Grid Strategies

# Enabling Large Scale Transmission

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# Five-Year Load Growth Up Five-Fold to 116 Gigawatts

**THE ERA OF FLAT POWER DEMAND IS BEHIND US …**

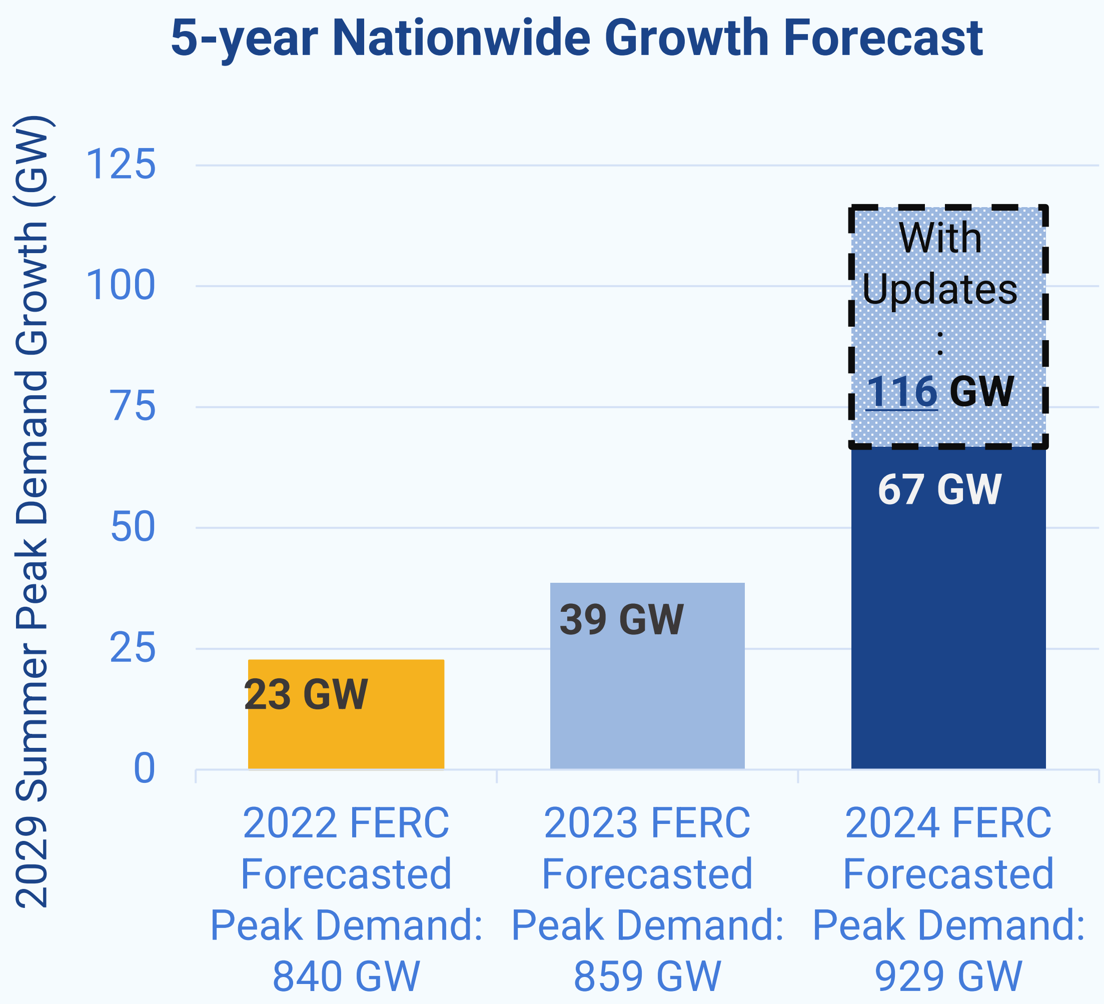
**5-year load growth forecast increased by almost a factor of five, from 23 GW to 128 GW**

- Nationwide electric demand forecast to increase by 15.8% by 2029.

**Key drivers are data centers and manufacturing.**

- Data center growth forecasts 65 GW (tech industry) to over 90 GW (sum of utility forecasts).
- Manufacturing demand forecasts ~20 GW growth, while electrification forecasts ~20 GW.

**AND THE FORECASTS ARE MORE SHOCKING …**



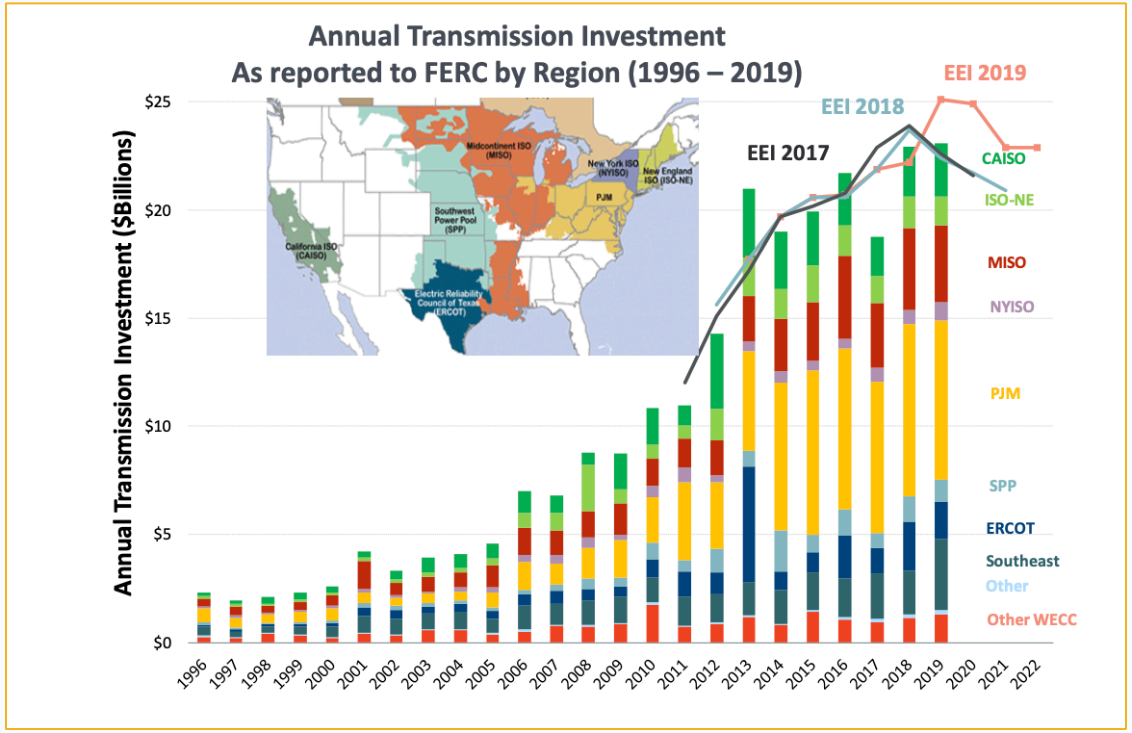
# Very little long-distance transmission has been built recently

## Many miles of new transmission in 2013, then dropped to a trickle…

*Miles of 345 kV + transmission lines added each year*


**SOURCE** | Grid Strategies LLC, Fewer New Miles (July 2024)

## …with investment rising but capacity not increasing—mostly replacing aging assets




**SOURCE** | The Brattle Group, Annual US Transmission Investments 1996-2023 (June 2024)

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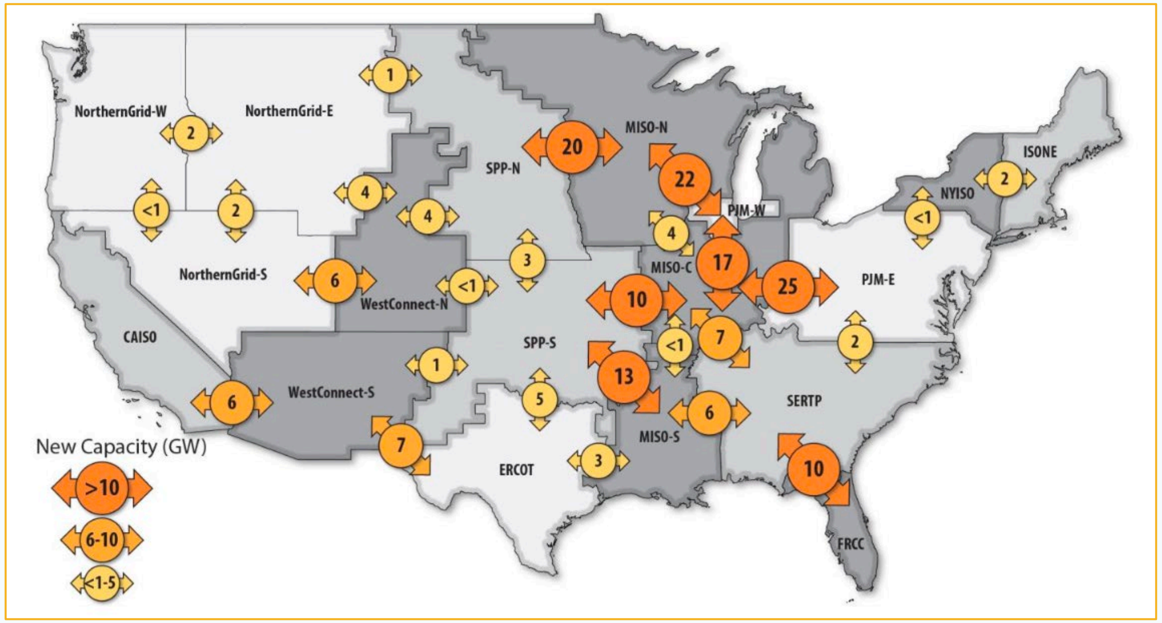
# National Transmission Planning Study (NTPS) findings

**Grid Reliability**: Interregional transmission improves reliability particularly in response to extreme weather.

**Consumer Savings**: Would save the U.S. $270-$490 billion through 2050, approximately $1.60 to $1.80 in system cost savings for each $ spent.

**Integrating new, cleaner generation onto the grid**: Enables the grid connection of new generation projects, balancing the variability of wind and solar.




**High Opportunity Transmission (HOT) interfaces:** potentially beneficial transmission capacity expansion between regions found across many future power system scenarios.

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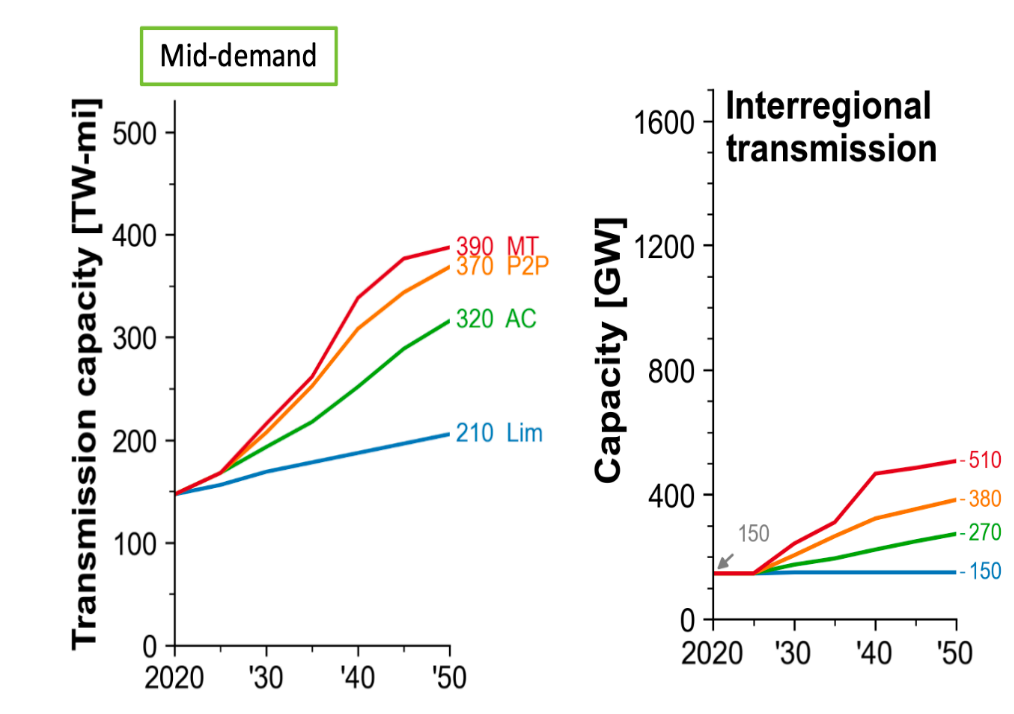
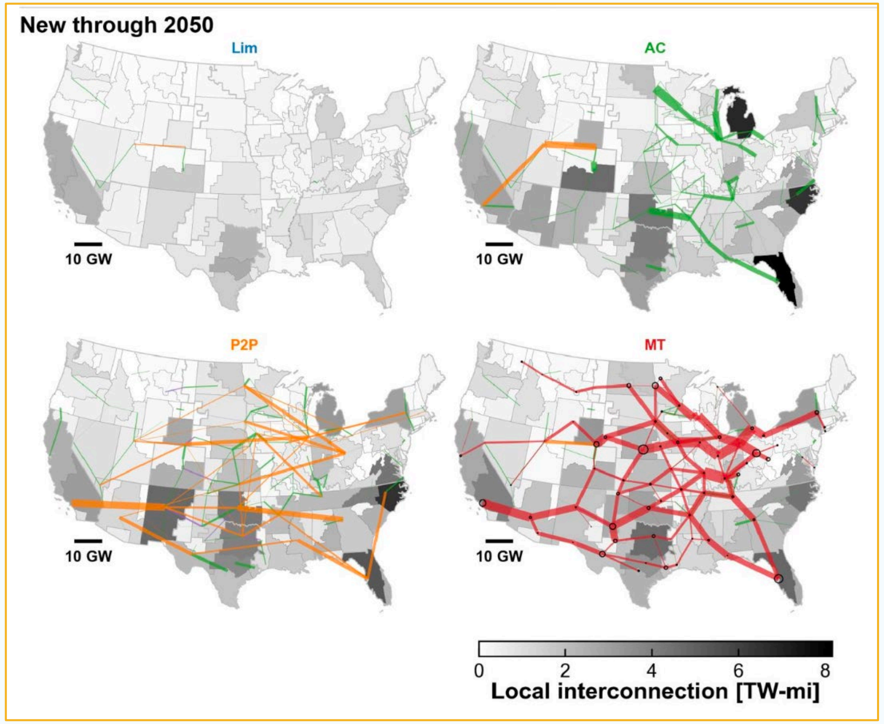
**Source**: DOE GDO, National Transmission Planning Study webinar

# Key NTPS takeaway: large aggregate capacity expansion

## The total transmission system of the contiguous United States expands 2.1 to 2.6 times the size of the 2020 system by 2050 and interregional transmission grows 1.9 to 3.5 times.

*Total transmission includes local (VRE inter-connection), regional, and interregional transmission

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Source: DOE GDO, National Transmission Planning Study webinar

# NERC's Interregional Transfer Capability Study (ITCS)

## Key Takeaways:

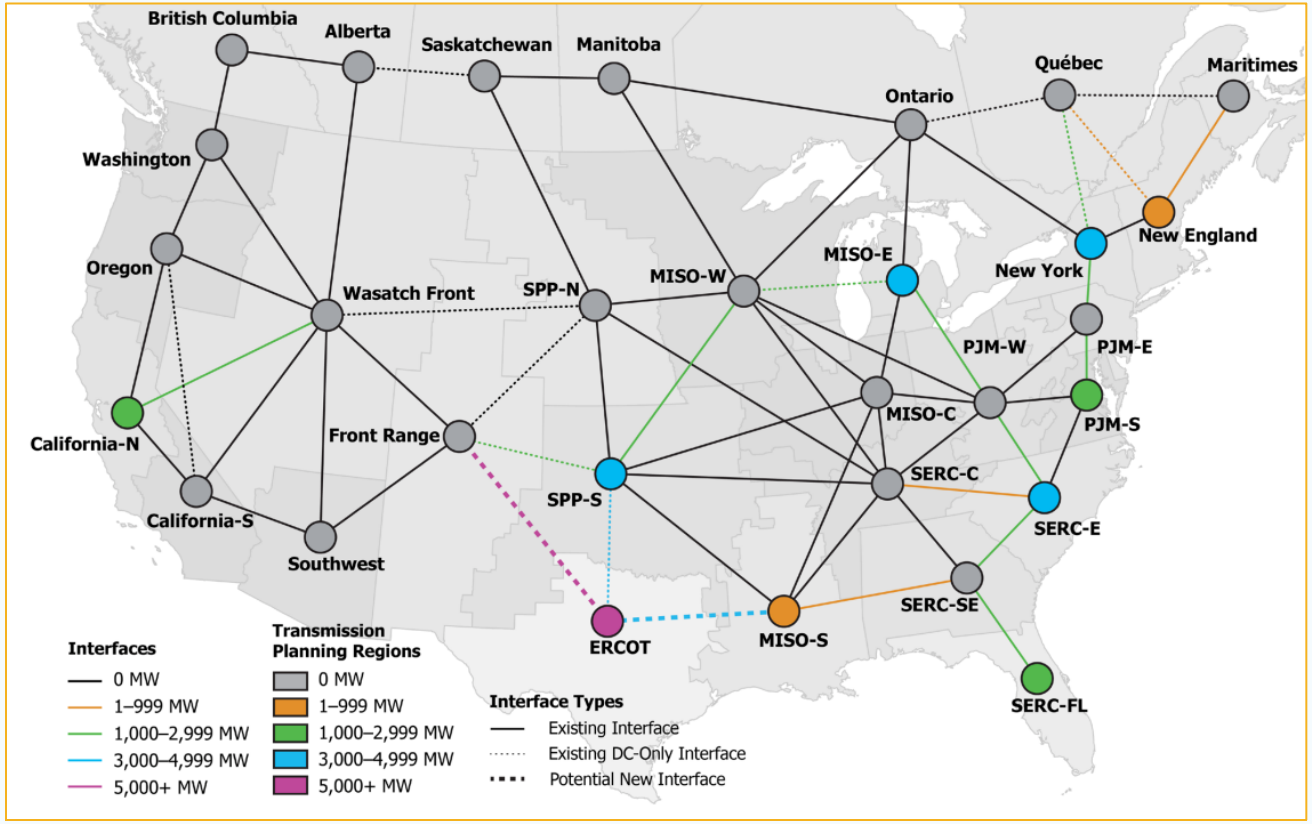
- Recommends an additional 35 GW of transfer capability across the US
- In the absence of additional transfer capability, 11 regions face resources deficiencies during extreme weather

## Key limitations:

- Does not consider economic benefits of transmission build-out
- Does not reflect recent load forecast increases

### Prudent Additions to Transfer Capability

*Based on 2033 Resource Mix*

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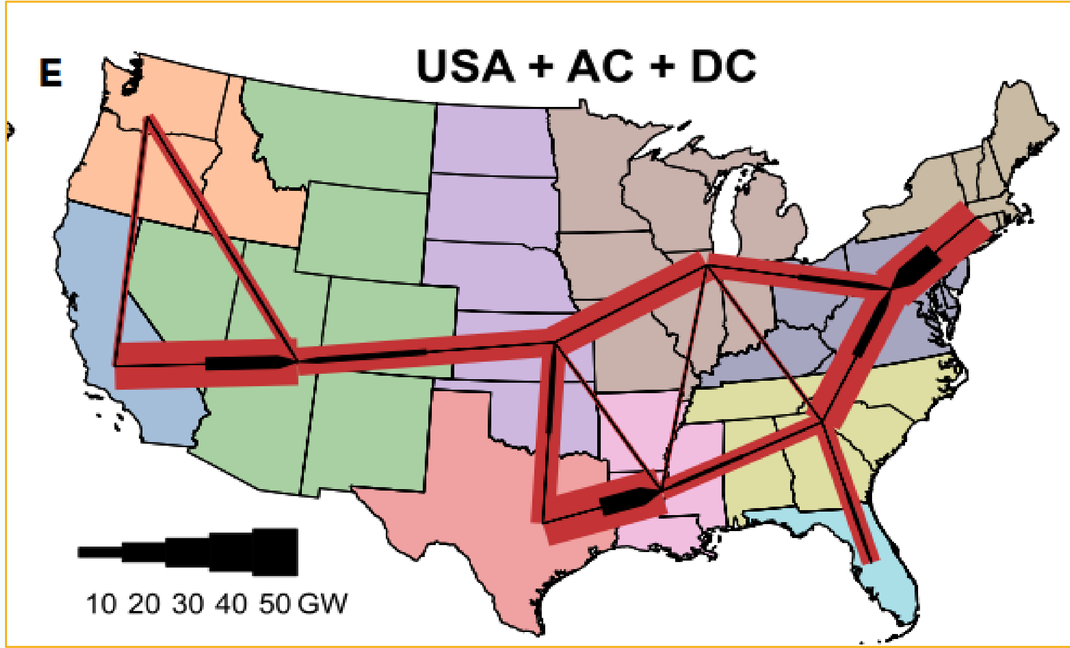
**Source**: NERC, Interregional Transfer Capability Study (ITCS), Nov 2024.

# Transmission vision: full macro grid

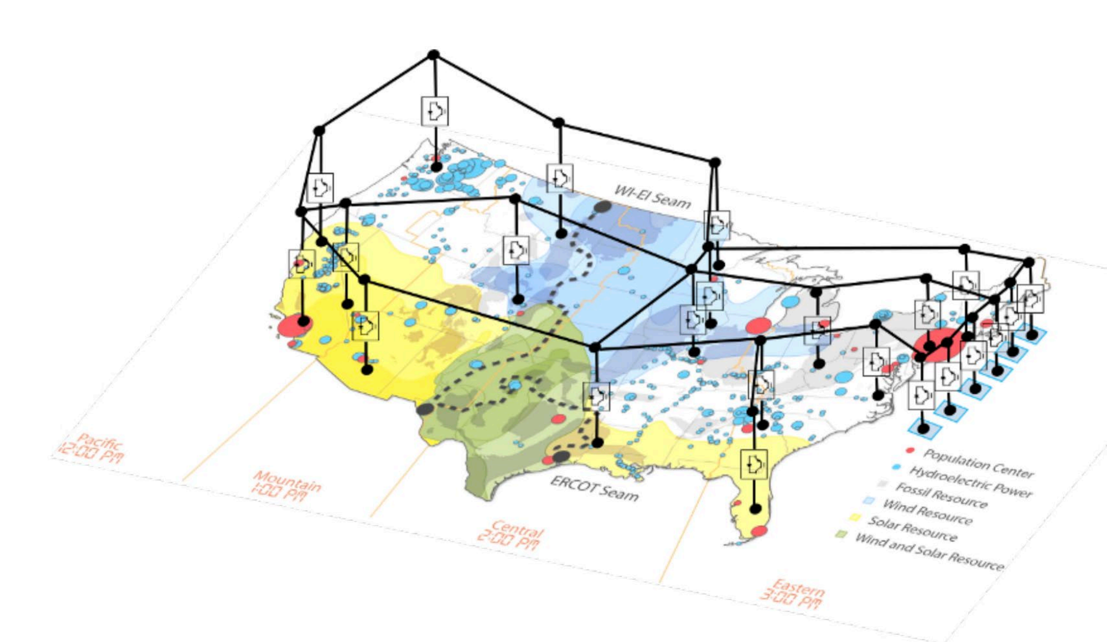
10s of GWs of power transfer back and forth across and between regions. Benefit > cost with 2-3x increase in national transmission capacity

## MIT Value of Interregional Transmission Study




**Source**: Brown (MIT), The Value of Interregional Coordination and Transmission in Decarbonizing the US Electricity System (January 2021).

## NREL Seams Study (updated by Jim McCalley)




**Source**: Bloom (NREL), Macro Grids in the Mainstream: An International Survey of Plans and Progress (November 2020).

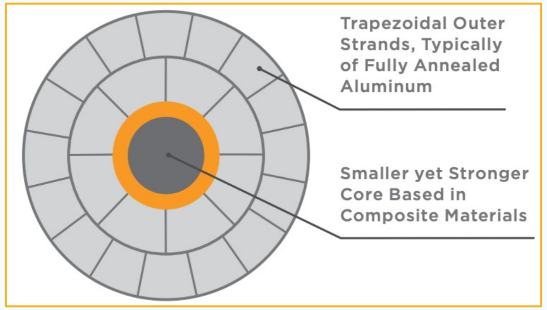
# Transmission barriers: the “3 Ps”

| Barrier | Description | Solution |
|---|---|---|
| 1 **Planning** | Lack of proactive, long-term planning for transmission and grid upgrades. | Implement 20-year, scenario-based planning that considers full electricity system benefits, evaluates all technology options and identifies a portfolio of upgrades. |
| 2 **Permitting** | Local opposition and complex, fragmented permitting processes. | Streamline permitting by clarifying rules, coordinating across jurisdictions, and using alternative rights of way (e.g., along highways, railroads). Federal backstop siting. |
| 3 **Paying** | Lack of policy on who pays. | Use broad, beneficiary-based cost allocation and leverage federal support such as DOE grants and loan programs. |

# Alternatives: more efficient High Performance Conductors (HPCs)

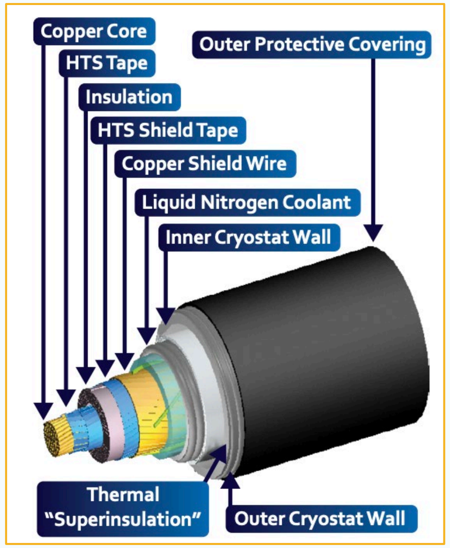
## Carbon and composite core conductors

Overhead, bare conductors that use a trapezoid shaped wire of annealed aluminum to carry electrical current and use a carbon or composite core for support, reducing sag and increasing power-flow capacity.




## Superconductors

A class of metallic compounds that exhibit negligible resistive losses when cooled using liquid nitrogen, enabling very low losses and very high power-flow capacities.

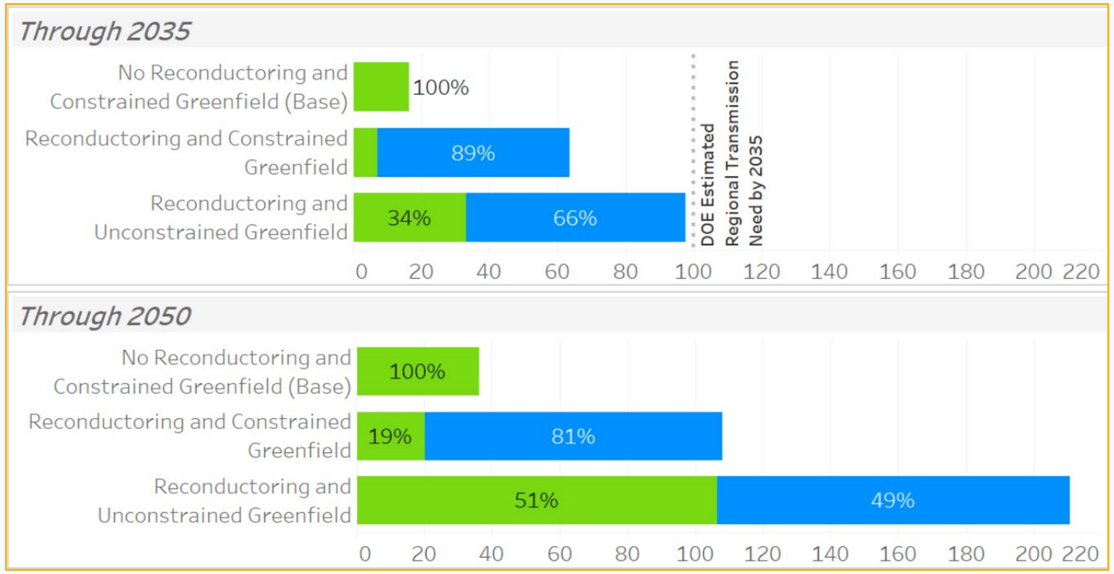



## Capacity Expansion with HPCs

Reconductoring generally takes 1-3 years and can 2x the capacity of a corridor at approximately half the cost of a new transmission line, while rebuild options can add significantly more capacity.

New Transmission Miles (TW-mi)

Power System Savings




**Source:** GridLab, Reconductoring Technical Report (April 2024); ACORE, High Performance Conductor Playbook (October 2024)..

# Complementary solution: leverage Grid Enhancing Technologies to use existing transmission more efficiently

Grid Enhancing Technologies (GETs) are hardware, software, or both that dynamically increase the capacity, efficiency, reliability or safety of power lines, faster and at lower cost than traditional grid infrastructure.

**Advanced Power Flow Control** redirects power to lines with extra capacity, preventing overloads and balancing the use of the grid.

- **2022 UK:** Unlocked 1.7 GW network capacity in UK, saving ratepayers $500M
- **2023 New York:** Unlocked capacity for 185 MW of generation, with $10M+ savings over legacy tech

**Topology Optimization** is software that finds the best use of grid infrastructure to redistribute power and unlock more capacity.

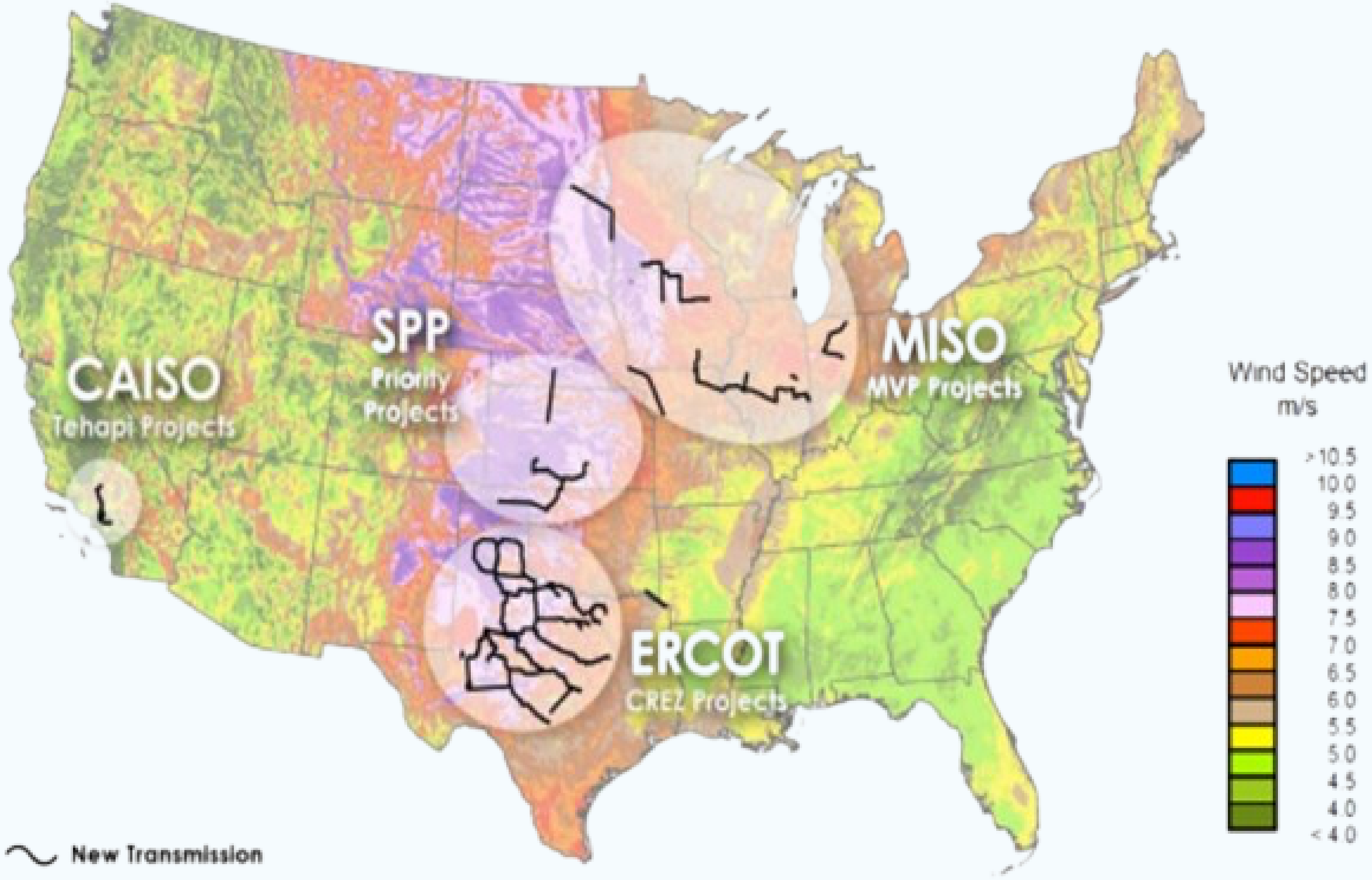
- **Alliant Energy 2025:** Reducing congestion costs by 50% in implementation since 2021
- **2022 SPP ex-post:** could resolve 98% of overloads in utility's territory

**Dynamic Line Ratings (DLRs)** measure and calculate the true carrying capacity of transmission lines – often finding 20% or more capacity than assumed.

- **2022 Pennsylvania:** DLR increases line capacity by 25% on average.
- **2012 Belgium:** DLR increases capacity by 20%+ over 90% of the time

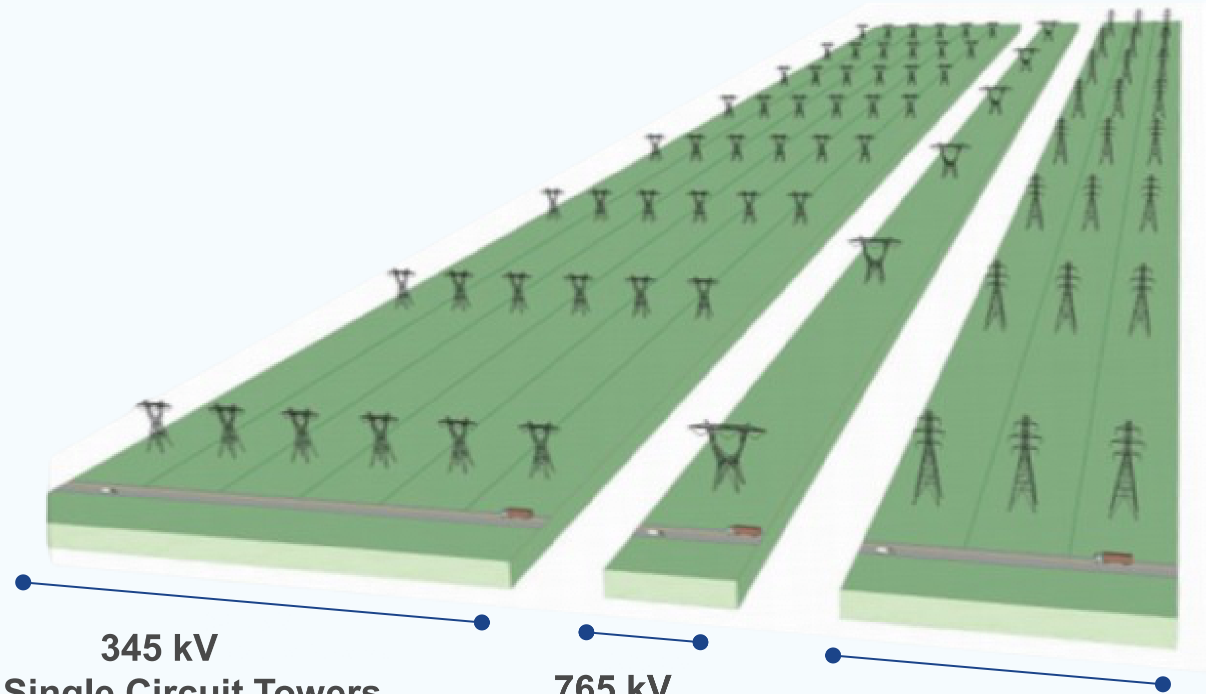
# Big transmission CAN be built: Address the 3Ps

- **Planning:** Proactive, all electricity system benefits, probabilistic/scenario based, portfolio of network upgrades, all technology options, community engagement
- **Permitting:** Demonstration of benefits with credible regional authorities leads to high batting average
- **Paying:** Broad beneficiary pays cost allocation



# Bigger is better–uses less $ and land

| Transmission Voltage (kV) | Cost per Mile ($ Million /Mile) | Capacity (MW) | Cost per Unit of Capacity ($/MW-Mile) |
|---|---|---|---|
| 230 | $2.253 | 657 | $3,430 |
| 345 | $3.613 | 1792 | $2,016 |
| 500 | $4.507 | 2598 | $1,735 |
| 765 | $5.667 | 6625 | $855 |

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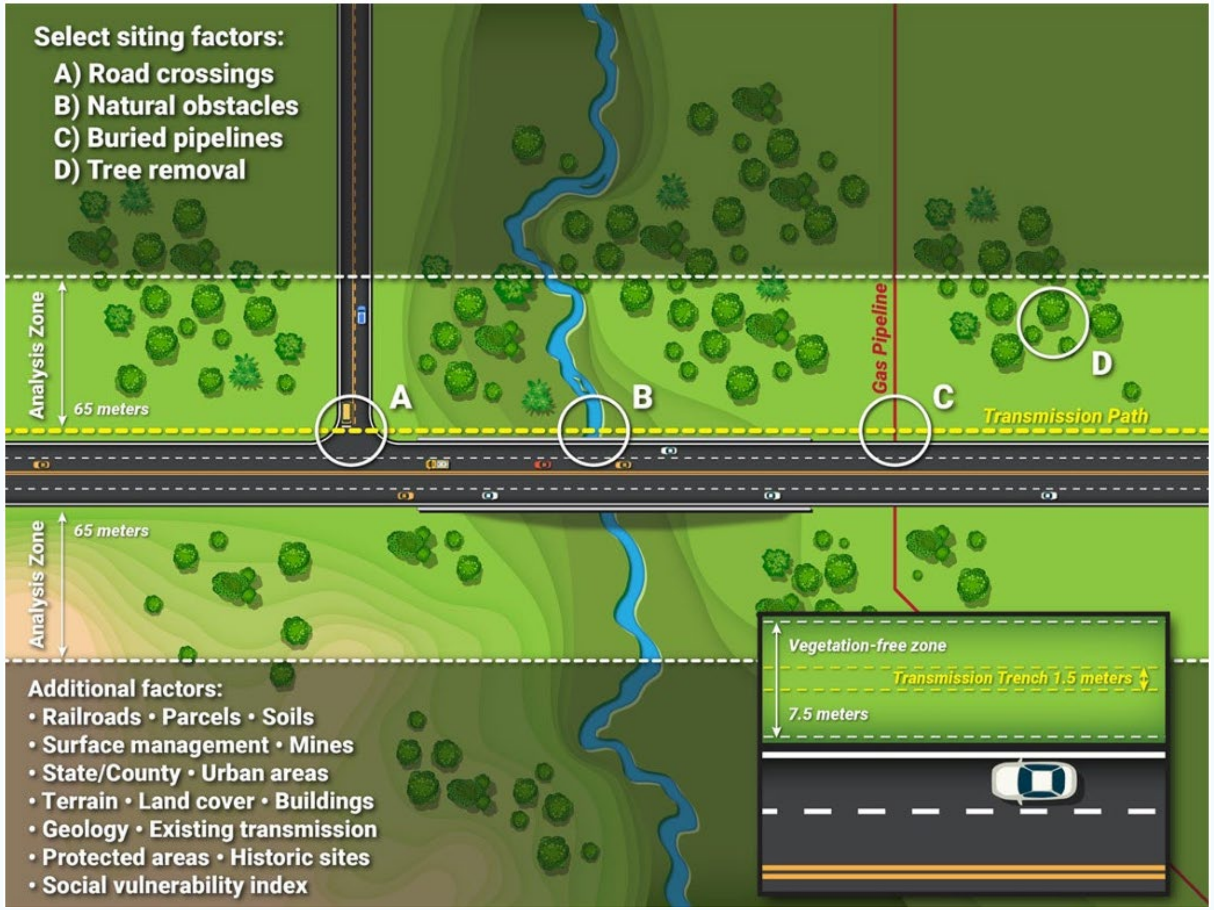
**SOURCES** | MISO, Transmission Cost Estimation Guide (May 2024) at 31, 33, and 38.

# Colocation of transmission in existing ROW may be possible, but not without complication

**DOE's *National Transmission Needs Study* assessed the feasibility of siting underground HVDC transmission along U.S. Interstates.**

- Desktop analysis to develop a methodology for assessing rights-of-way
- Identified several factors which must be considered (see Figure)
- Feasibility of collocating along each interstate ranked for each factor individually

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**SOURCES** | DOE, National Transmission Needs Study (Oct 2023) at 96-103.

# FERC Order No. 1920: Regional Transmission Planning

**Transmission providers are required to do the following:**

- Identify Long-Term Transmission Needs;
- Identify transmission facilities that meet such needs;
- Measure the benefits of those transmission facilities;
- Evaluate those transmission facilities for potential selection in the regional transmission plan and for purposes of cost allocation. (1920A P 218)

**"A requirement to develop a structured process to analyze whether building certain transmission facilities would yield benefits greater than their costs, over the long term and based upon various future scenarios, will help transmission providers and states to assess the value that those projects could bring." (1920A P4)**

**Commission-jurisdictional processes associated with regional transmission planning and cost allocation should…**

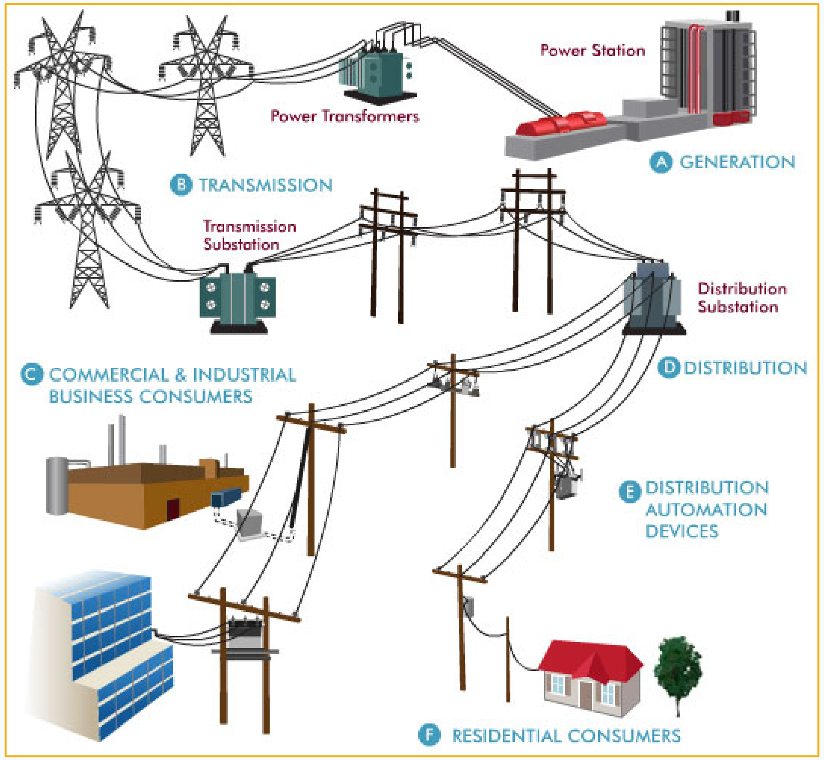
- "Result in rates that are just and reasonable and not unduly discriminatory or preferential"; (1920A P56)
- "Adequately "account for" changes occurring outside of the Commission's jurisdiction, including the resource decisions that are the exclusive jurisdiction of states." (1920A P56)



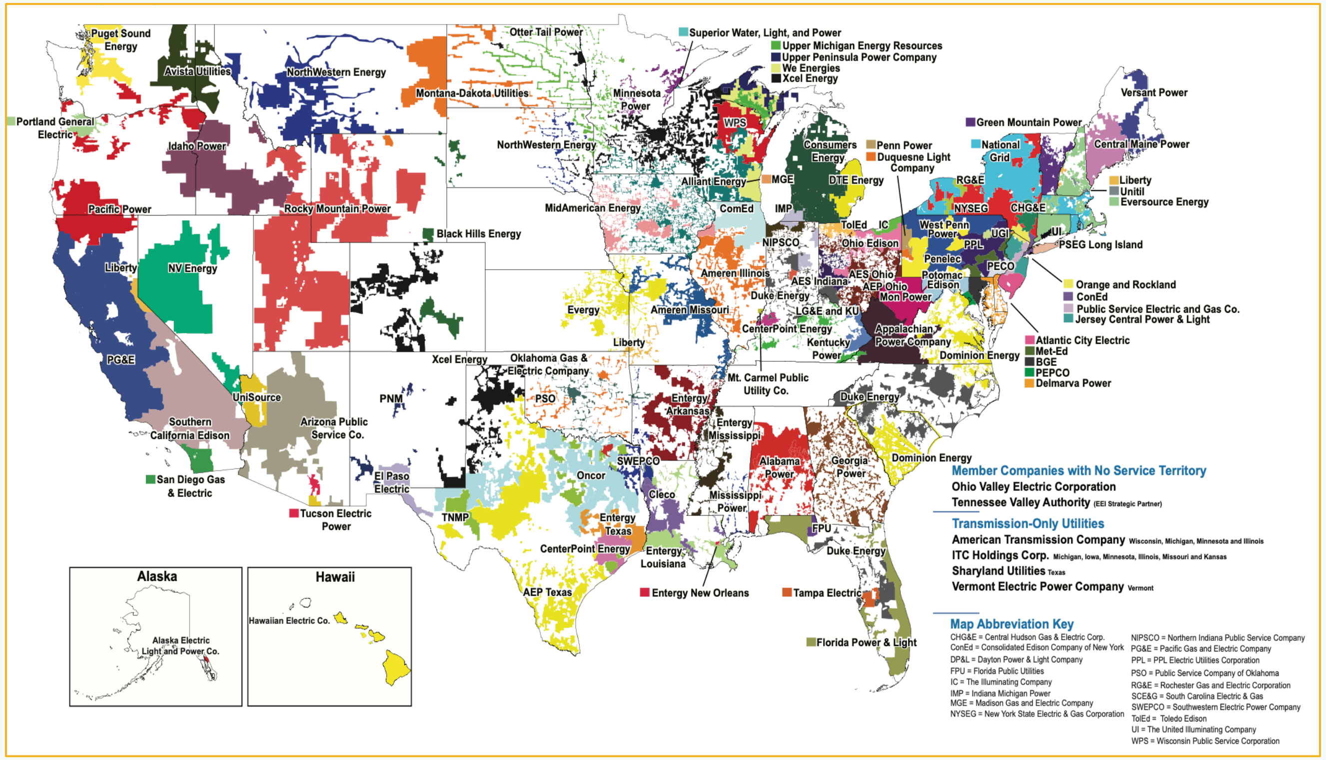
**SOURCES** | DOE, National Transmission Needs Study (Oct 2023) at 96-103.

# Fragmented US utility industry not designed to build large regional networks

## Utilities operate individual systems…




## …with around 3000 separate utilities focused on their own small footprint

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# Key organizations: Who does what?

## Economic regulators

### FERC

Regulates all transmission and wholesale power markets in RTO areas, and the wholesale transmission and power sales for utilities in non-RTO areas

### State PUCs

Build and maintain safe, reliable, and high-quality electric infrastructure. Regulate most aspects of utilities outside of RTOs.

## Market operators

### ISOs/RTOs

Oversee electricity grid operations, wholesale market functions, and transmission planning across multi-state regions.

## Reliability regulator

### NERC

North American Electric Reliability Corporation ensures reliability of bulk power system

## Other stakeholders

Includes those who develop and build transmission (i.e., utilities, independent developers), consumers (e.g., residential, commercial, industrial), independent power producers, environmental NGOs, and the clean energy industry.