies Dynamic Line Ratings and Advanced Power Flow Control deployments to support reliability and reduce production costs under a modeled 2030 resource mix with over 50% renewable energy. Optimal deployment of the two technologies reduced renewable curtailment at the interconnection point by more than half. GETs deployments would pay for themselves in less than a year.

April 20, 2023 - Building a Better Grid: How Grid-Enhancing Technologies Complement Transmission Buildouts
T. Bruce Tsuchida, Linquan Bai, and Jadon M. Grove, The Brattle Group
This report investigates how Grid Enhancing Technologies synergize with traditional transmission infrastructure expansion by reducing costs and improving performance before, during, and after new lines are built. Before upgrades are underway, GETs can reduce the impact of the constraints that make new lines necessary by increasing transfer capacity on existing infrastructure by as much as 40%. During construction, GETs can be installed to mitigate outages – increasing capacity and rerouting power to minimize costs and disruptions. After new lines are in service, GETs can increase the utilization of the line. A model of the SPP system showed a 16% increased utilization of 345kV lines averaging. By cheaply increasing the utilization of lines, GETs increase the infrastructure's cost-benefit ratio, which will affect planning decisions.

October 2022 - A Guide to Case Studies for Grid Enhancing Technologies
Idaho National Laboratory
This report catalogs 28 deployments or models of Grid Enhancing Technologies and their impact. The examples show benefits in reducing the cost of transmission infrastructure and reducing transmission congestion and curtailment, resulting in net savings that far exceed the cost of the technologies.



February 2022 - Grid Enhancing Technologies: A Case Study of Ratepayer Impact U.S. Department of Energy
The model looked at Dynamic Line Ratings (DLR) and Power Flow Control (PFC) in upstate New York. They found complementary value in the two technologies, which achieved more together than individually. A combined DLR and PFC case avoided 42% of renewable curtailment. Only considering the value of enabling lower-cost generation, the GETs paid for themselves in about two years.

February 1, 2021 - Unlocking the Queue With Grid-Enhancing Technologies
T. Bruce Tsuchida, Stephanie Ross, and Adam Bigelow, The Brattle Group
The Brattle Group modeled an optimal deployment of Grid Enhancing Technologies using the Southwest Power Pool system in Kansas and Oklahoma and projects in the interconnection queue with signed interconnection agreements. They investigated how much new generation could economically interconnect if GETs unlocked additional capacity on the grid. Without GETs, 2,580 MW of wind and solar generation could interconnect in the next five years. With GETs, twice as much new generation could plug in - 5,250 MW. The GETs deployments would have one-time installation costs of $90 million, but the production cost savings would be $175 million annually. GETs would pay for themselves in 6 months of full operation, reduce emissions, and create jobs in the region.

Grid Enhancing Technologies solve problems for grid operators

GETs: Dynamic Line Ratings (DLR), Advanced Power Flow Control (APFC), and Topology Optimization

Generator interconnection: lower costs and faster timelines, and reduce curtailment

- At the system level, GETs can double the capacity for new generation on existing infrastructure, per a study of the Kansas and Oklahoma systems and interconnection queues done by the Brattle Group.[1]
- At the project level, GETS:
    - Reduce interconnection costs: WATT members report interconnection costs of $50-400 million for 1-3% projected line overloads, which would likely be resolved by DLR at a fraction of the cost.
    - Shorten study and construction timelines: new lines and other traditional upgrades can take years to design and deploy, while GETs can be operational within months. One WATT member reported being quoted a 7-year upgrade timeline.
    - Serve as bridge projects: GETs can provide additional provisional transmission service for projects awaiting traditional upgrades.
    - Fewer project withdrawals: high upgrade costs lead to projects dropping out of the queue, requiring restudies and increasing uncertainty around interconnection costs. By including GETs in interconnection studies, more projects should move through the queue more smoothly.
- GETs also reduce curtailment for operational projects. One DLR deployment in the UK is estimated to provide an increase in capacity averaging more than 45%, which will allow 500 MW more renewable power to be carried. National Grid U.K. estimates the project will save £1.4 million (roughly $1.75 million) in network operating costs.[2]

Transmission planning: increase value of traditional transmission infrastructure and upgrades

- In an extension of the modeling of the SPP system in Kansas and Oklahoma (see footnote 1), the Brattle Group found that GETs increased utilization of the 345kV lines in the states by 15-22%.[3]
- An empirical analysis of the operational efficiencies & risks posed by static ratings, AAR, and DLR said that DLR exceeds static ratings 94-97% of the time with an average increase of 47% in line capacity.[4]
- DLR could enhance the transmission capability up to 60% for selected transmission lines, per Alan Ettlinger, senior director of Research, Technology Development and Innovation at the New York Power Authority.[5]
- Smart Wires Inc. power flow control technology will allow an addition 170 MW of power to be transferred into New South Wales and is expected to deliver net benefits of up to $268 million to electricity customers.[6]
- National Grid UK is deploying 48 Smart Wires Inc. SmartValve power flow control devices at three substations. These devices will enable 1.5 GW of new renewable energy in that system, enough to power 1 million homes and deliver net savings of over $500 million.[7]
- National Grid ESO finds topology optimization increases transfer capability by 3-12% on large interfaces

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[1] https://watt-transmission.org/unlocking-the-queue/
[2] https://watt-transmission.org/wp-content/uploads/2023/04/Building-a-Better-Grid-How-Grid-Enhancing-Technologies-Complement-Transmission-Buildouts.pdf
[3] https://watt-transmission.org/wp-content/uploads/2023/04/Building-a-Better-Grid-How-Grid-Enhancing-Technologies-Complement-Transmission-Buildouts.pdf
[4] https://cigre-usnc.org/wp-content/uploads/2021/11/An-Empirical-Analysis-of-the-Operational-Efficiencies-and-Risks-Associated-with-Line-Rating-Methodologies.pdf

[5] https://www.youtube.com/watch?v=_GTzg_BV03Q&t=6s
[6] https://www.smartwires.com/global-impact/regional-story-australia/
[7] https://www.smartwires.com/global-impact/regional-story-united-kingdom/

- Topology optimization studies in PJM, MISO, SPP and ERCOT markets show reduced congestion costs by 25-50% and reduce renewables curtailment by 50%.[8][9]

Transmission planning: defer upgrades or provide bridge service while large infrastructure is built

- In 2006, AEP installed real-time line ratings on a congested 138 kV transmission line in Texas, which allowed them to avoid a $20 million upgrade which would have quickly become a stranded asset as new lines were built to serve increased wind generation.[10]
- PPL evaluated multiple technologies to resolve congestion, finding that DLR could solve the issue for less than $1 million, compared to $20 million for reconductoring, and $40 to $60 million for rebuilding transmission. DLR would also be operational in less than 1 year with no outages, compared to 2 to 3 years with extended outages for reconductoring, and 3 to 5 years with extended outages for rebuilding transmission.[11] DLR was installed.
- A DLR project in upstate New York will avoid the need to rebuild 26 miles of transmission lines. With an estimated cost of $3.2 million, the project budget is less than the average cost of rebuilding just a single mile of a 115 kV line in the area.[12]

Reliability: mitigate outages and improve visibility and flexibility across the grid

- APFC was used to mitigate an outage in Colombia: The annual costs of the modular FACTS devices were estimated to be between $1.5 million and $4 million, and the savings induced by avoiding redispatch during the 3.5 year outage period were estimated to be over $20.5 million a year, therefore suggesting a savings of over $70 million (net-savings of $61.5 million to $69.7 million) depending on when the construction starts.[13]
- MISO implemented a reconfiguration solution identified by NewGrid to mitigate costs from a transmission outage. The reconfiguration successfully and reliably increased throughput by up to 56% in the area. Conservatively assuming a similar amount of congestion (typically congestion would increase during the summer with higher loads), the reconfiguration is estimated to have saved about $40 million in regional market costs during the nine months-period.[14]
- The value of DLR was demonstrated during the 2018 “Bomb Cyclone” -- a 13-day cold snap that affected much of the Northeast U.S. ISO-NE was able to increase their transmission line ratings during the storm because of DLR, and thus avoid significant congestion costs.[15]

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[8] https://www.brattle.com/wp-content/uploads/2021/05/16192_transmission_topology_optimization.pdf

[9] https://watt-transmission.org/wp-content/uploads/2023/04/Building-a-Better-Grid-How-Grid-Enhancing-Technologies-Complement-Transmission-Buildouts.pdf

[10] https://cms.ferc.gov/sites/default/files/2020-05/20100623162026-Aivaliotis%2C%2520The%2520Valley%2520Group%25206-24-10.pdf

[11] https://watt-transmission.org/wp-content/uploads/2023/04/Building-a-Better-Grid-How-Grid-Enhancing-Technologies-Complement-Transmission-Buildouts.pdf

[12] https://watt-transmission.org/wp-content/uploads/2023/04/Building-a-Better-Grid-How-Grid-Enhancing-Technologies-Complement-Transmission-Buildouts.pdf

[13] https://watt-transmission.org/wp-content/uploads/2023/04/Building-a-Better-Grid-How-Grid-Enhancing-Technologies-Complement-Transmission-Buildouts.pdf

[14] https://watt-transmission.org/wp-content/uploads/2023/04/Building-a-Better-Grid-How-Grid-Enhancing-Technologies-Complement-Transmission-Buildouts.pdf

[15] https://www.brattle.com/wp-content/uploads/2023/04/Building-a-Better-Grid-How-Grid-Enhancing-Technologies-Complement-Transmission-Buildouts.pdf