SMART WIRES

REIMAGINE THE GRID

G-PST/ESIG Webinar Series:

Connect Faster: Improving Renewable Energy Integration With Modular Power Flow Control

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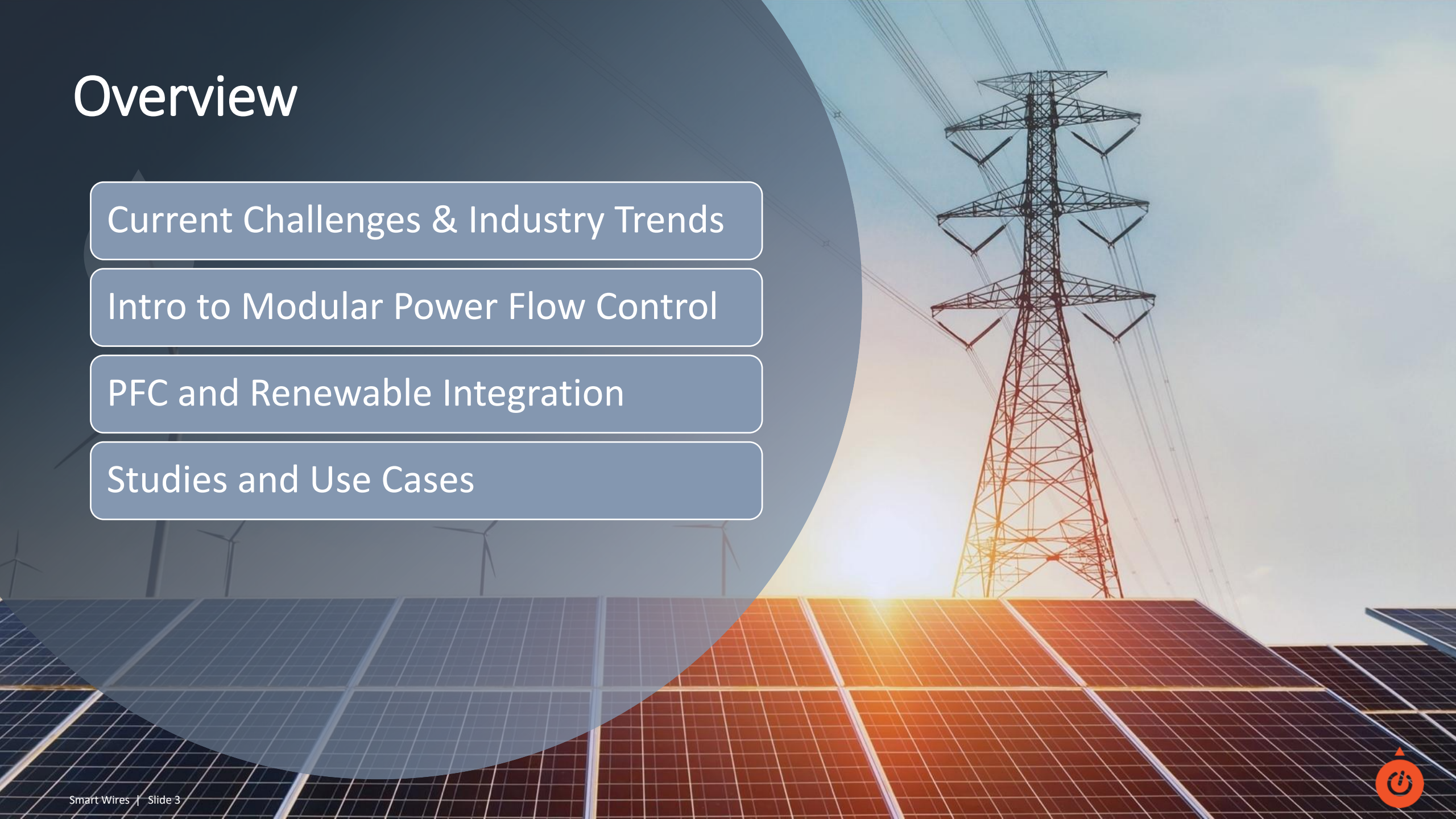
A Global Mission

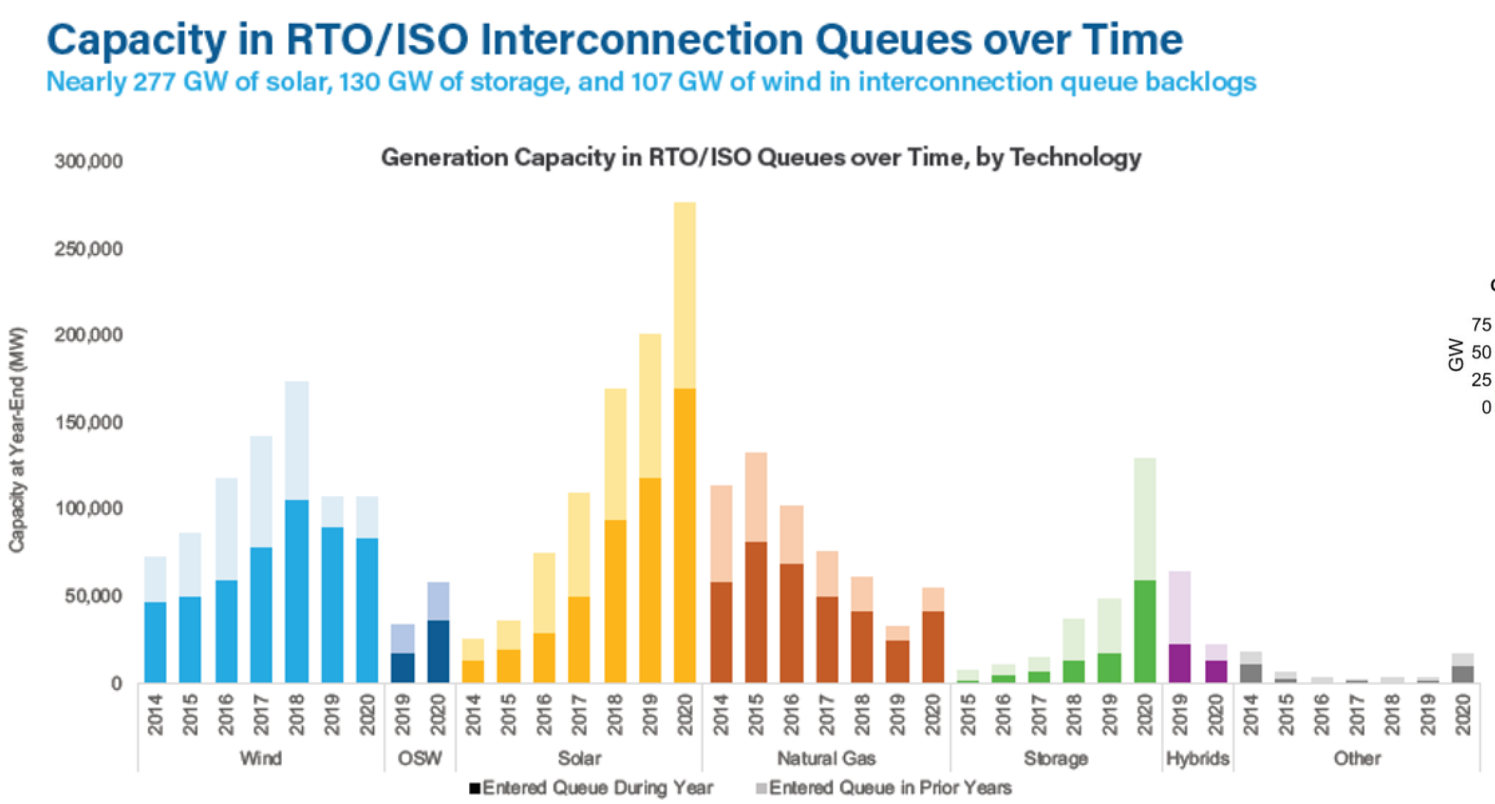
G-PST	Dramatically accelerate the transition to low emission and low cost, secure, and reliable power systems
ESIG	Address the technical challenges associated with integrating multiple energy systems to enable clean, reliable, and affordable energy systems worldwide
Smart Wires	Maximize the grid's transfer capacity in order to rapidly integrate renewable generation and accelerate the transition to an affordable, clean energy future

Overview

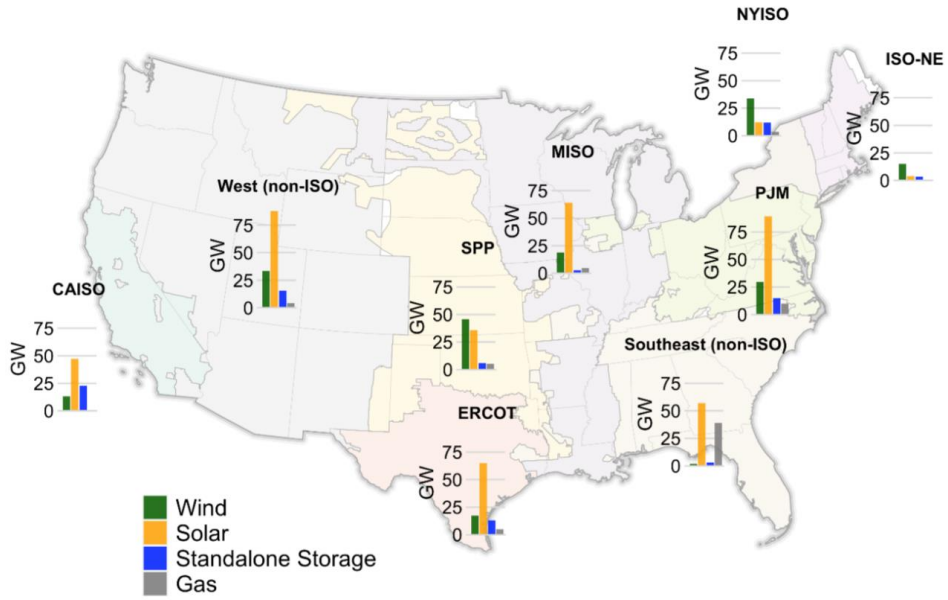
- Current Challenges & Industry Trends
- Intro to Modular Power Flow Control
- PFC and Renewable Integration
- Studies and Use Cases



Trends - Large queues of RES waiting to connect

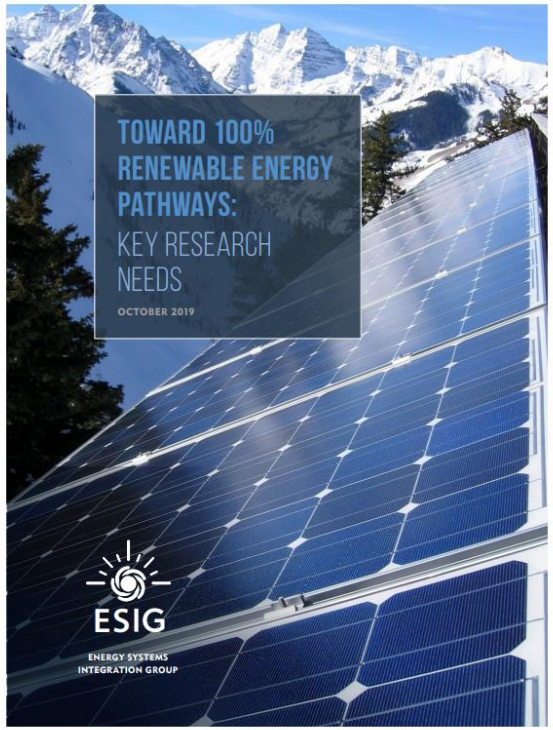


Source: 2020 ACP Clean Power Review



Source: 2021 LBNL

Trends - Industry wants to electrify to decarbonize

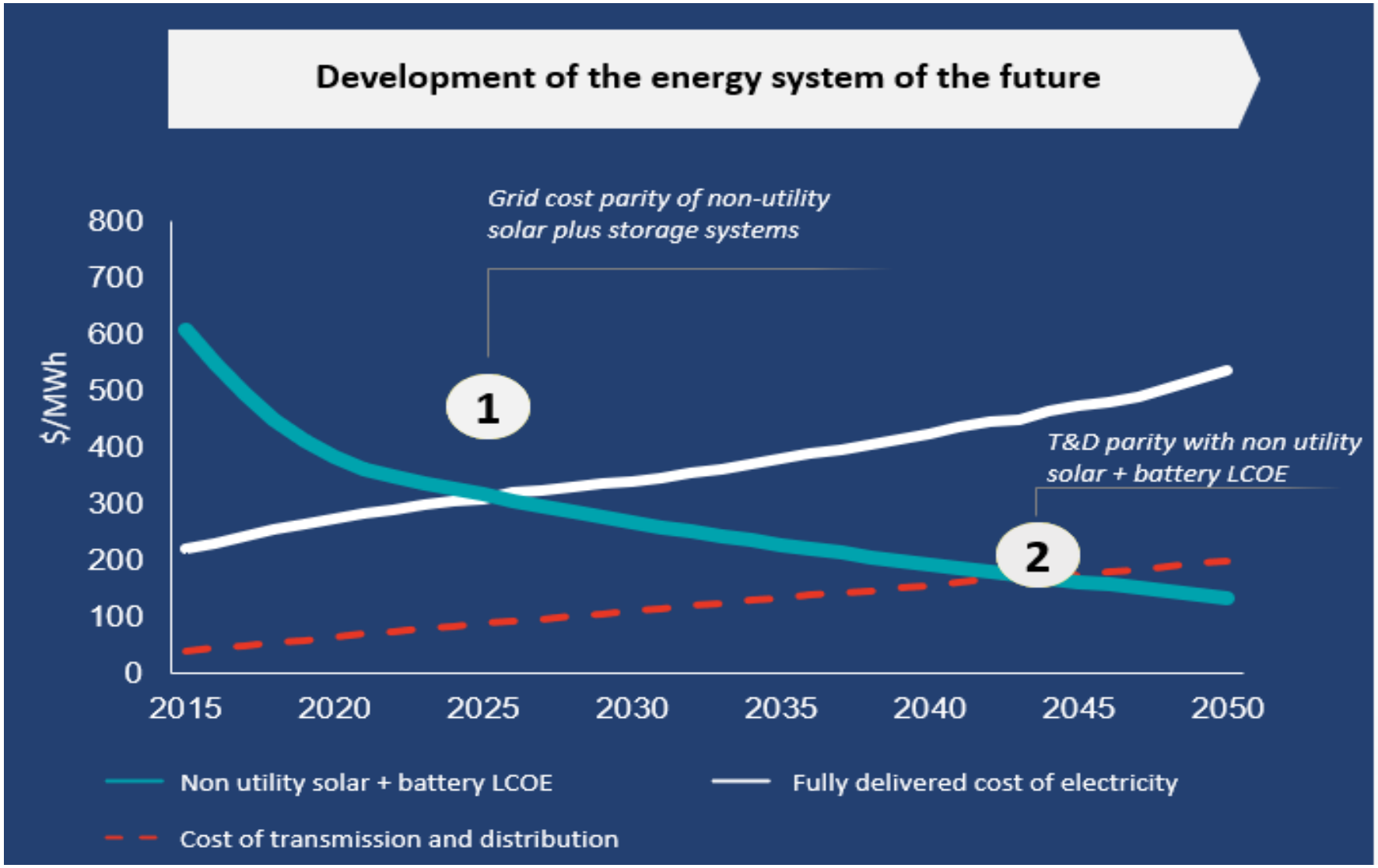


"Very likely pathways, based on technological and economic grounds, are renewable energy harnessed through the electricity system and the electrification of large parts of the economy"

"To speed up industrial electrification efforts, we must abolish grid bottlenecks quickly, ensure that cross-border interconnectors enable free flow of energy between countries….."

Extract from open letter to Eu from Industry Leaders and MEP Group 10 July 2021

Trends - Grid costs becoming more significant component of energy costs, while solar and storage costs fall



Trends - 4. Technology is Mature

As a result of these trends, the power sector is currently facing several key challenges:

Transmission constraints and curtailment on the grid	A significant backlog of new renewable generation stuck in interconnection queues	Integration and balancing of intermittent renewable sources	Long distances separating RE generation from load centers
Long wait times for industrial demand increases	Reduction in system inertia	Rise in voltage fluctuations	Higher ramp rates

The Benefit of Modular Power Flow Control

Safe & Reliable

- Deployed since 2012
- 2,500+ device-years
- Leverages decades of high-voltage power electronics experience

Valuable Capabilities

- Modular SSSC injects controllable voltage
- Increase/decrease power flows and perform dynamic services

Adaptable

- Flexible, scalable, redeployable
- Rapidly installed
- Voltage agnostic up to 500 kV

Economic

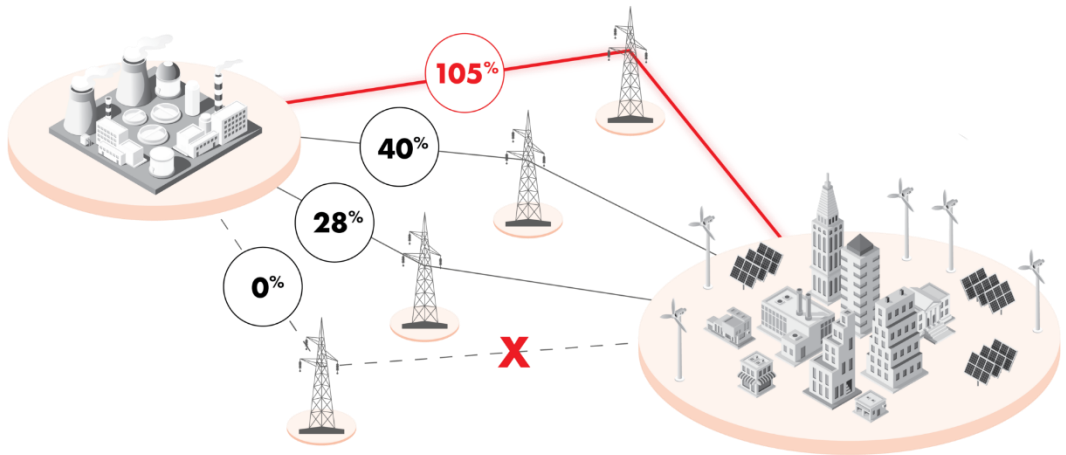
- Effectively solve problems
- Scale or redeploy solution in-step with needs
- Minimize risk & capital

Maximizing the grid's transfer capacity to accelerate affordable, clean energy

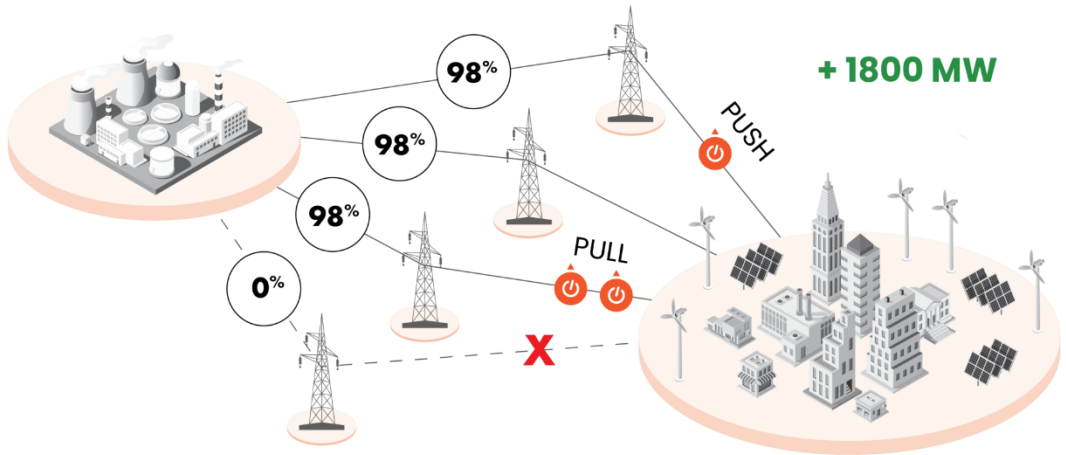
Power Flow Control Impact

Improving the Value of the Existing Grid

Before Power Flow Control



After Power Flow Control



Power flow control enables the efficient operation of the existing transmission grid

Why are RE Developers and IPPs Engaging?

*In the US, less than 20% of renewable energy projects in GI queues reach commercial operation (LBNL). **Transmission constraints are the #1 reason for project failure.** RTOs/ISOs are looking for cost effective ways to integrate renewables.*

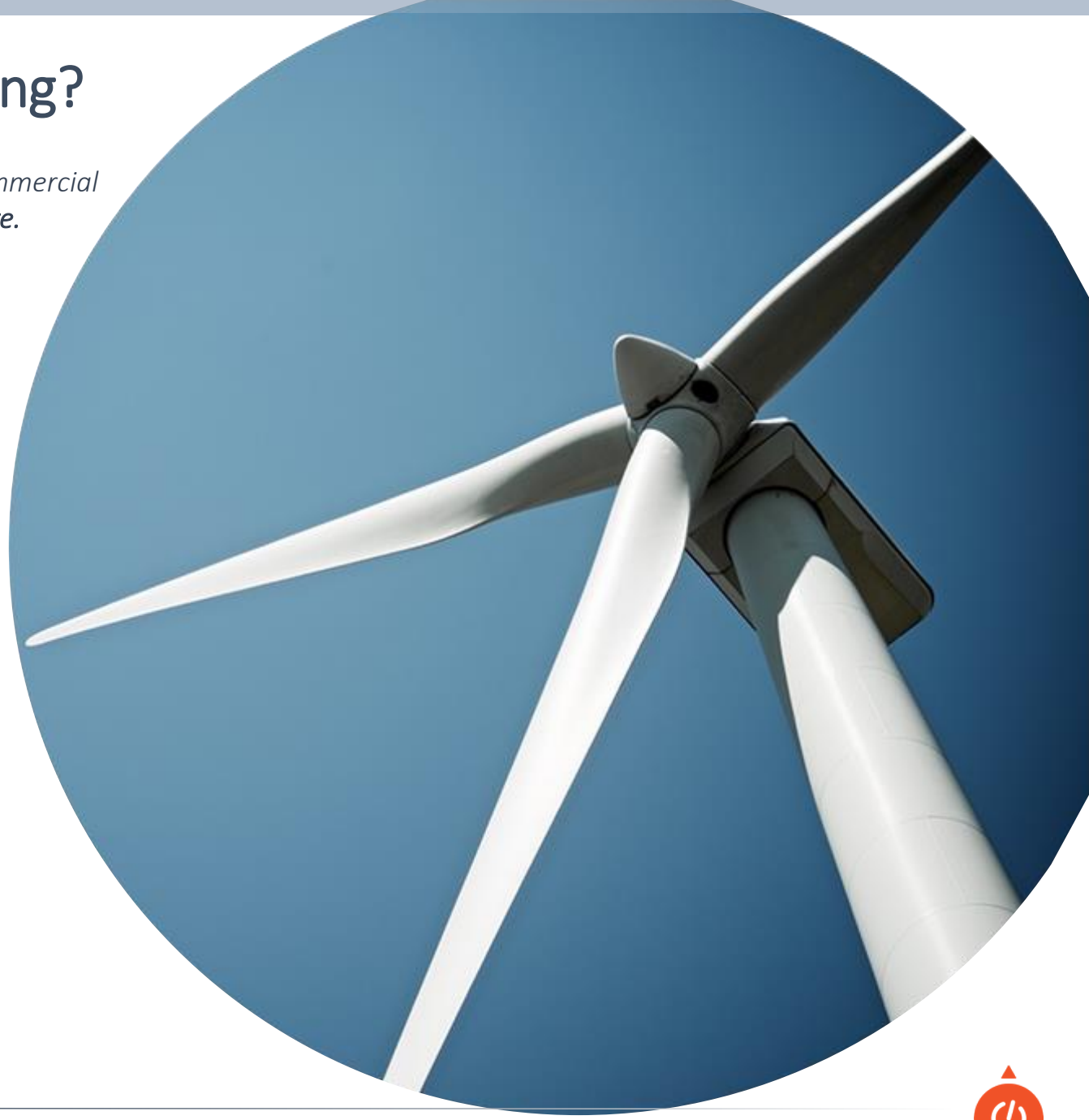
Enable more and faster interconnection of new solar, wind, and storage projects

Lower cost of generation interconnections, including ancillary upgrades for high voltage interconnections

Increase gross margin and reduce curtailment of generation by mitigating congestion

Balance intermittent generation from various sources across the across the grid

Increase flexibility of site selection

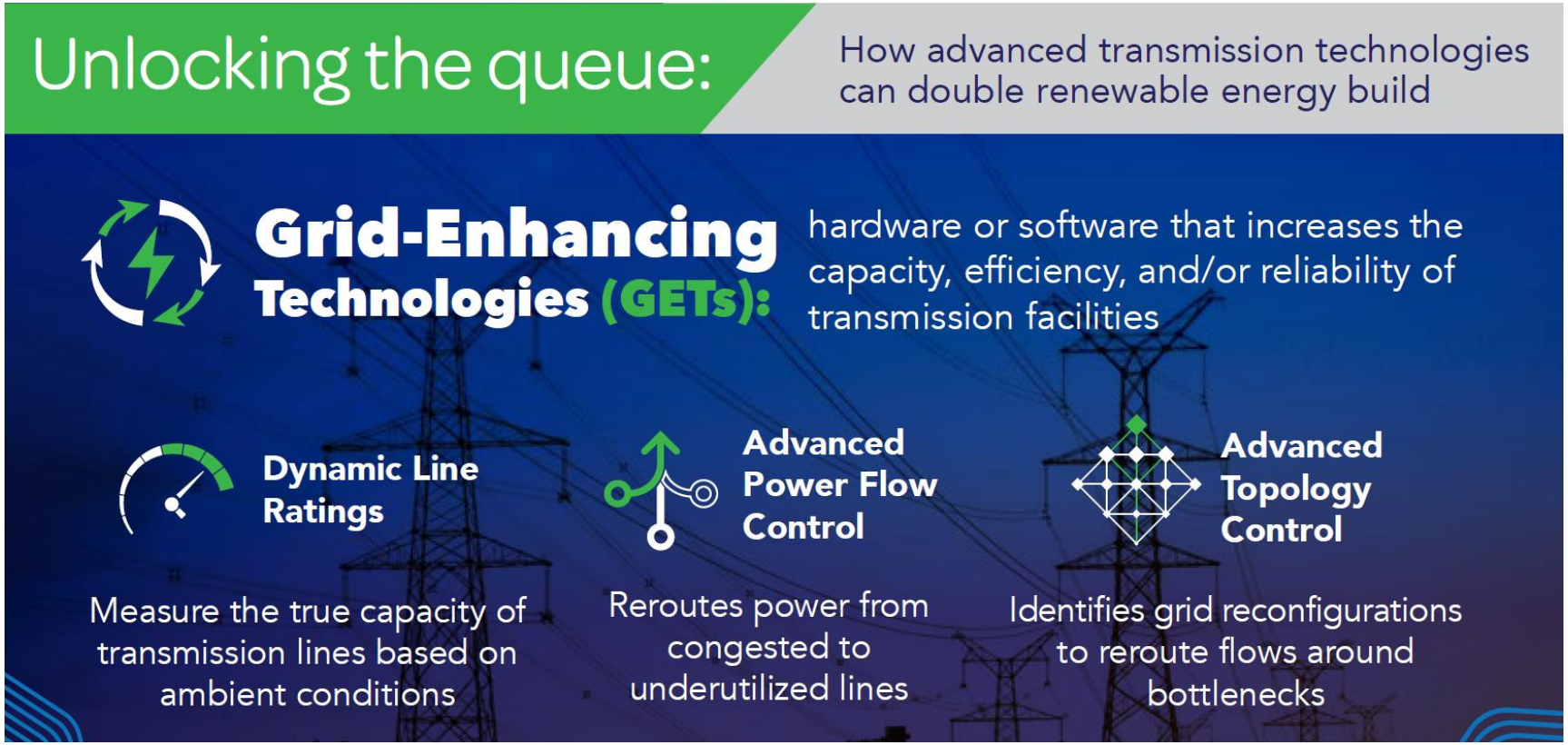


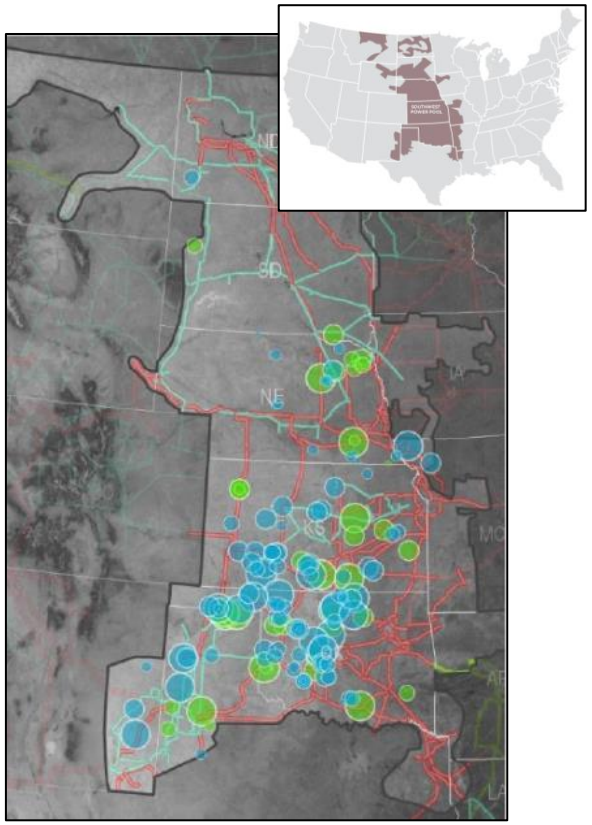
Unlocking the Queue

Grid Enhancing Technologies (GETs) Study in Southwestern Power Pool (SPP)

THE Brattle GROUP

WATT COALITION





SPP Generation Interconnection Queue

9,400 MW of RE projects in queue

**Source: Download the full report here from WATT Coalition website.*

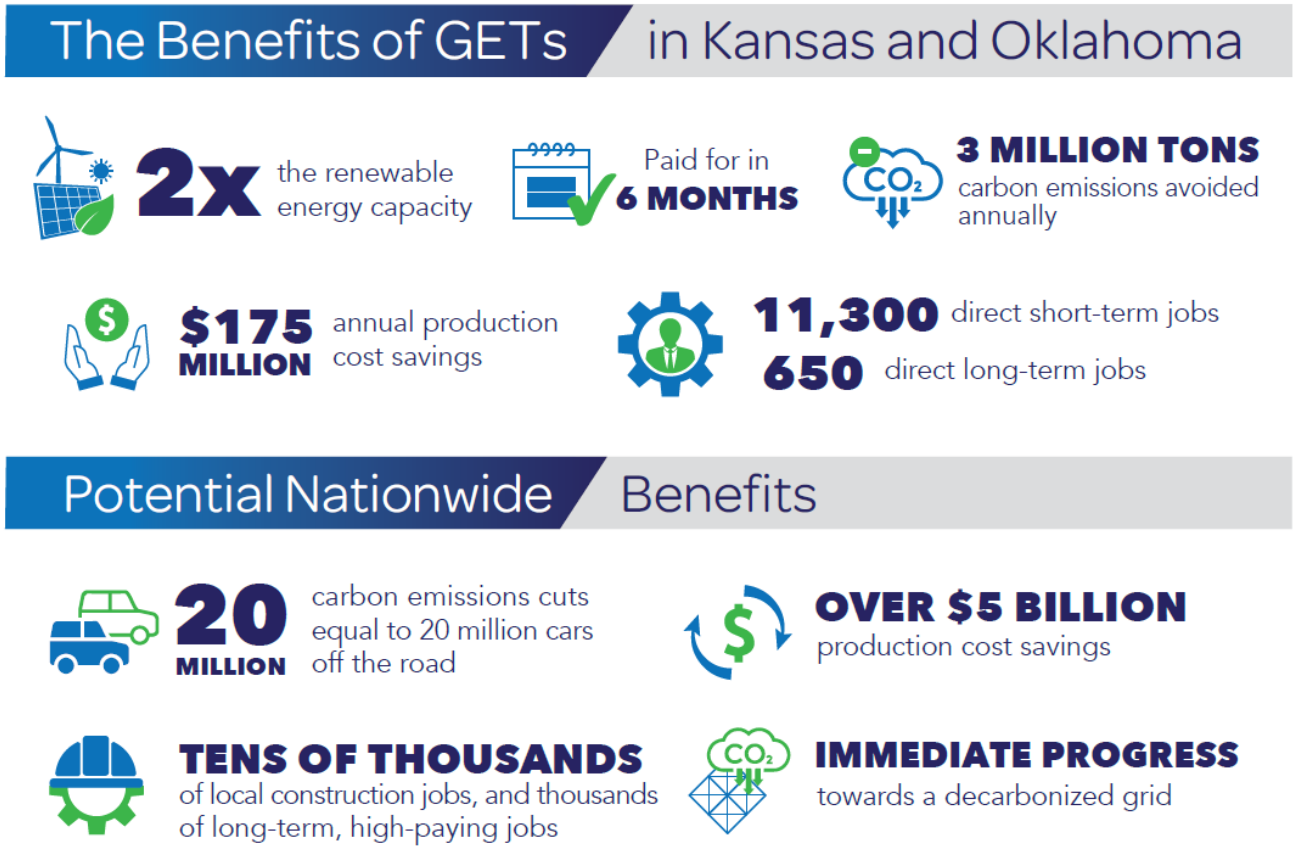
Unlocking the Queue

Results

When utilizing GETs, SPP can integrate an additional

2.7 GW

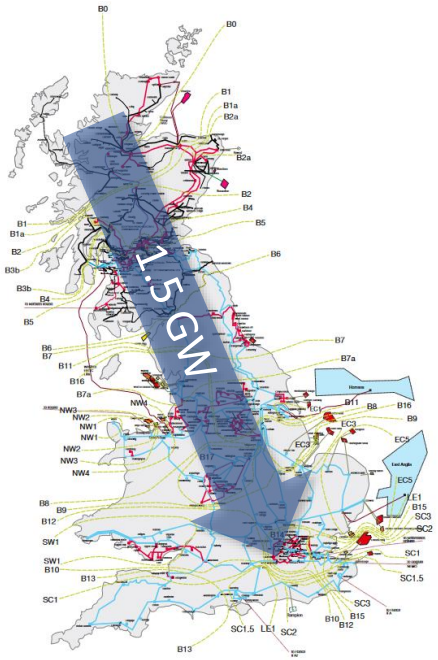
of renewable energy

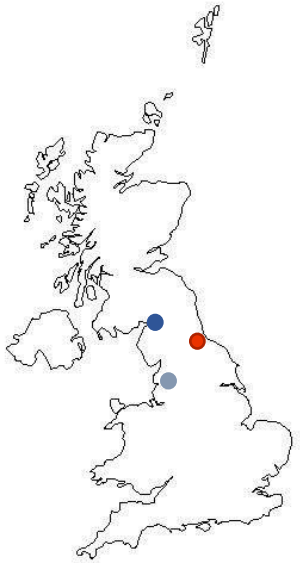


NextEra Energy, EDF Renewables, and Duke Energy funded the SPP Brattle study to develop a real-world use case of broad GETs impact on RE integration.

Regional Wind Integration

nationalgrid





500 MW across 3 boundaries

48 Devices

5 Circuits

3 Sites

< 18 months — Manufacturing to commissioning

< 12 months — For delivery of expansion

> $500 M — Savings for UK consumers

1

2

3

4

5

Increasing Cross Border Capacity

GETs provide multiple benefits by enhancing cross border capacity:

1. **Resource sharing** – use of excess renewables
2. **Efficiency and markets**, more competitive generation benefits consumers and industry
3. **Improves resilience** to unforeseen or natural events
4. Larger systems enable **efficient decarbonization at scale**
5. Easier to manage certain other technical issues e.g. inertia in larger systems

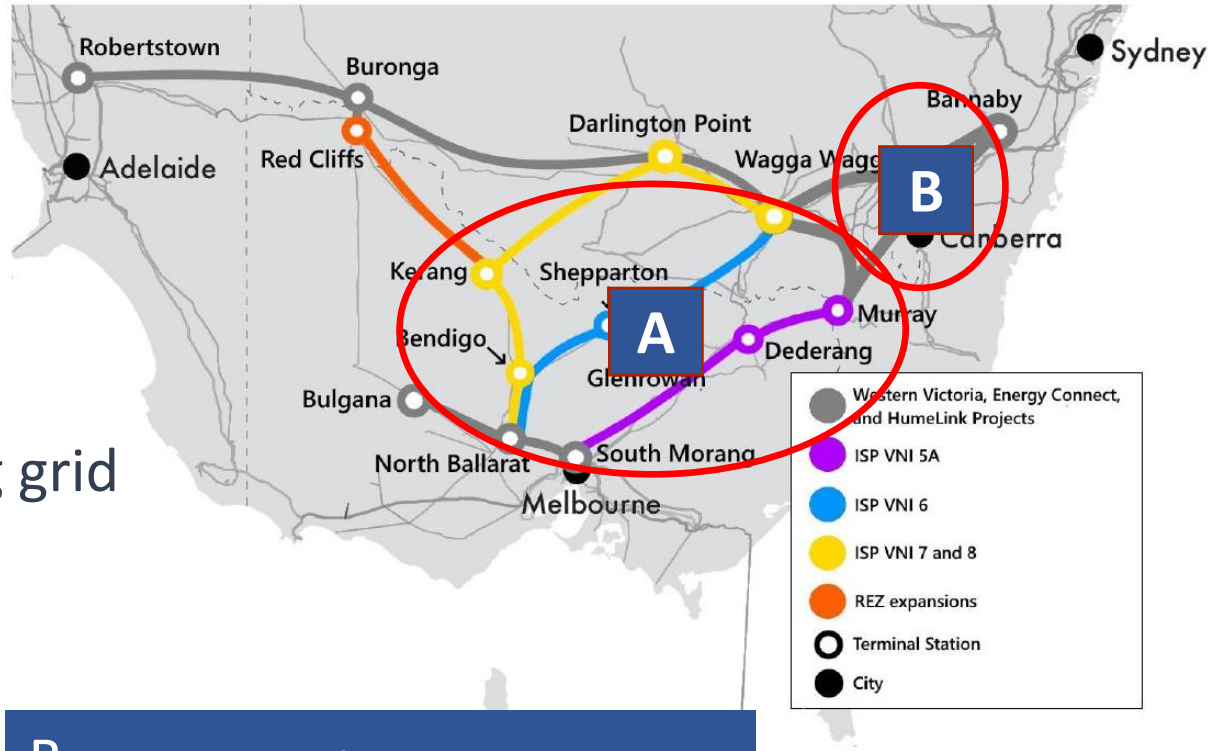
FARCROSS

- 5 GW+ cross border capacity required by 2030 across Europe and available capacity on cross border lines must be minimum 70% by 2025 for all EU countries
- Project implements state-of-the art technologies including PFC, DLR, and WAMPAC to enhance the capacity and efficiency of transmission grid assets.
- PFC deployment increases cross-border capacity between Greece and its neighbors, enable local renewable generation and in N-1 contingency. Initial analysis shows up to 140MW increase.

Decarbonization will require some new large-scale traditional infrastructure

GETs can enhance and/or enable projects that would otherwise be marginal:

1. Release some benefit early
2. Enable outages for construction
3. Resolve downstream constraints
4. Balance flows between new and existing grid



A. New 500kV/330kV Infrastructure is required to increase transfer capacity between Victoria and NSW. GETs allows you to fully utilitise the capacity delivered by new infrastructure.

B. New 500kV Infrastructure to connect Snowy Hydro plus other REZ to Sydney adding GETs north of Bannaby future proofs the overall solution by unblocking a downstream constraint.

What Next?

1. Wide-Area Optimization

2. On-Grid Cost Competitiveness

3. Power Electronics Based System

4. Digitization of the Grid

5. Improve Global Incentives

6. Broad Rollout