National Transmission Planning (NTP) Study : High Opportunity Transmission Analysis

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NOTICE

This presentation includes specific examples from preliminary modeling to facilitate discussion and feedback; final results will differ from any results shown here.

Where does the NTP Study fit into other national scope activities? (not a comprehensive list!)

- This is not the DOE National Transmission Needs Study

Related DOE/Lab Led studies:

- Atlantic Offshore Wind Transmission Study – recently published
  - Coordination in offshore assumptions
- Western Offshore Wind Transmission Study – Completion in 2025

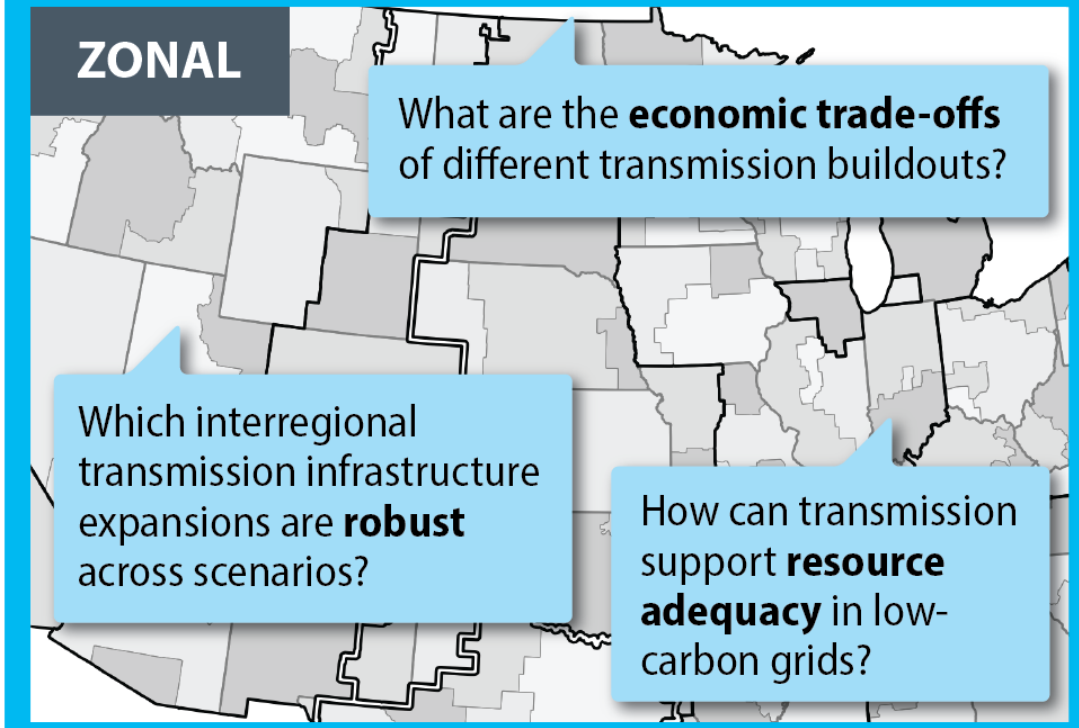
Other relevant but separate activities:

- National Interest Electric Transmission Corridor (NIETC) Designation
- NERC Interregional Transfer Capability Study

Multimodel framework for better understanding the role, value and opportunities for transmission in the U.S.

Capacity Expansion | **Economic Analysis** | **Resource Adequacy**

ZONAL



What are the **economic trade-offs** of different transmission buildouts?

Which interregional transmission infrastructure expansions are **robust** across scenarios?

How can transmission support **resource adequacy** in low-carbon grids?

Translate scenarios into transmission network solutions

Production Cost | **Power Flow** | **Stress Test**

NODAL

How does transmission impact **commitment** and **dispatch** of resources?

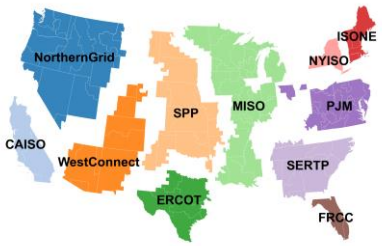
How can transmission support the grid during **stressful periods** like extreme weather events?

What is the role of **transmission** in operational reliability?

~100 scenarios out to 2050

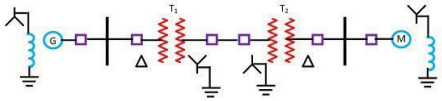
3 scenarios for a single year (2035)

Today we will demonstrate that:



(presentation 1) There are many opportunities for interregional transmission,

(2) The benefits of transmission usually exceed the costs,



(3) There exist network solutions and the grid can balance in transformative futures,

(4) Reliability can be maintained in transformative systems.

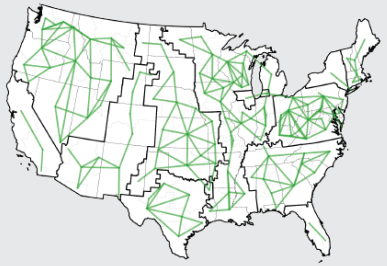
NTP Study Scenarios – Key Findings

Regional Energy Deployment System (ReEDS)

Scenario Framework: Transmission Expansion Paradigms

Reference Transmission Framework

Limited (Lim)



- No new interregional transmission
- Total annual transmission expansion limited to recent observed maximum

Scenario Framework: Transmission Expansion Paradigms

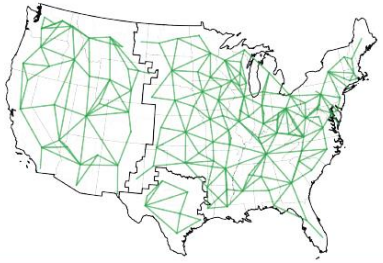
Reference Transmission Framework

Limited (Lim)

- No new interregional transmission
- Total annual transmission expansion limited to recent observed maximum

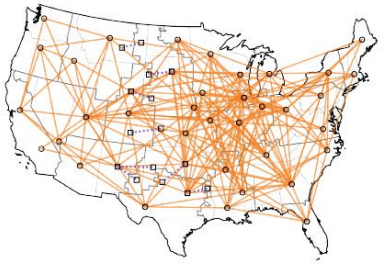
Accelerated Transmission Framework

Alternating Current (AC)



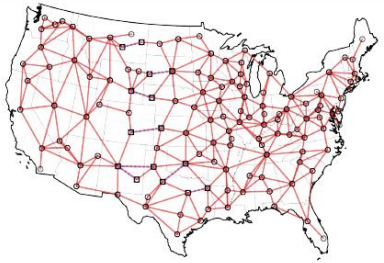
- Expansion allowed within interconnections
- No new DC connections

Point-to-Point (P2P)



- Expansion allowed across the country
- Includes long-distance point-to-point HVDC options

Multi-Terminal (MT)



- Expansion allowed across the country
- Includes multi-terminal HVDC options between neighboring zones

Scenario Framework:

Transmission
×
Demand
×
Emissions Targets

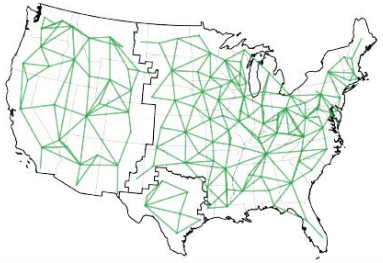
36 core scenarios

Reference Transmission Framework

Limited (Lim)

Accelerated Transmission Framework

Alternating Current (AC)



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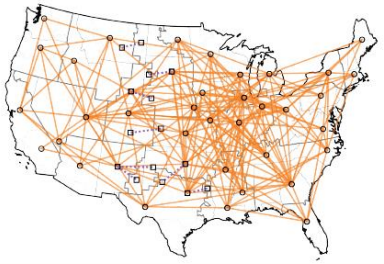

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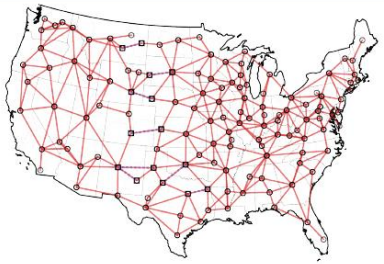
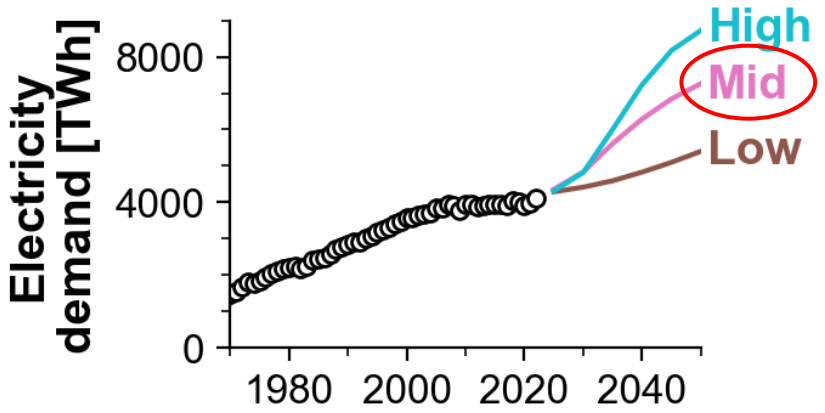


× 3 Demand Growth



× 3 Emissions Targets

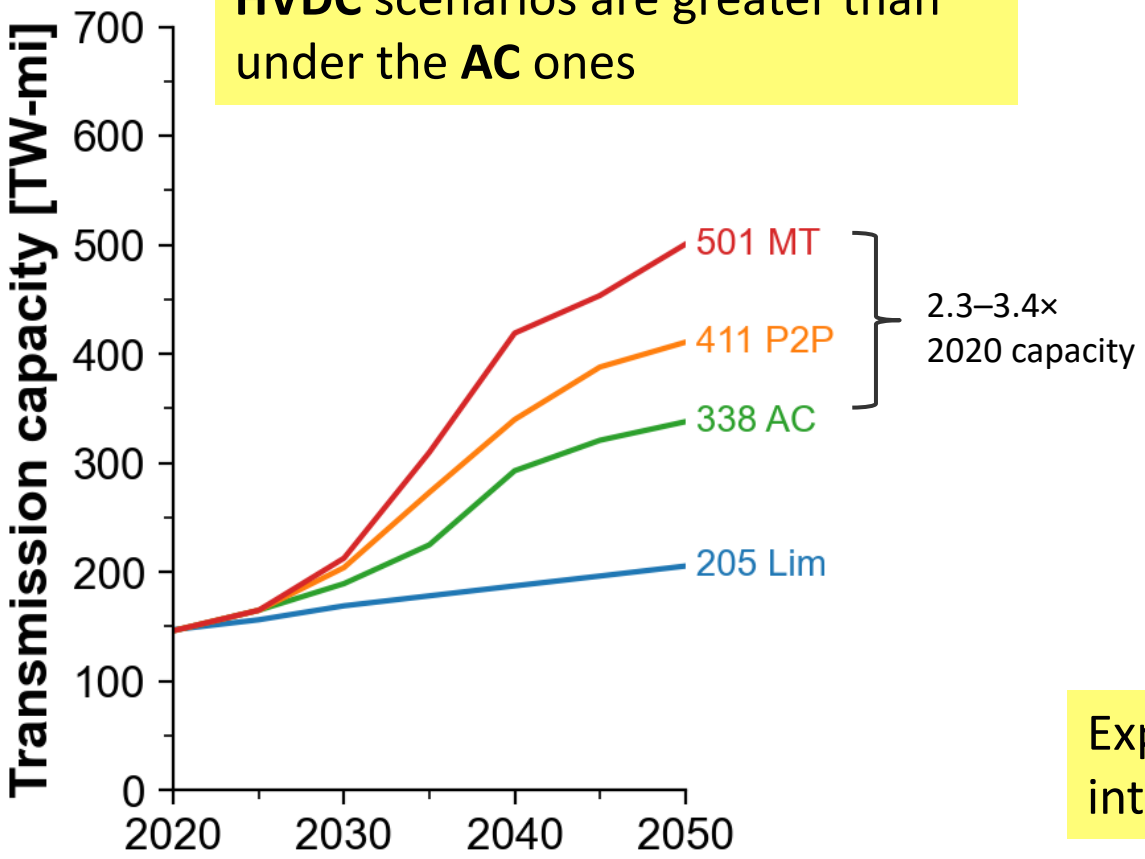
- Current policies
- 90% CO2 reduction by 2035
- 100% by 2035

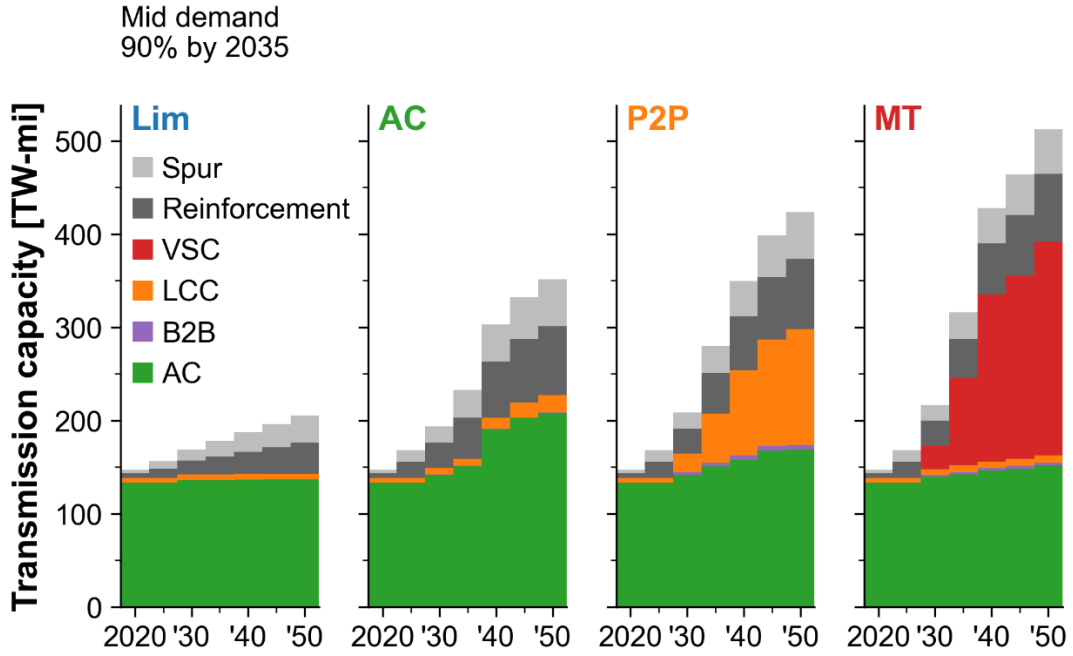
Goal is to understand role of transmission across many possible futures

Rapid and significant growth in new transmission capacity occurs under the decarbonization scenarios

90% by 2035, mid demand

Transmission additions under the **HVDC** scenarios are greater than under the **AC** ones





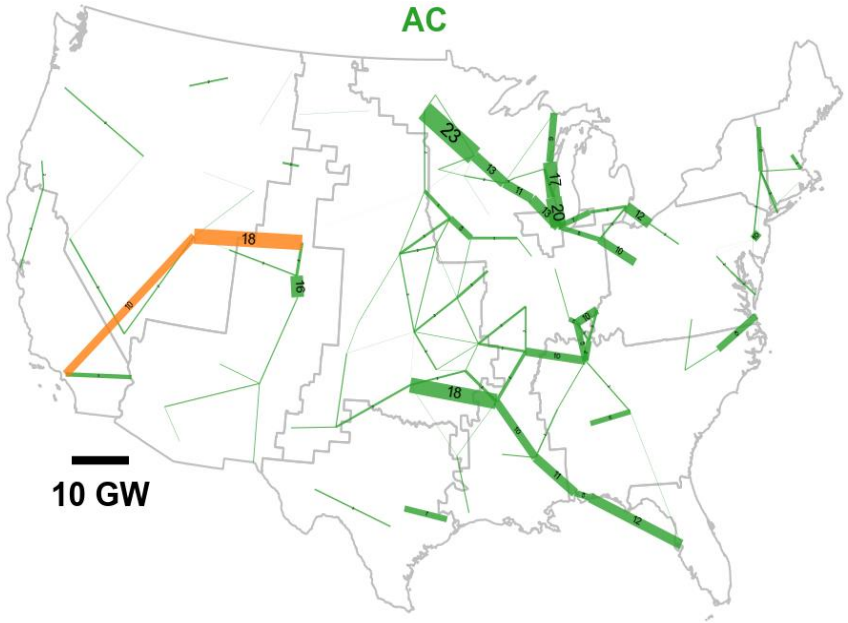
Expansion of **all types** of transmission—local, regional, and interregional—is observed under low-carbon futures

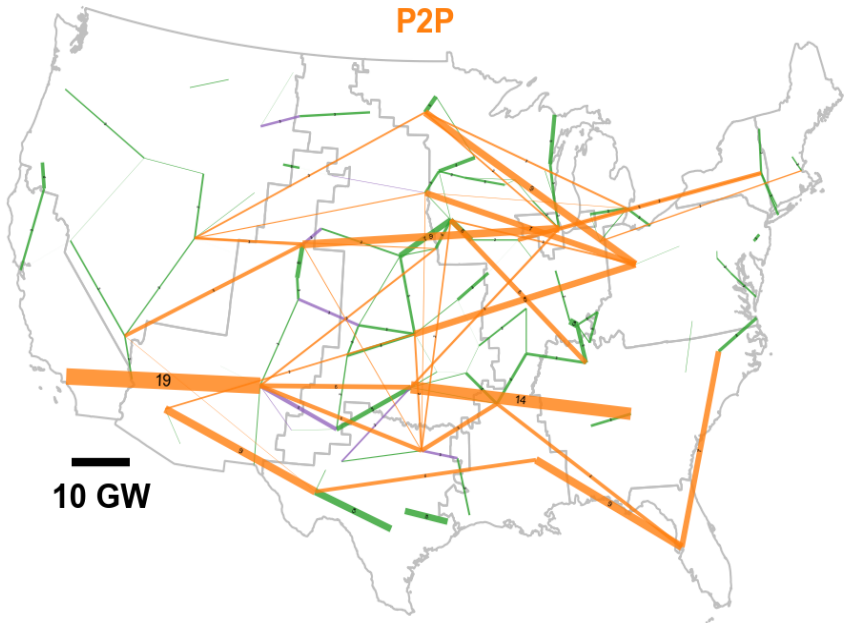
Preliminary results

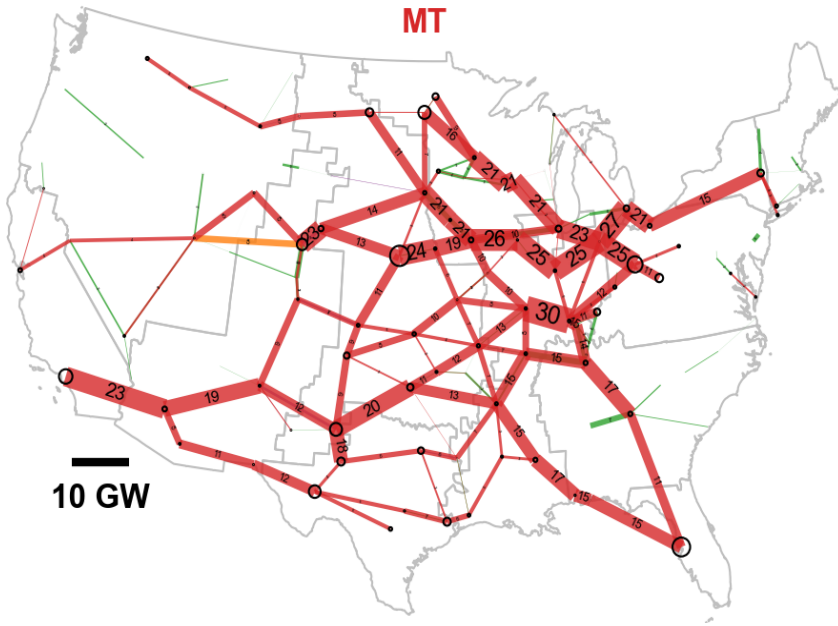
What have we learned from the capacity expansion modeling?

90% by 2035, mid demand

Transmission is added in **all regions**, but expansion is particularly pronounced around the **central wind belt**







Including significant expansion across the interconnection seams (when allowed)

Preliminary results

Scenario Framework: Transmission Expansion Paradigms

Reference Transmission Framework

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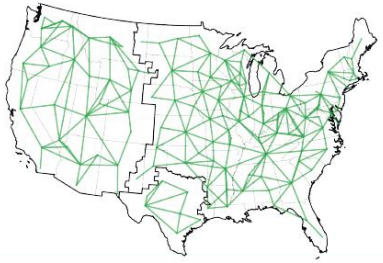
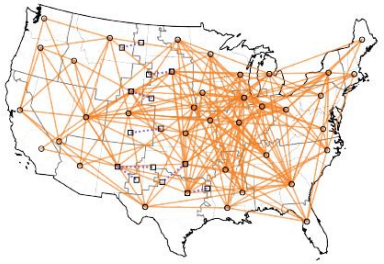
Accelerated Transmission Framework

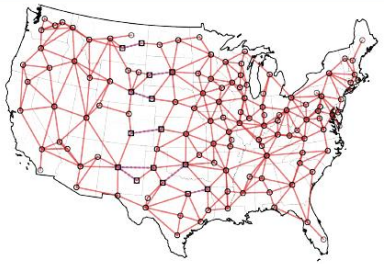
Alternating Current (AC)



Point-to-Point (P2P)



Multi-Terminal (MT)



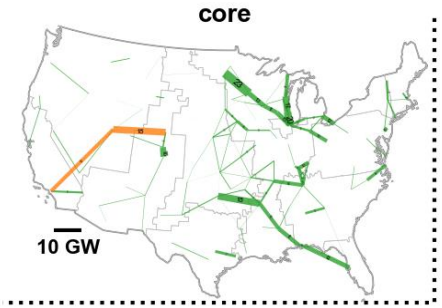
× 3 Demand Growth

× 3 Emissions Targets

× 15 Sensitivities

Sensitivity
PV + battery low cost
Wind low cost
Electrolyzer low cost
+Nuclear SMR +DAC
No interface expansion limit
Transmission cost 2x
No RA sharing
Siting limited for PV and wind
CCS high cost
Many challenges
No H2
No CCS
No H2 or CCS
No H2 or new nuclear
Climate

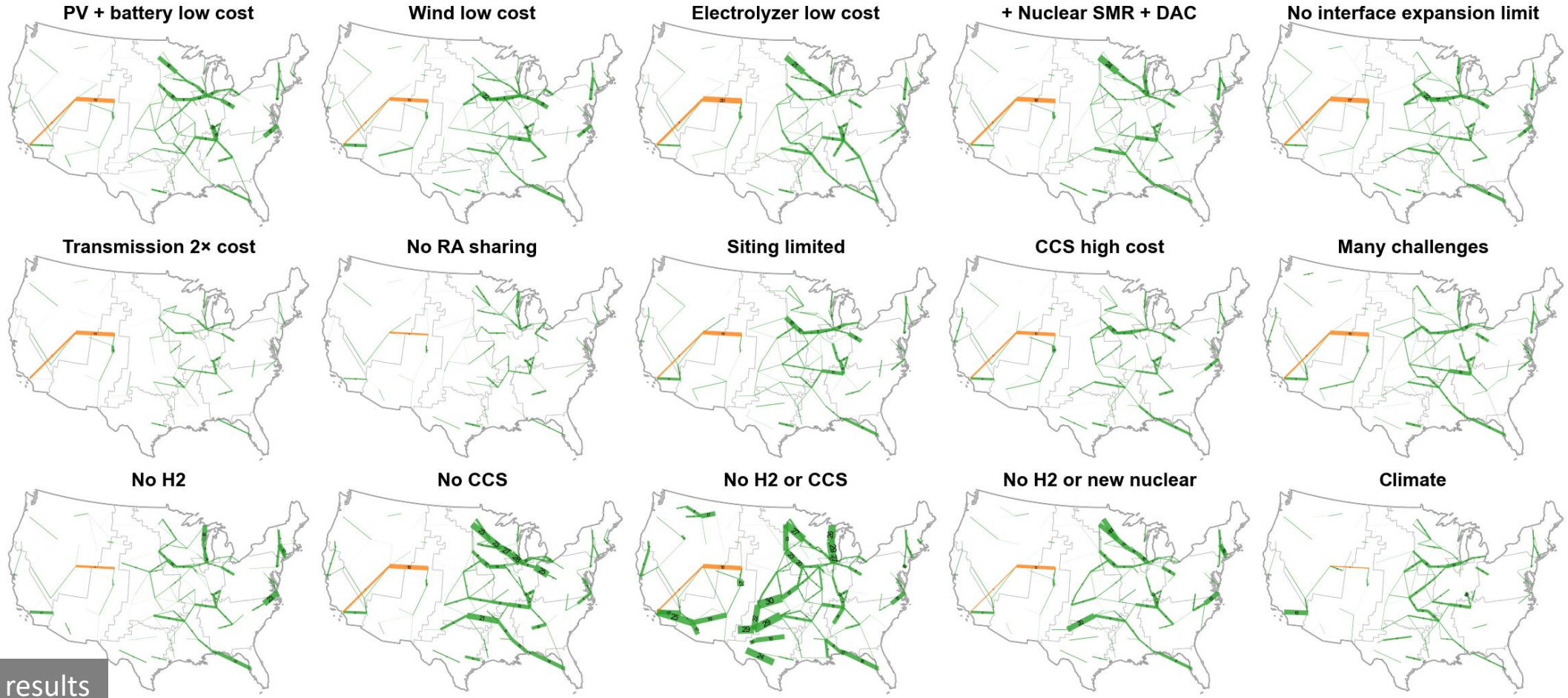
Spatial distribution of transmission expansion is robust across many possible futures



AC paradigm

90% by 2035 mid demand

But with variability in expansion magnitude—especially for individual regional interfaces



Preliminary results

High Opportunity Transmission (HOT)

Scenario-based approach to identify robust solutions from transmission expansion

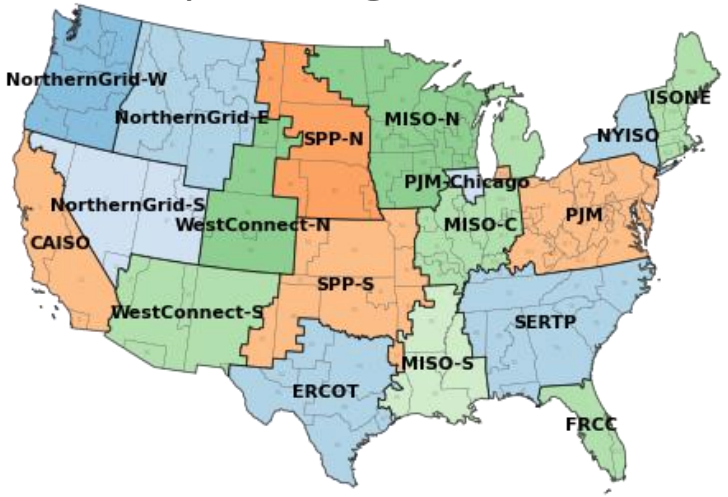
The results in this section are for 2035

High Opportunity Transmission: Overview

- **Objective:** Use results across a large collection of scenarios to identify high opportunity transmission (HOT) expansion options to spur further assessment

- **Definition of HOT options**
  - Robust development across many scenarios → common and significant installations across majority of the sensitivities (next slide)
  - Applicable to ambitious, but not lowest, emission futures → 90% by 2035, Mid Demand
  - Timescales appropriate for early-stage transmission planning → focus on 2035

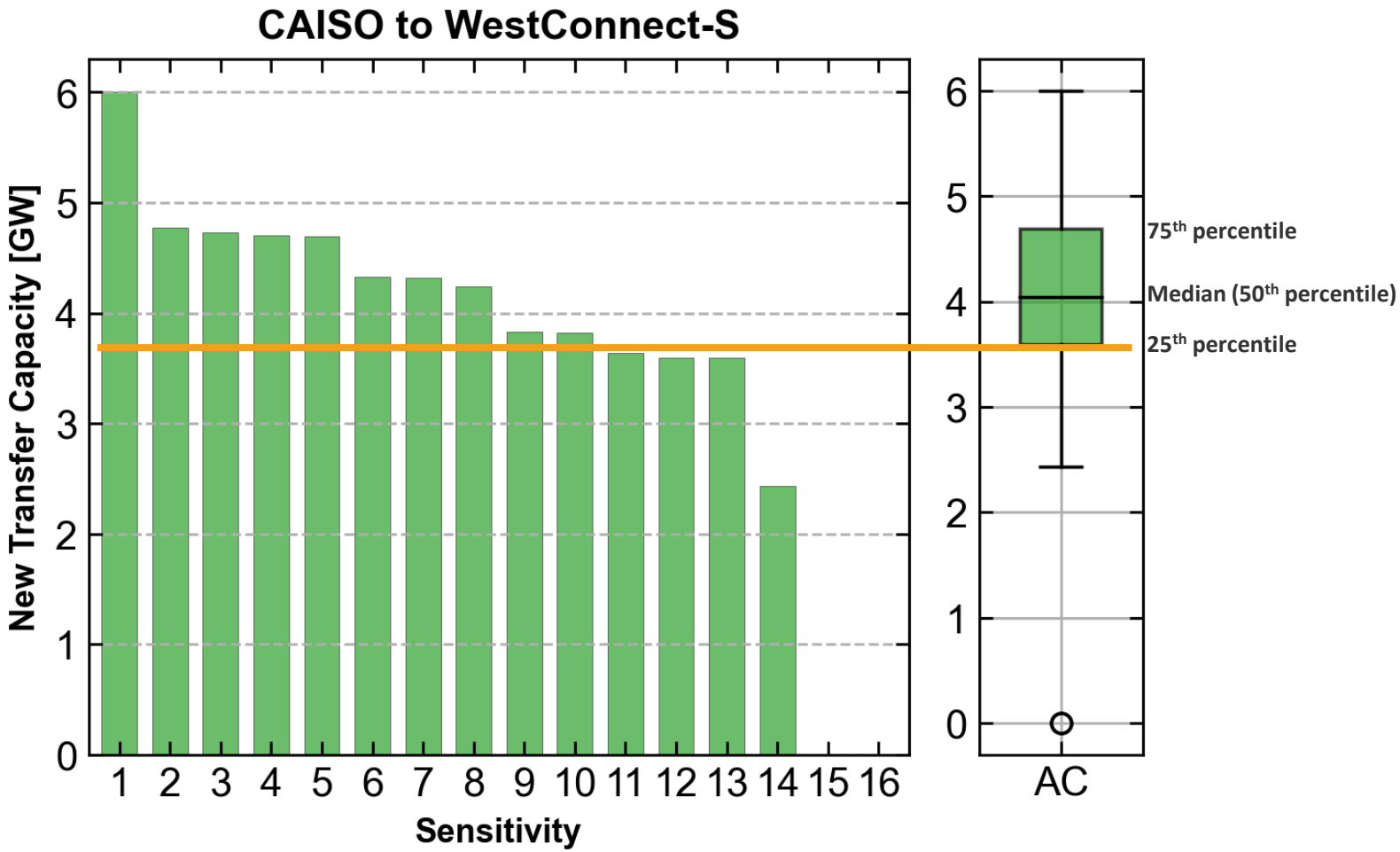
- **Geographic specificity**
  - Zonal interfaces across 18 sub-regions



Diversity of transmission expansion across transmission paradigm, sensitivity, region

Distribution of new (2020-2035) transmission under all 16 sensitivities

Range and quartiles



My slides focus on 25th percentile results to reflect robustness.

The 25th percentile ≈ 3/4 of scenarios resulted in greater capacity expansion across the interface

Note: Limited sample size and nonrandom selection of sensitivities

Preliminary results

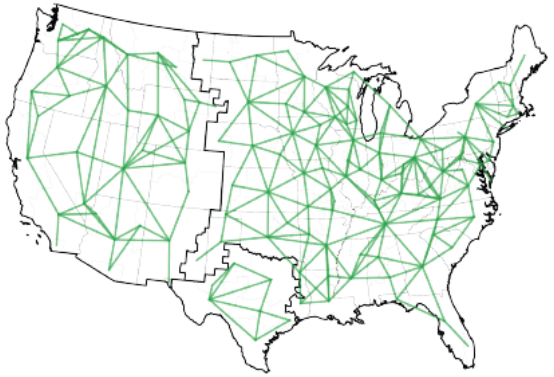
90% by 2035, mid demand, AC paradigm

Caveats and Notes

- **All results are directly from the capacity expansion scenarios.** ReEDS builds transmission because they are part of the least cost solution to meet policy, demand, and grid reliability needs.
  - Other NTP tasks are evaluating economics, operability, and reliability in greater detail
  - Options are examined zonally only; further investigation (e.g., siting feasibility) would be needed to evaluate specific transmission projects

- Analysis applied for **all three transmission paradigms** (AC, P2P, and MT)
  - Model implementation required distinction between AC and DC (and VSC vs. LCC), but ultimately increased interface capacity could be from either technology option
  - Increased transfer capacities could be achieved from a combination of new greenfield transmission, upgrades to existing transmission, or grid-enhancing technologies

Alternating Current (AC)



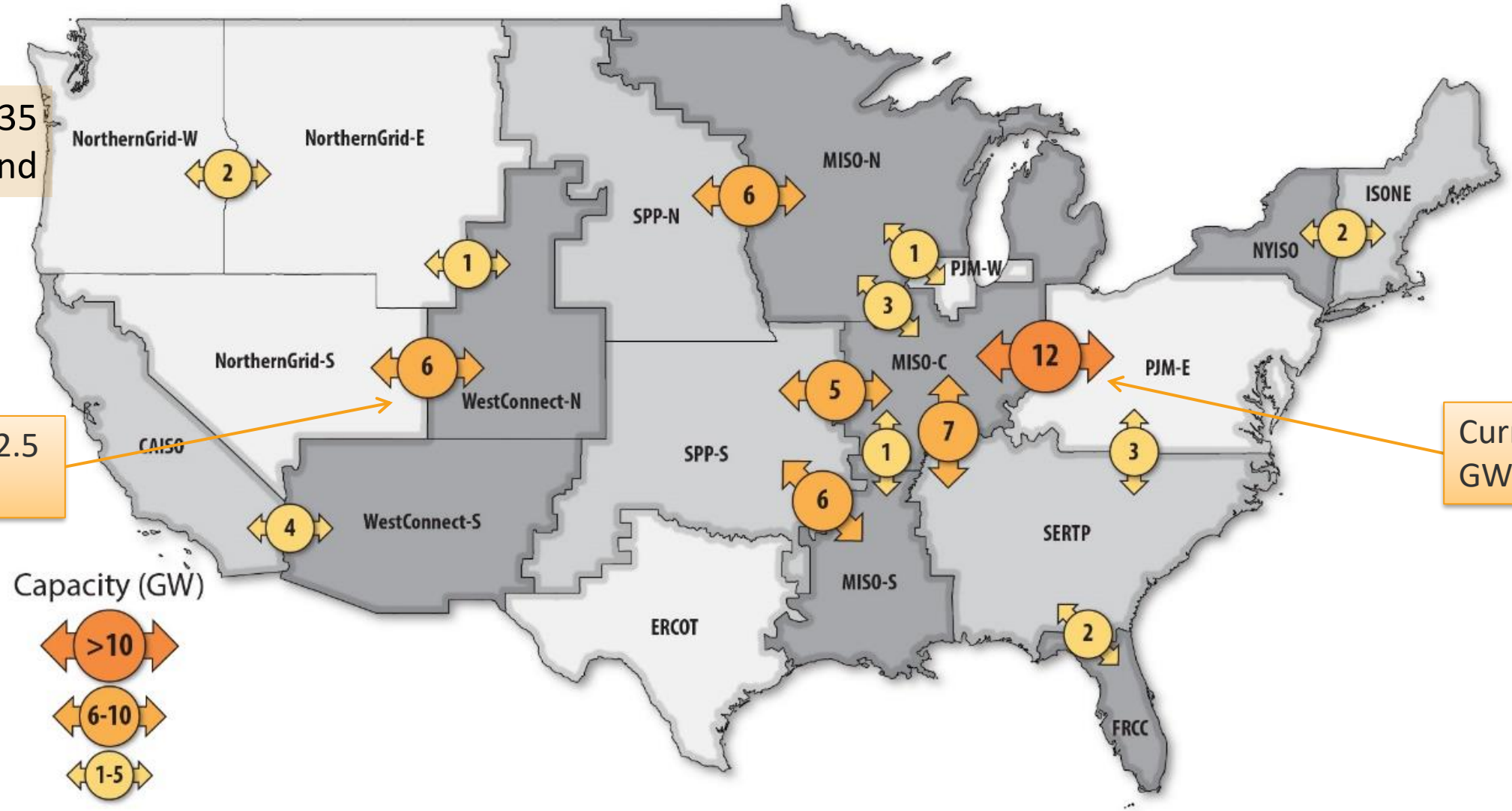
- Expansion allowed within interconnections
- No new DC connections

AC Transmission Paradigm

Ultimate selection of transmission technology (e.g., AC, DC-VSC, DC-LCC) requires further study and could differ from these assumptions. Upgrades, grid-enhancing technologies, and other non-greenfield expansion options could also be considered.

HOT: new interregional transfer capacity robustly developed by 2035 (AC paradigm)

90% by 2035 mid demand



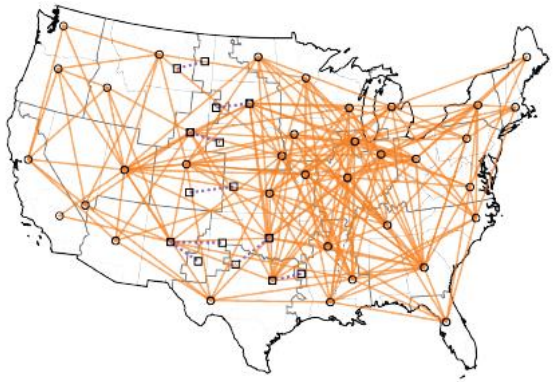
Currently ~2.5 GW

Currently ~28 GW

25th percentile capacity; > 1 GW expansions

Preliminary results

Point-to-Point (P2P)



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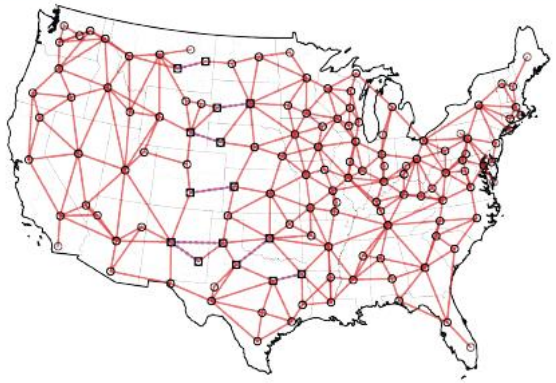
- Includes long-distance point-to-point HVDC options

Multi-Terminal (MT)



- Expansion allowed across the country
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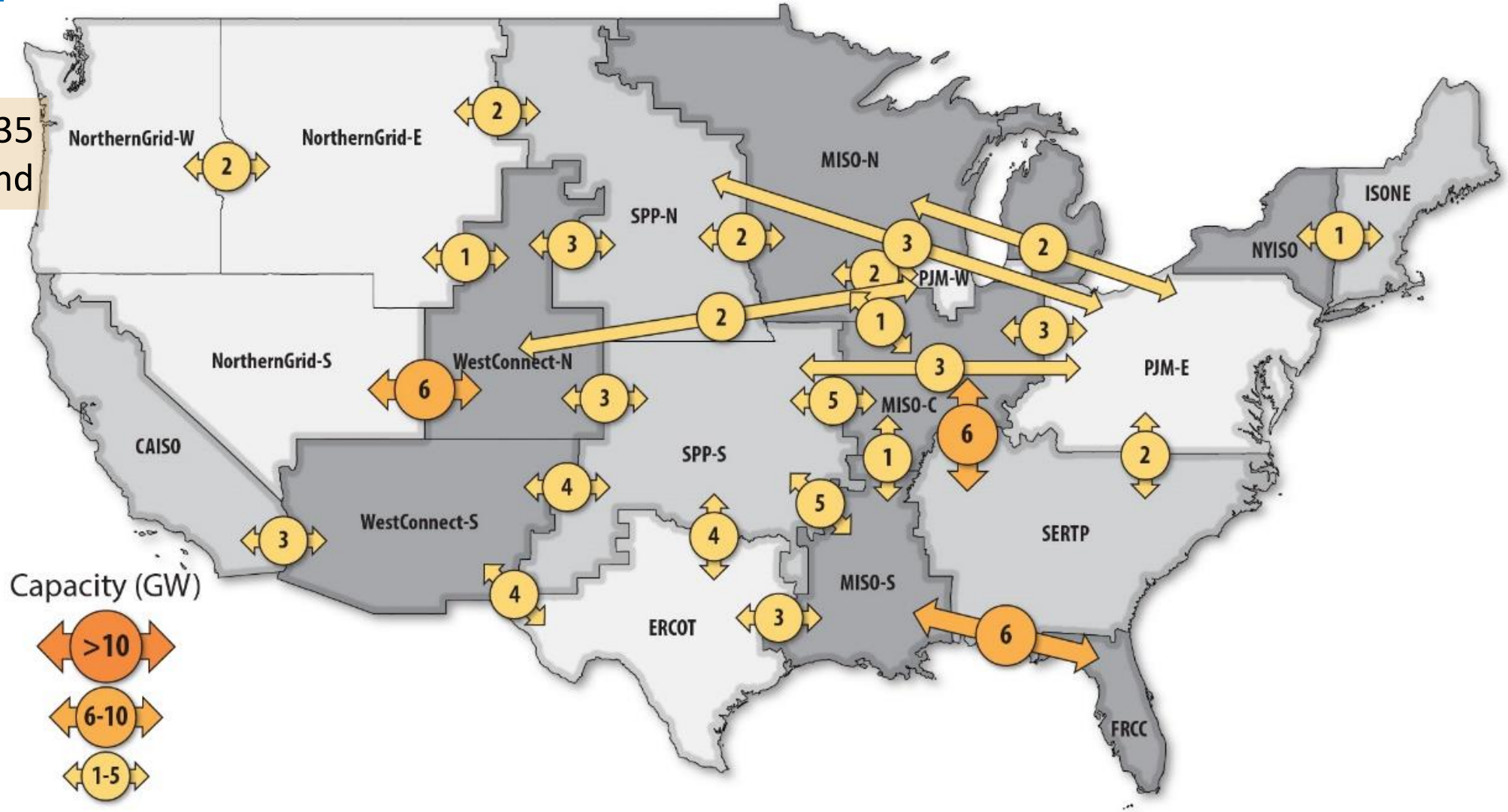
HVDC Transmission Paradigm

Ultimate selection of transmission technology (e.g., AC, DC-VSC, DC-LCC) requires further study and could differ from these assumptions. Upgrades, grid-enhancing technologies, and other non-greenfield expansion options could also be considered.

HOT: new interregional transfer capacity robustly developed by 2035 (Point-to-Point HVDC paradigm)

90% by 2035
mid demand

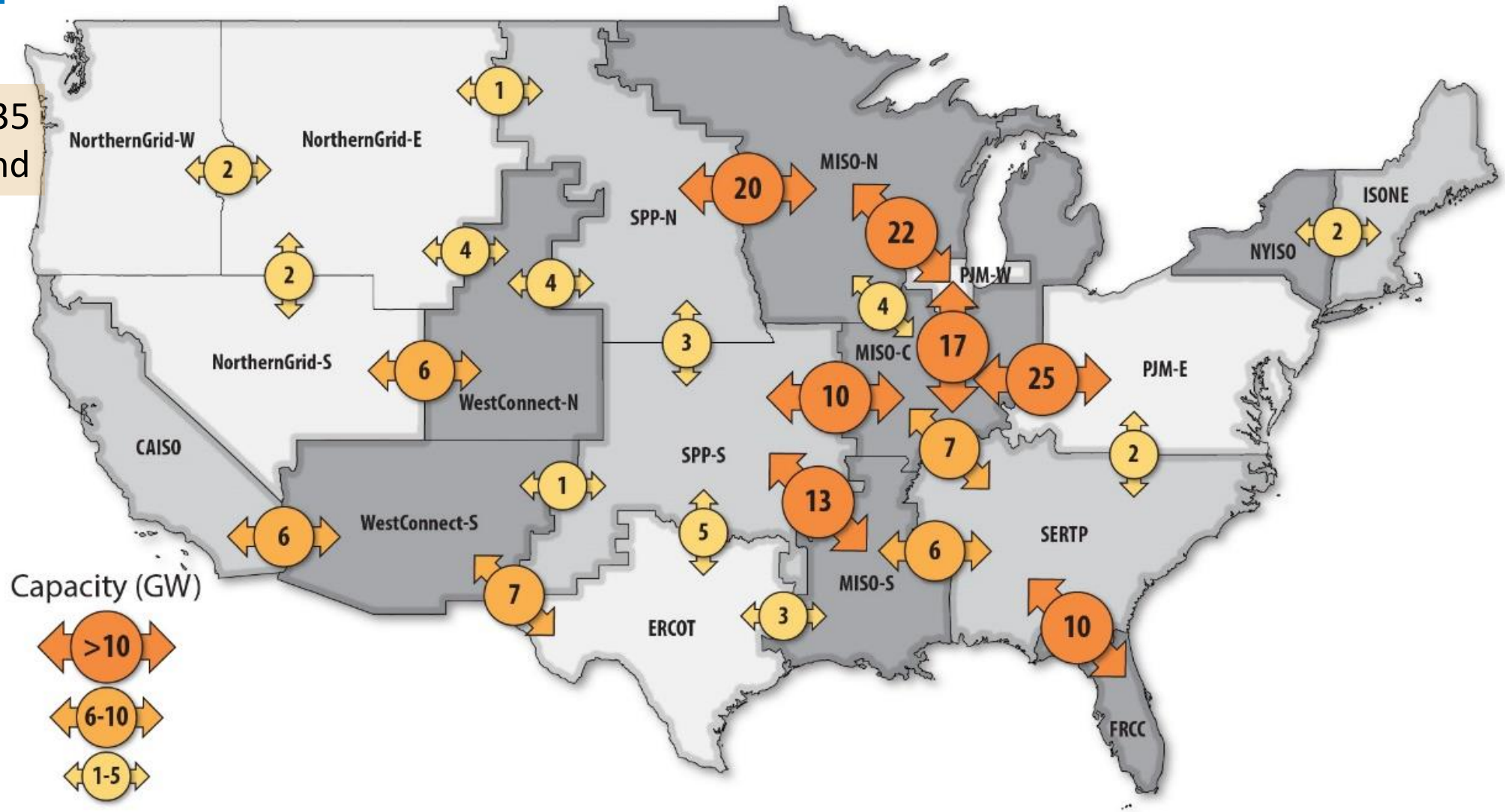


Preliminary results

25th percentile capacity; > 1 GW expansions

HOT: new interregional transfer capacity robustly developed by 2035 (Multi-Terminal HVDC paradigm)

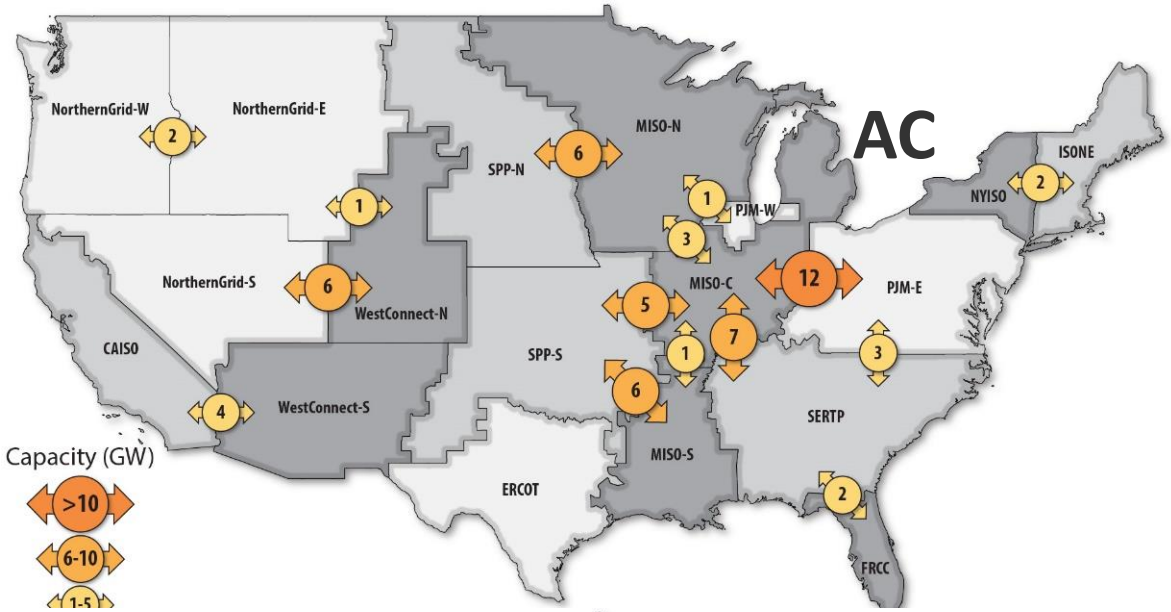
90% by 2035
mid demand

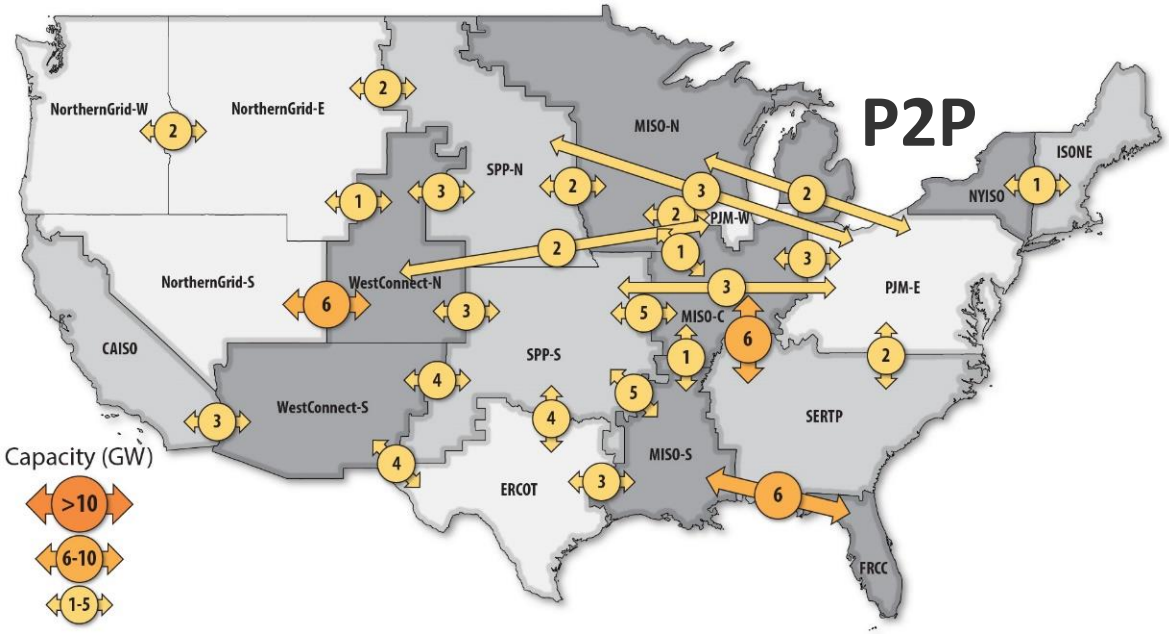


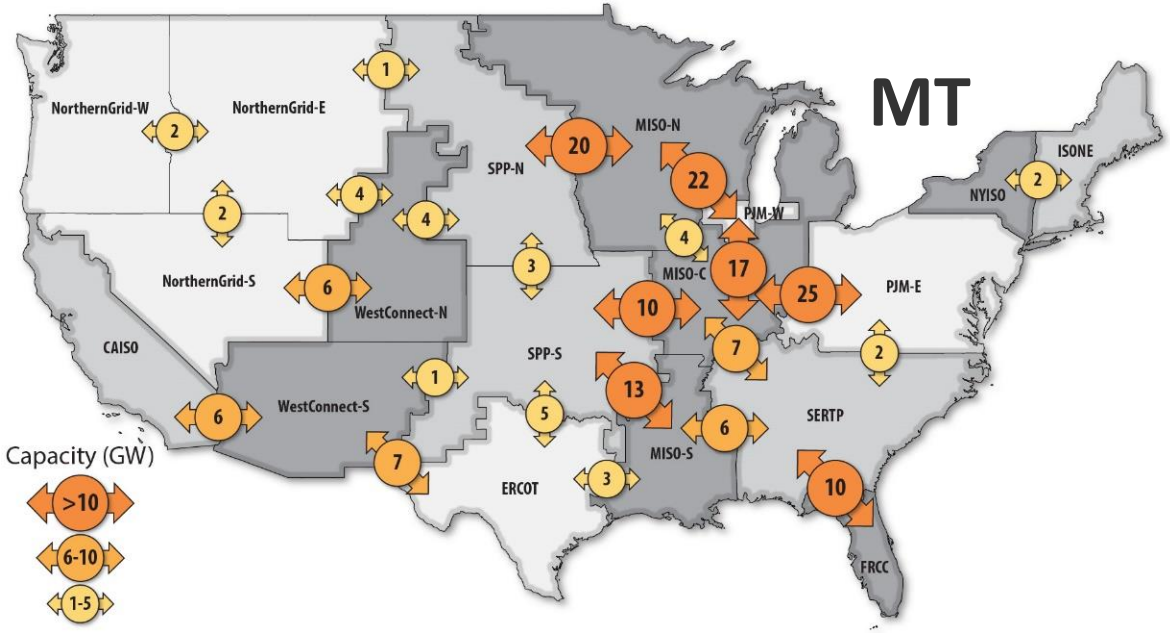
Preliminary results

25th percentile capacity; > 1 GW expansions

HOT options are starting points for further study





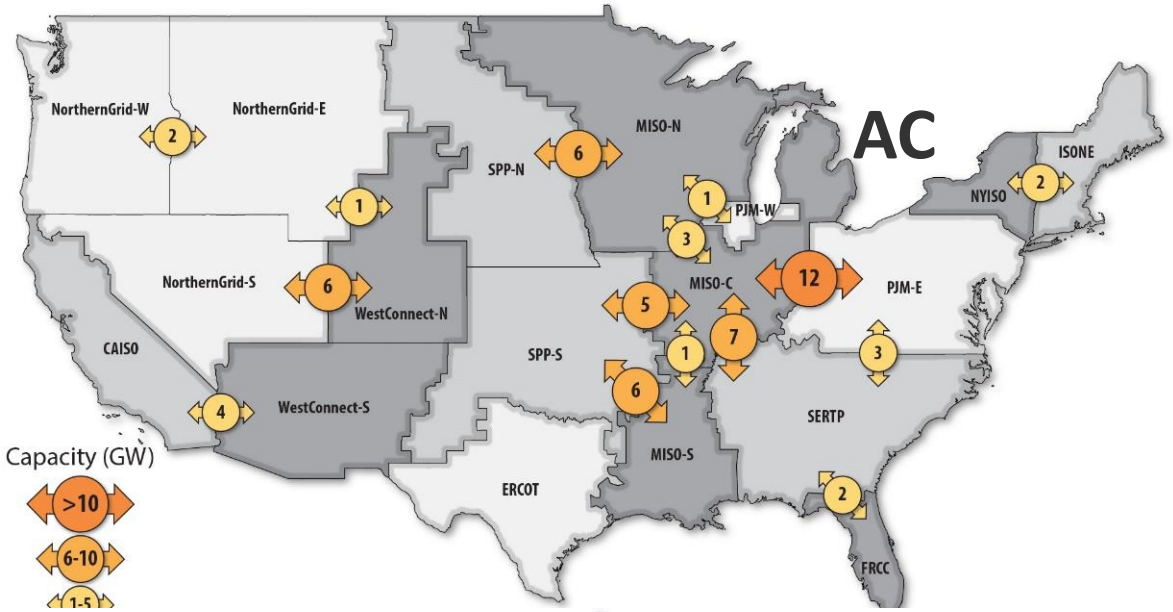


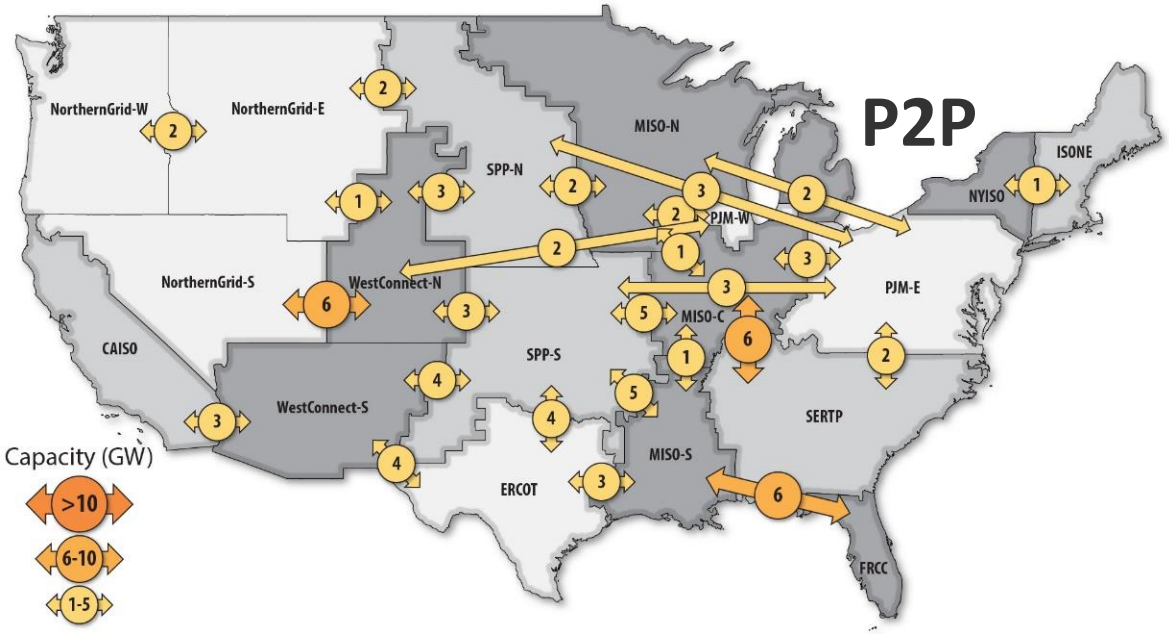
High Opportunity Transmission (HOT) options: interregional interfaces with robustly expanded capacity by 2035 across several decarbonization scenarios

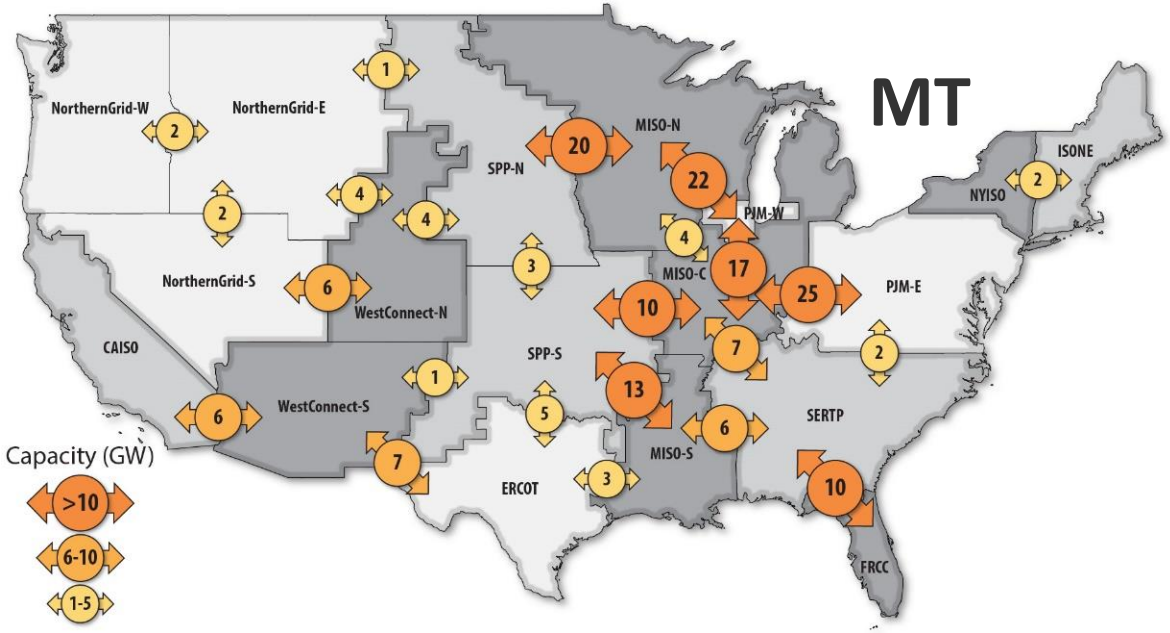
- HOT options exist for all planning regions, but are concentrated in the central Midwest
- Expansion *beyond* these capacities are found in several sensitivities, and when looking at longer timescales or higher load growth

Preliminary results | 90% by 2035, mid demand

HOT options are starting points for further study







Thank you!

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Preliminary results | 90% by 2035, mid demand