



National Transmission Planning Study

U.S. Department of Energy

October 2022

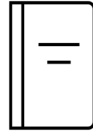


Building a Better Grid Initiative



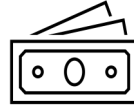
Engagement and collaboration

- States
- Tribal nations
- Stakeholders
- Federal Agencies
- ISO/RTOs
- EROs



Enhanced transmission planning

- Transmission Needs Study
- **National Transmission Planning Study**
- Atlantic Offshore Wind Transmission Study



Federal financing tools (\$20+B)

- Transmission Facilitation Program (\$2.5B)
- Smart Grid Investment Matching Grant Program (\$3B)
- Grid resilience grants for states, Tribes, and utilities (\$10+B)
- Loan guarantee programs
- Transmission Facility Financing (\$2B)
- Siting of interstate Electricity Transmission Lines (\$760M)



Transmission permitting process

- Streamline permitting with federal agencies
- Public private partnerships
- Designation of National Corridors



Transmission-related R&D

- “Next generation” electricity delivery technologies
- Supporting activities

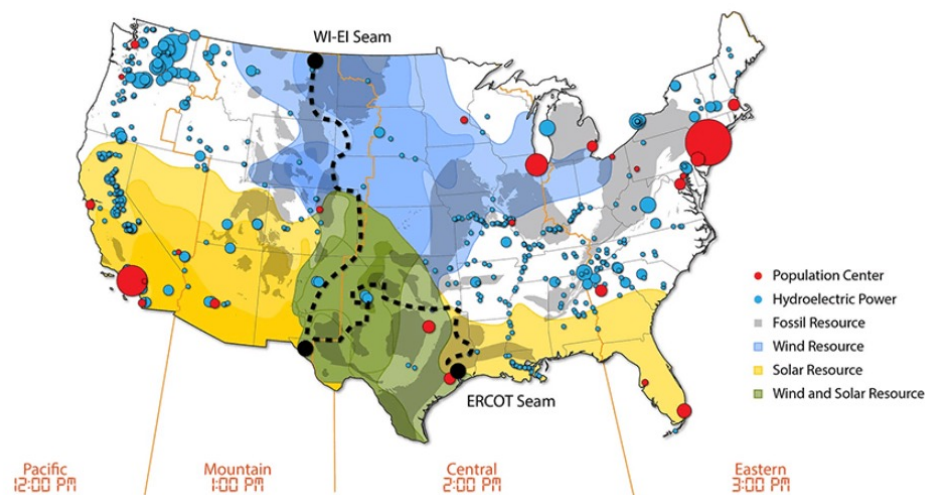
Project Team

- This study is conducted by a joint National Renewable Energy Laboratory (NREL) and Pacific Northwest National Laboratory (PNNL) project team
- This study builds on past projects and expertise at NREL and PNNL with the support and direction of DOE's Office of Electricity and Grid Deployment Office



Office of Electricity

North American Energy
Resilience Model



Objectives of the study

-  Identify **interregional and national strategies** to accelerate cost-effective **decarbonization** while maintaining system reliability
-  Inform regional and interregional transmission planning processes, particularly by **engaging stakeholders** in dialogue
-  Results help **prioritize future DOE funding** for transmission infrastructure support

What the Study is and is not doing

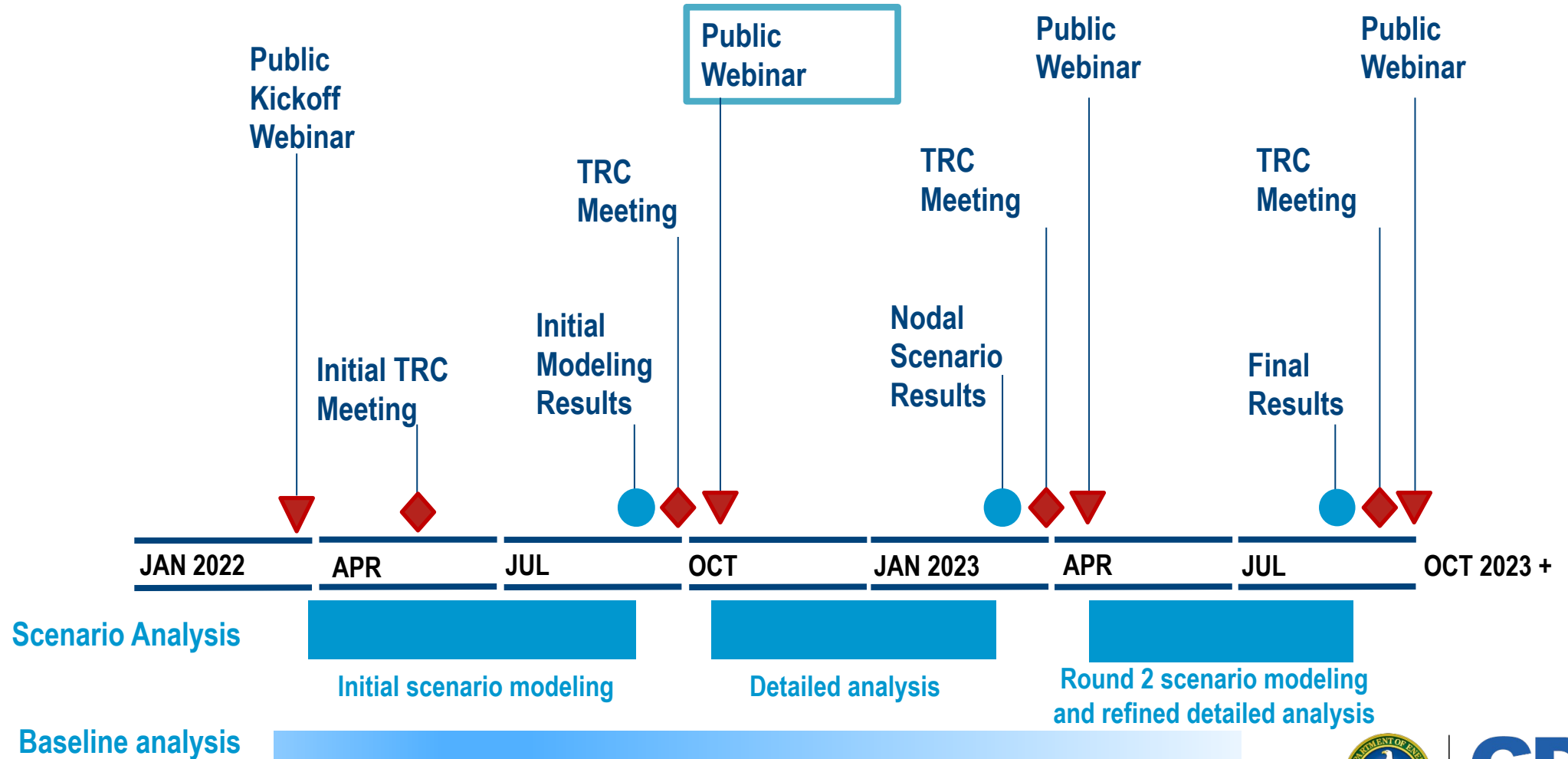
What the study will do

- ▶ Link several long-term and short-term power system models to test a number of transmission buildout scenarios
- ▶ Inform existing planning processes
- ▶ Test transmission options that lie outside current planning
- ▶ Provide a wide range of economic, reliability, and resilience indicators for each transmission scenario

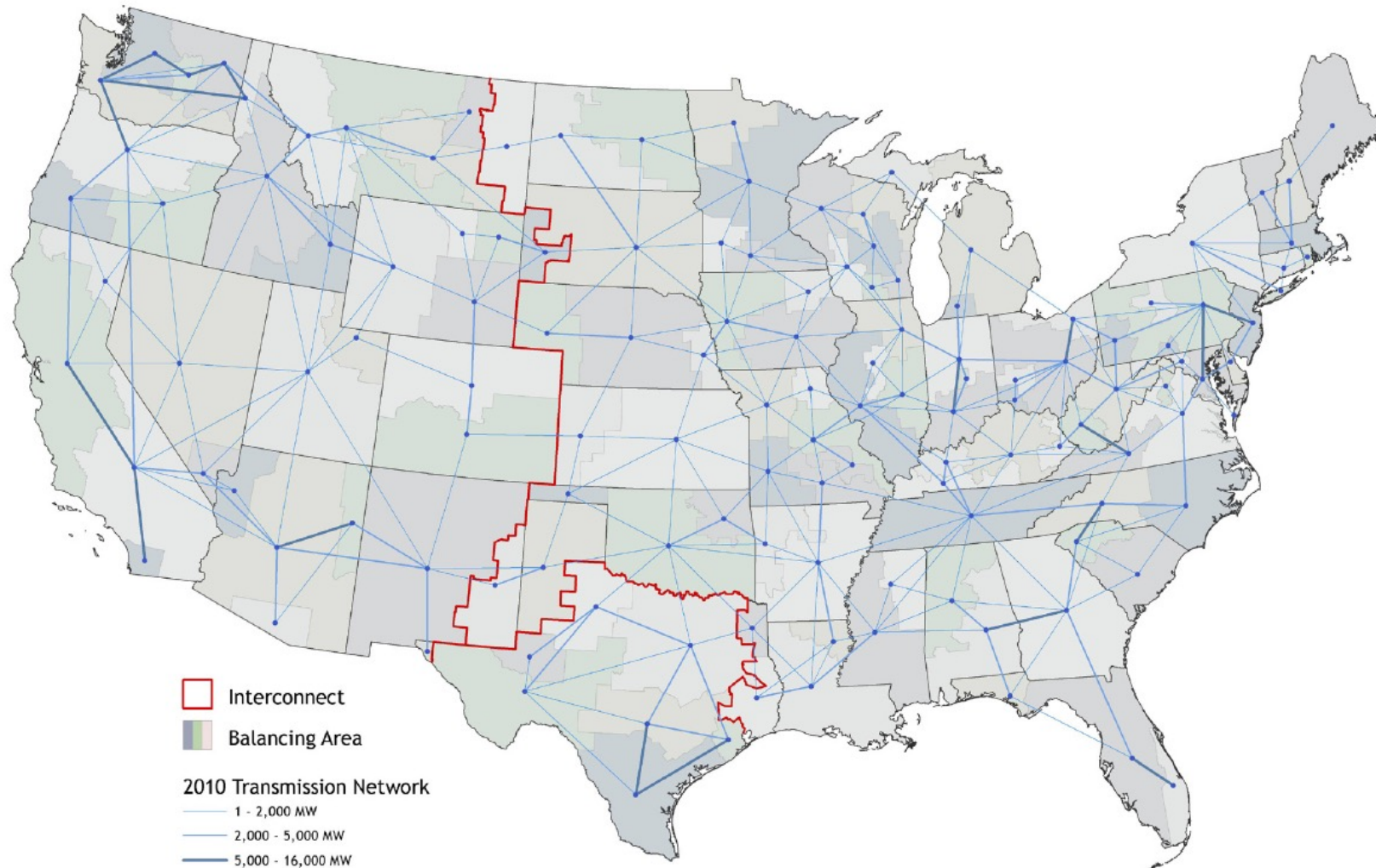
What the study will not do

- ▶ Replace existing regional and utility planning processes
- ▶ Site individual transmission line routes
- ▶ Address the detailed environmental impacts of potential future transmission lines
- ▶ Provide results that are as granular as planning done by utilities
- ▶ Develop detailed plans of service

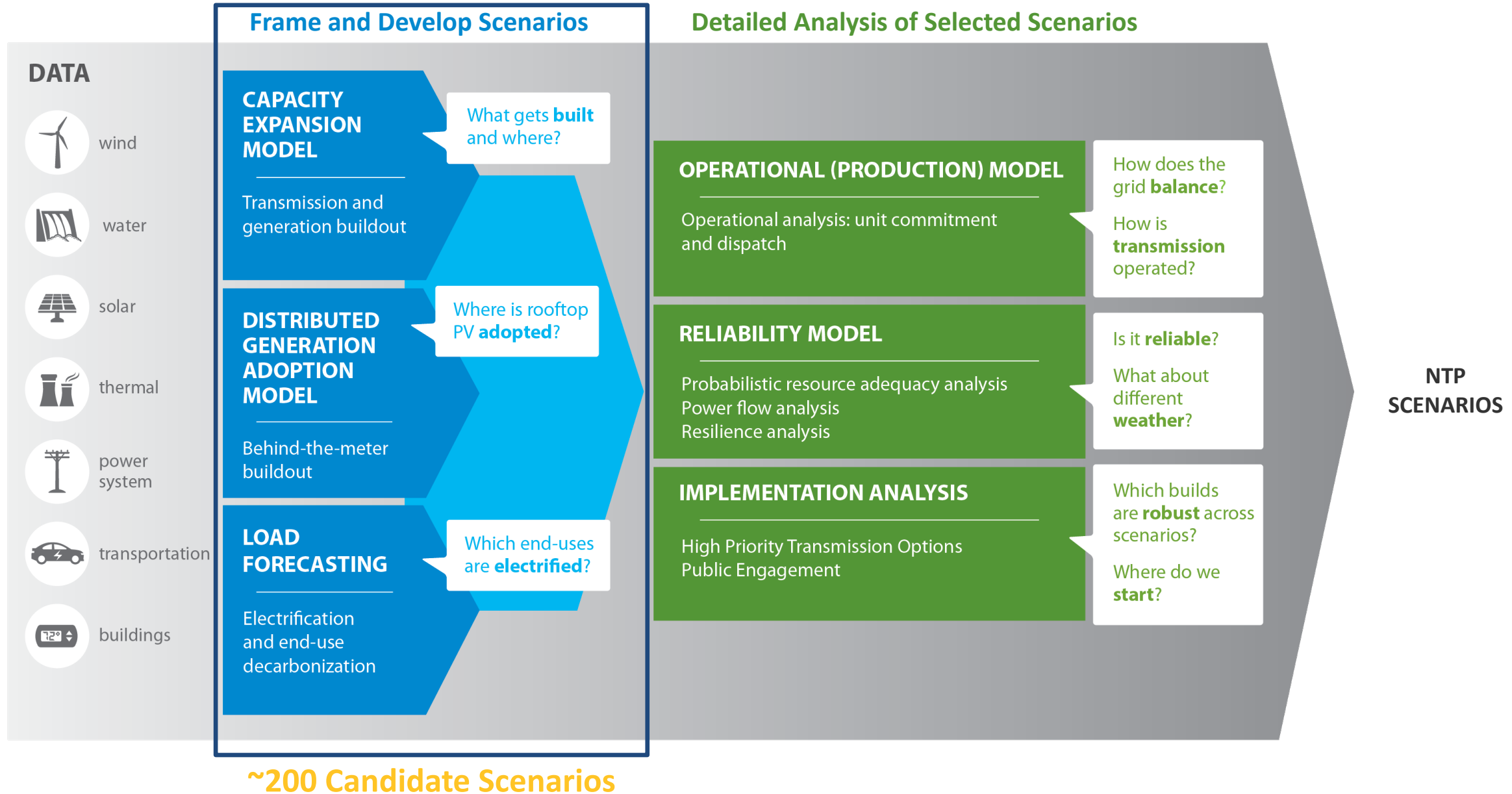
NTPS Timeline



Transmission System in ReEDS

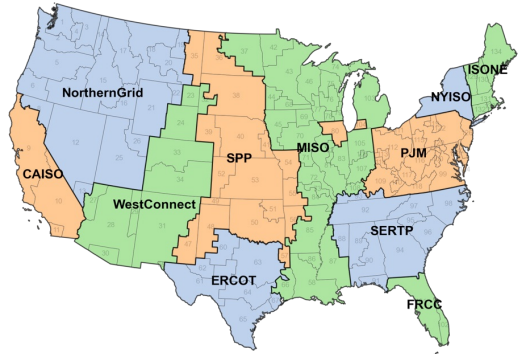


NTP Scenario Analysis Relies on Multiple Linked Modeling Exercises



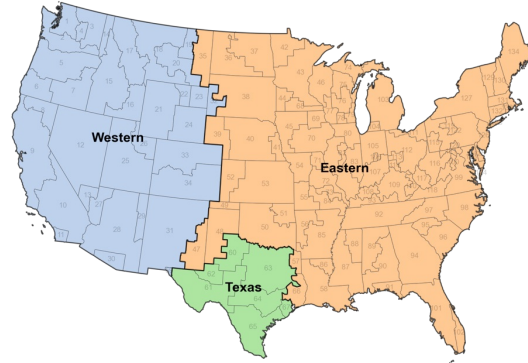
Transmission Paradigms

Limited



- **Intra-regional** transmission expansion within planning regions only
- Cap annual transmission builds based on recent (since 2009) average of ~1.4 TW-miles/yr.

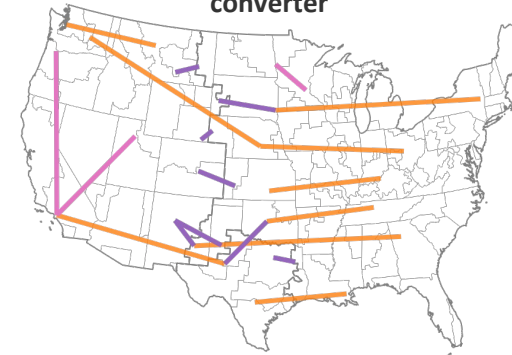
AC



- **Intra-interconnection** transmission expansion between 134 zones (no new back-back DC ties across seams)
- Transmission cost and losses based on AC transmission (500 kV).

LCC

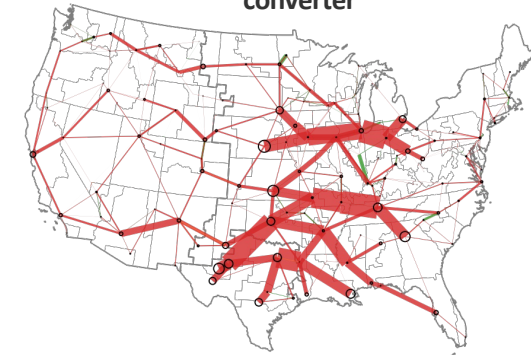
HVDC line-commutated converter



- **Inter-interconnection** transmission expansion (new back-back DC ties allowed)
- HVDC (point-to-point line-commutated converter) expansion allowed
- Available LCC connections identified based on preliminary scenarios.

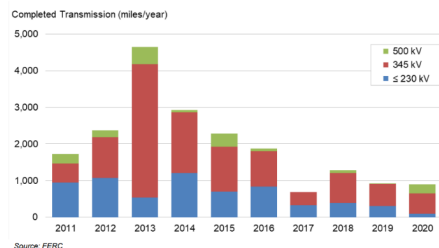
VSC

HVDC voltage-source converter



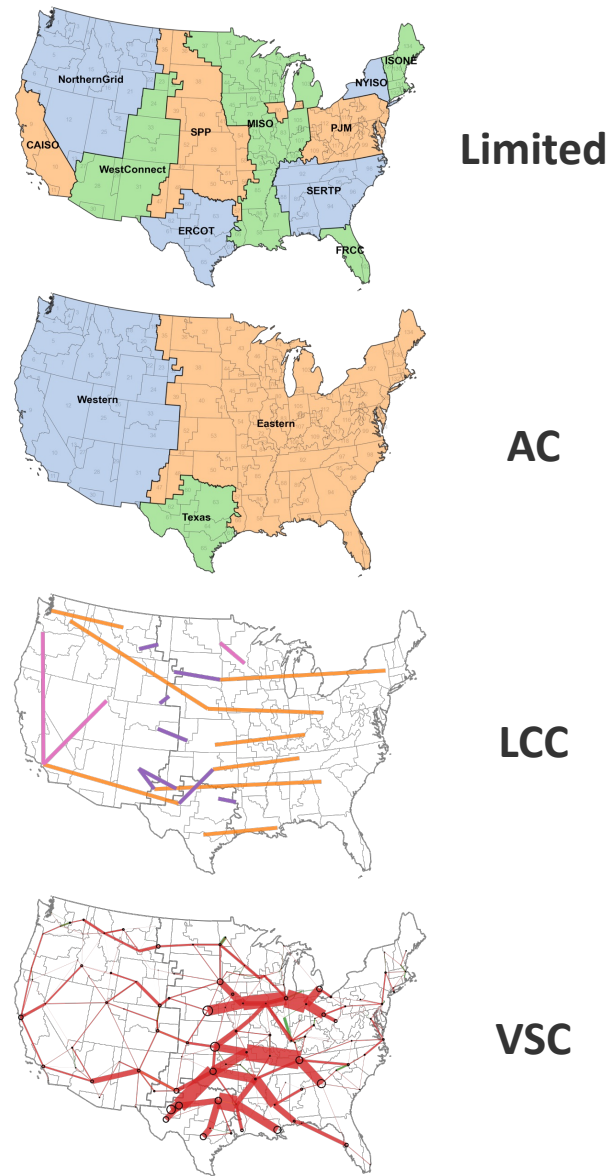
- **Macrogrid** multiterminal HVDC network designed by the model and specific to the scenario
- Transmission lines and voltage-source-converter capacities are decided separately
- VSC builds are not allowed until 2032.

New transmission build has been relatively modest in recent years



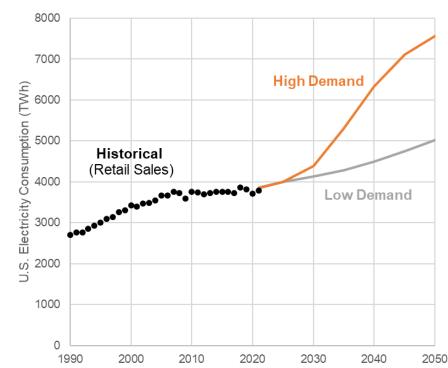
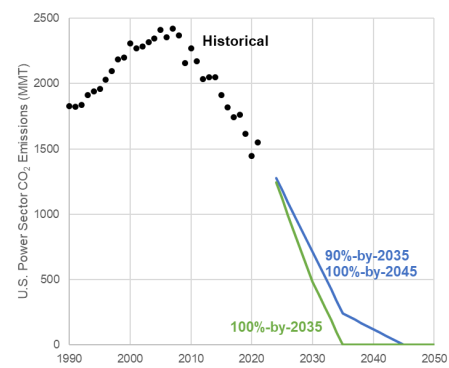
Scenario Framework: 24 Core Scenarios

4 transmission paradigms X 2 demand cases X 3 emissions targets



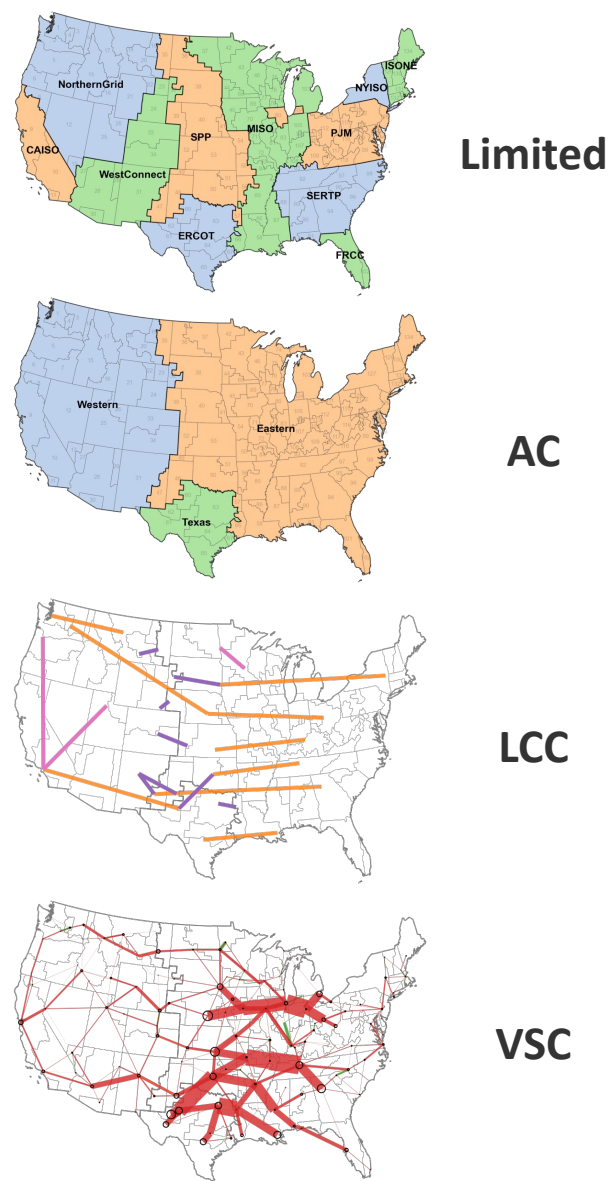
Demand Growth →

<i>Emissions Target</i>	↑	Current Policies Low Demand	Current Policies High Demand
		90-by-2035 Low Demand	90-by-2035 High Demand
	↓	100-by-2035 Low Demand	100-by-2035 High Demand

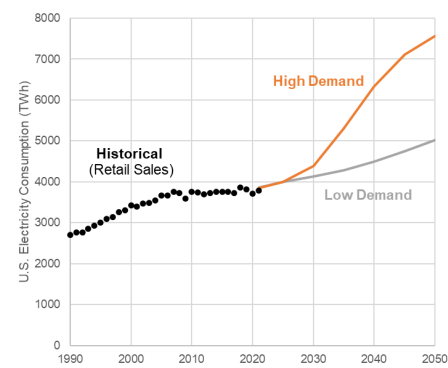
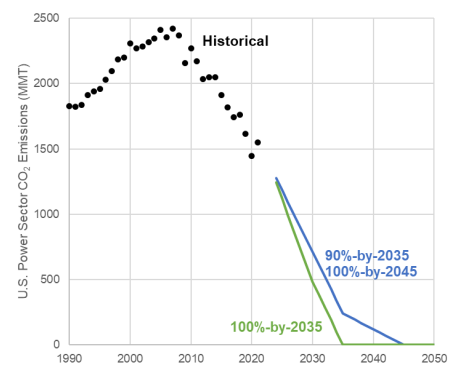


Scenario Framework: 168 Sensitivities

4 transmission paradigms X 3 emissions-demand combinations X 14 sensitivities



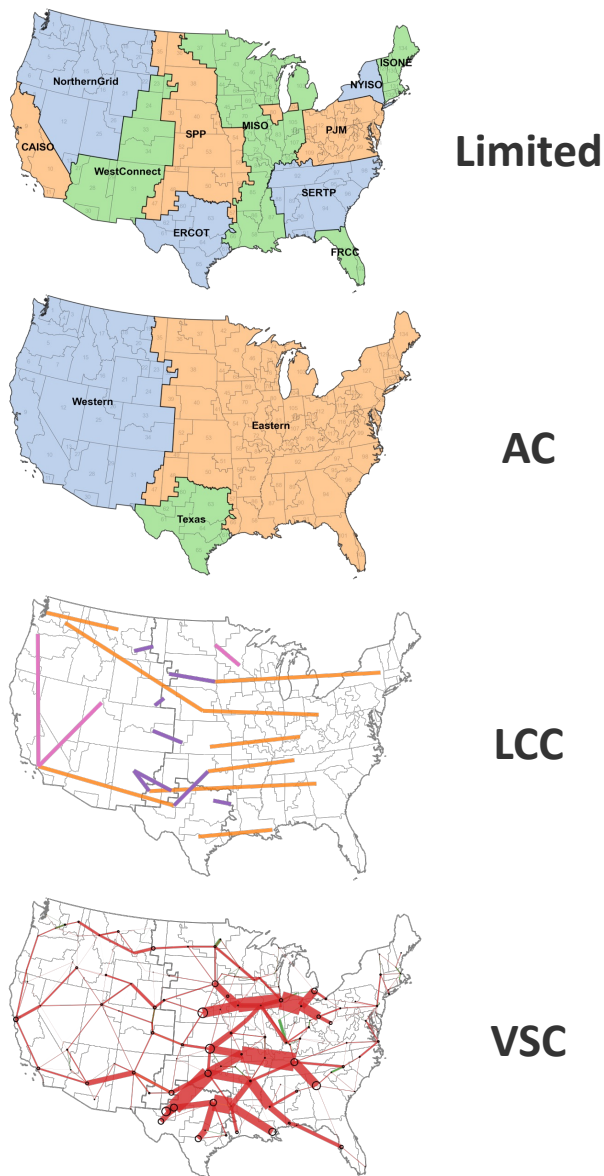
	Demand Growth	
Emissions Target	Current Policies Low Demand	Current Policies High Demand
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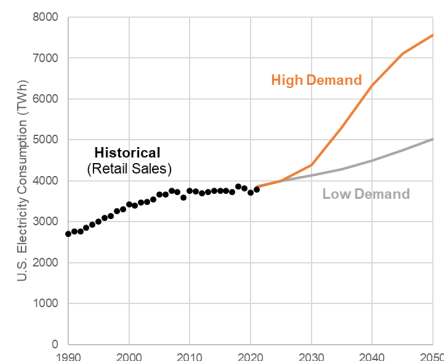
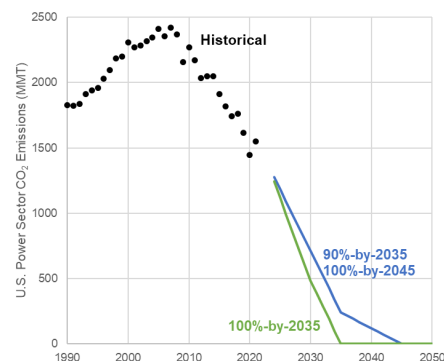
- | Sensitivity |
|--|
| Transmission 5x cost |
| Gas (high and low) price |
| PV + battery low cost |
| Wind low cost |
| Siting limited |
| More distributed PV |
| Demand peak shaving |
| H2 (high and low) price |
| + Nuclear SMR + DAC
No CCS or new nuclear |
| Climate |
| Many challenges |

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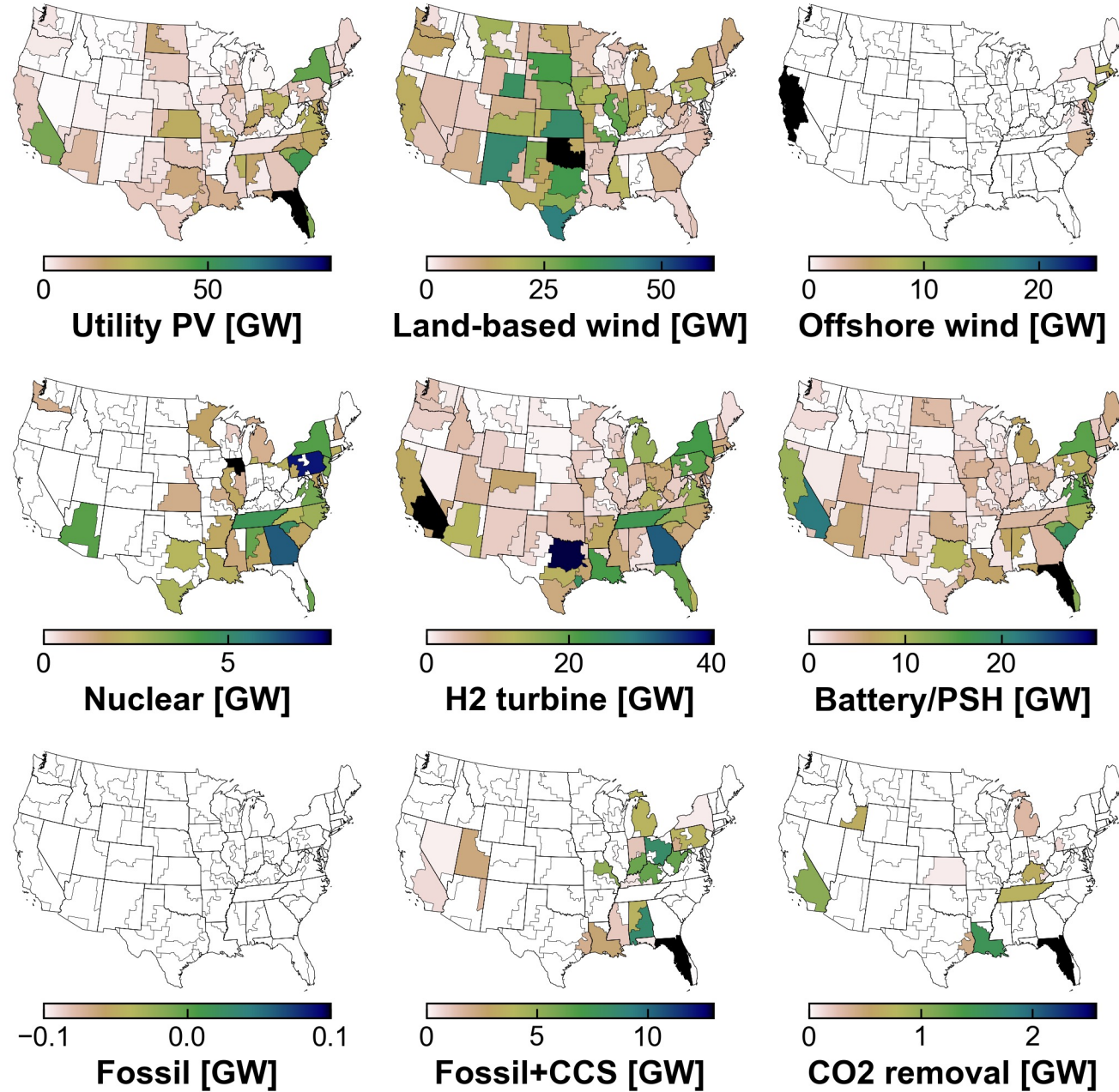


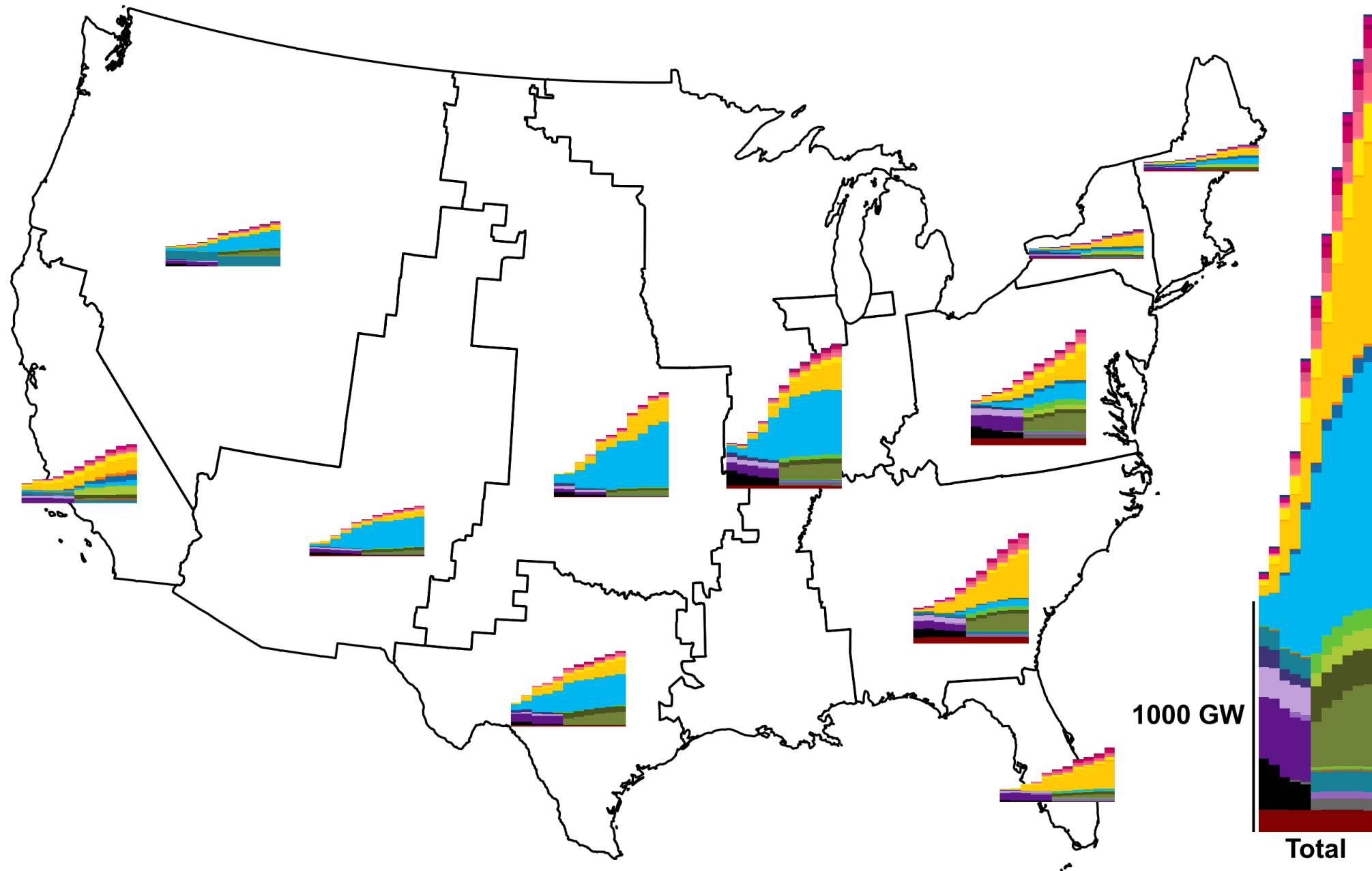
Sensitivity
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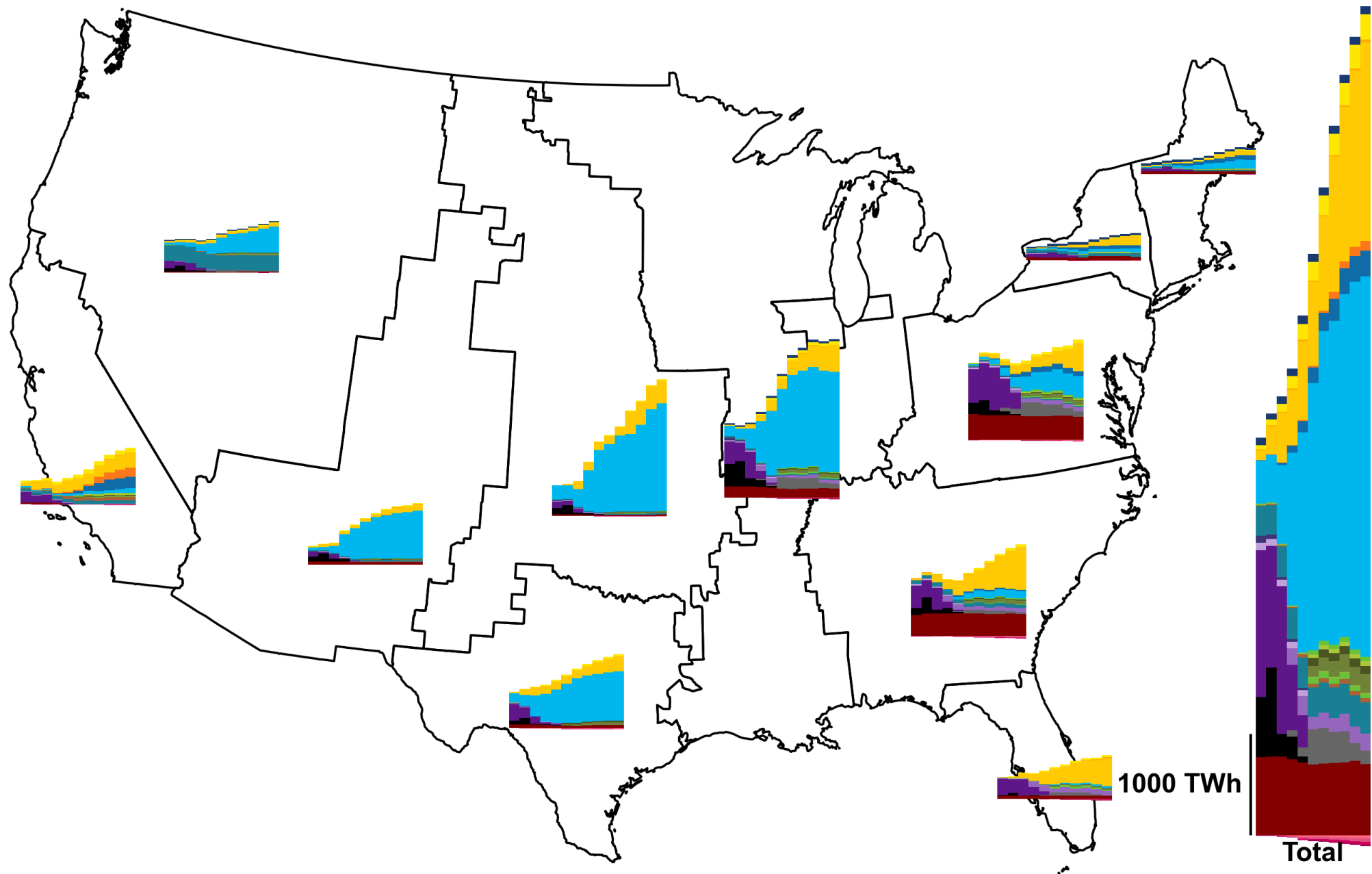
Wide-Ranging Sensitivities to Assess Robustness of Findings

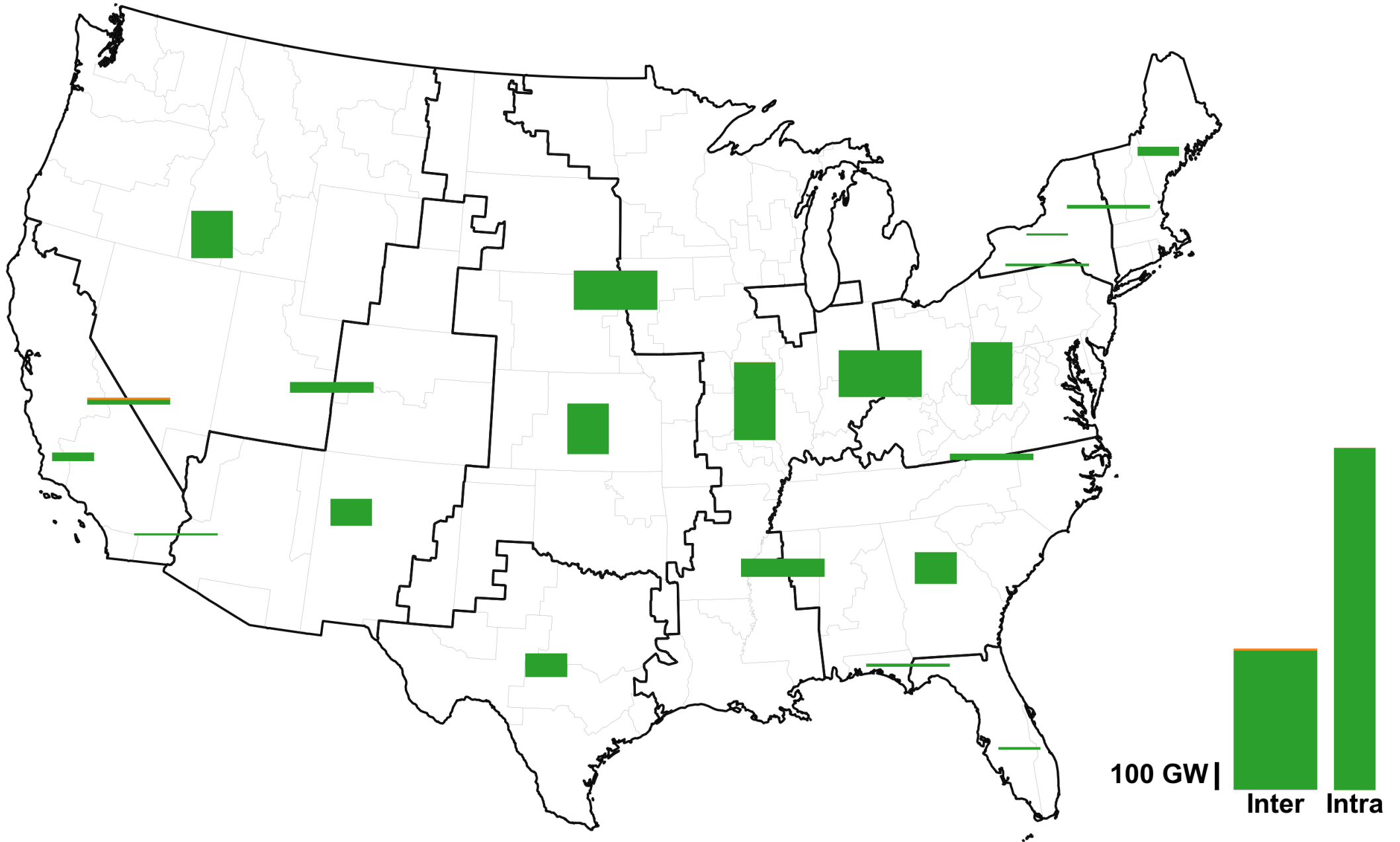
Sensitivity	Variation	Default
Transmission 5x cost	5x higher	Varied sources, regional variations
Gas (high and low) price	Higher (AEO LOGR) Lower (AEO HOGH)	AEO Reference
PV + battery low cost	ATB Advanced	ATB Moderate
Wind low cost	ATB Advanced	ATB Moderate
Siting limited	Limited Access	Reference Access
More distributed PV	190 GW by 2035, 363 GW by 2050	134 GW by 2035, 181 GW by 2050
Demand peak shaving	Top 80 hrs per half-year clipped	Top 40 hrs per half-year
H2 (high and low) price	Higher (\$40/MMBtu) Lower (\$10/MMBtu)	\$20/MMBtu
+ Nuclear SMR + DAC No CCS or new nuclear	Expanded (DAC, nuclear-SMR) Limited (no CCS, no new nuclear)	All except DAC, nuclear-SMR
Climate	Hydro availability from RCP8.5; reduced hydro capacity credit (80%), thermal summer capacity (85%), and transmission summer capacity (95%).	Historical performance
Many challenges	Limited access siting, no CCS and no new nuclear, high H2 costs, climate impacts	See above

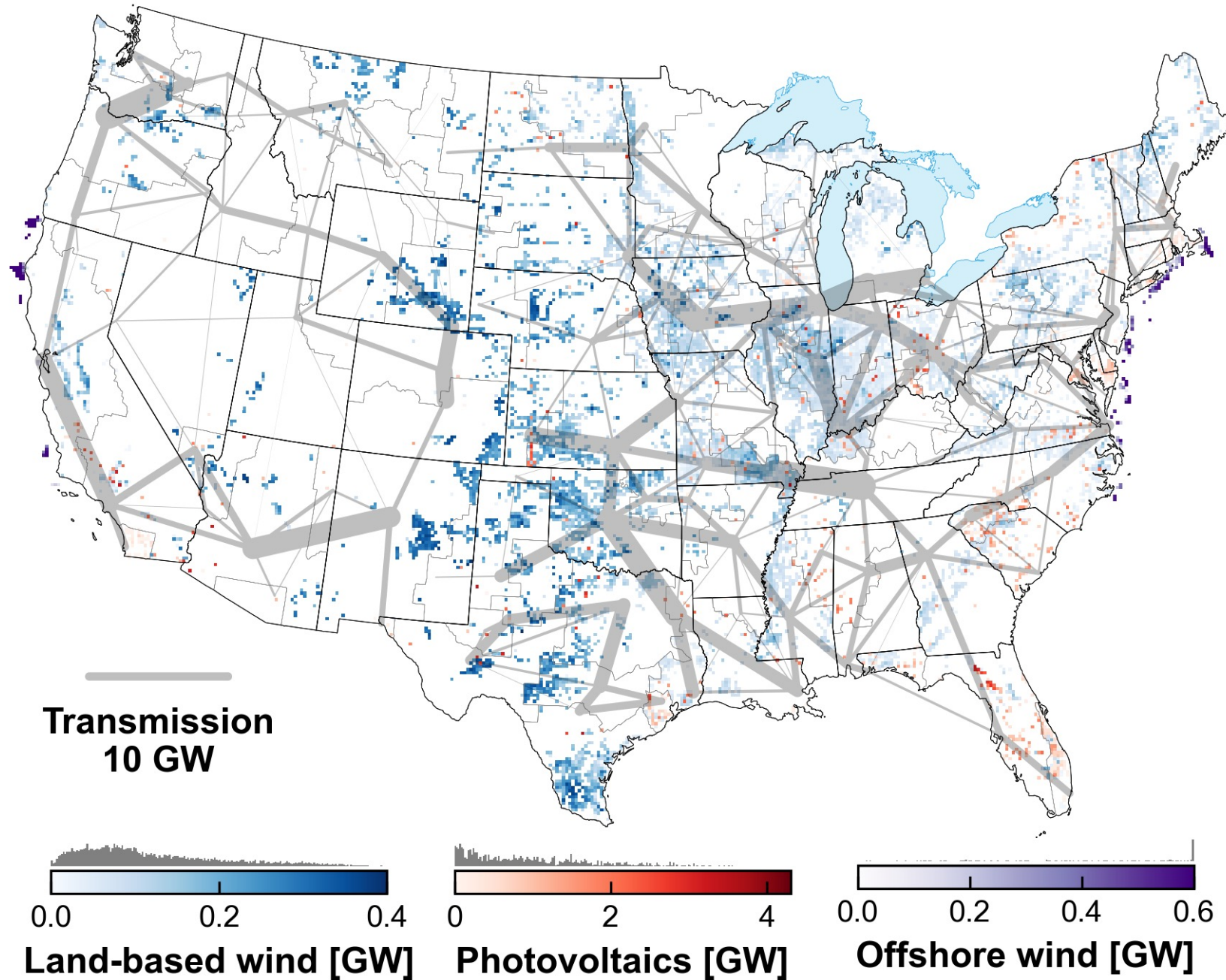
Example CEM Outputs for individual scenarios

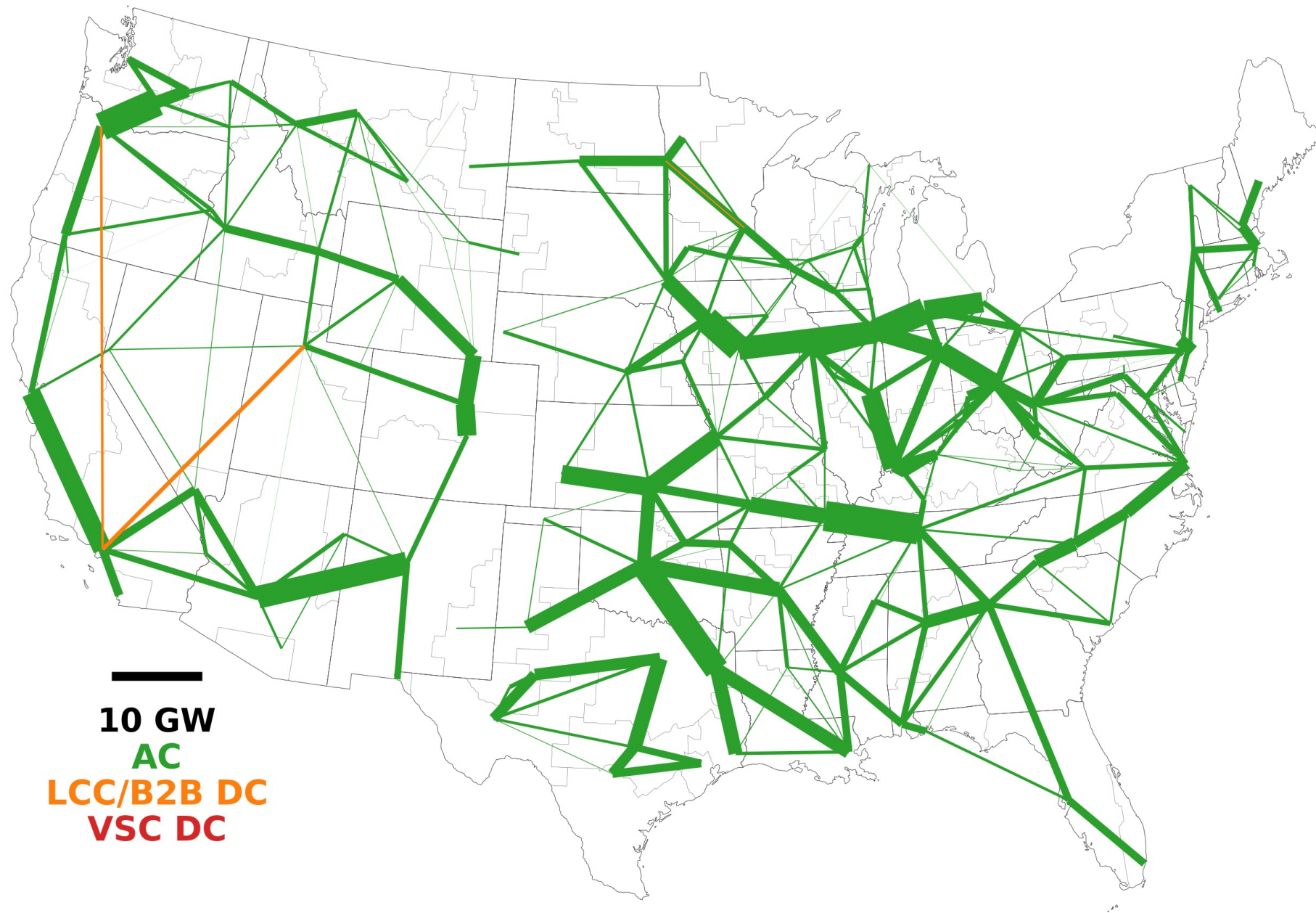






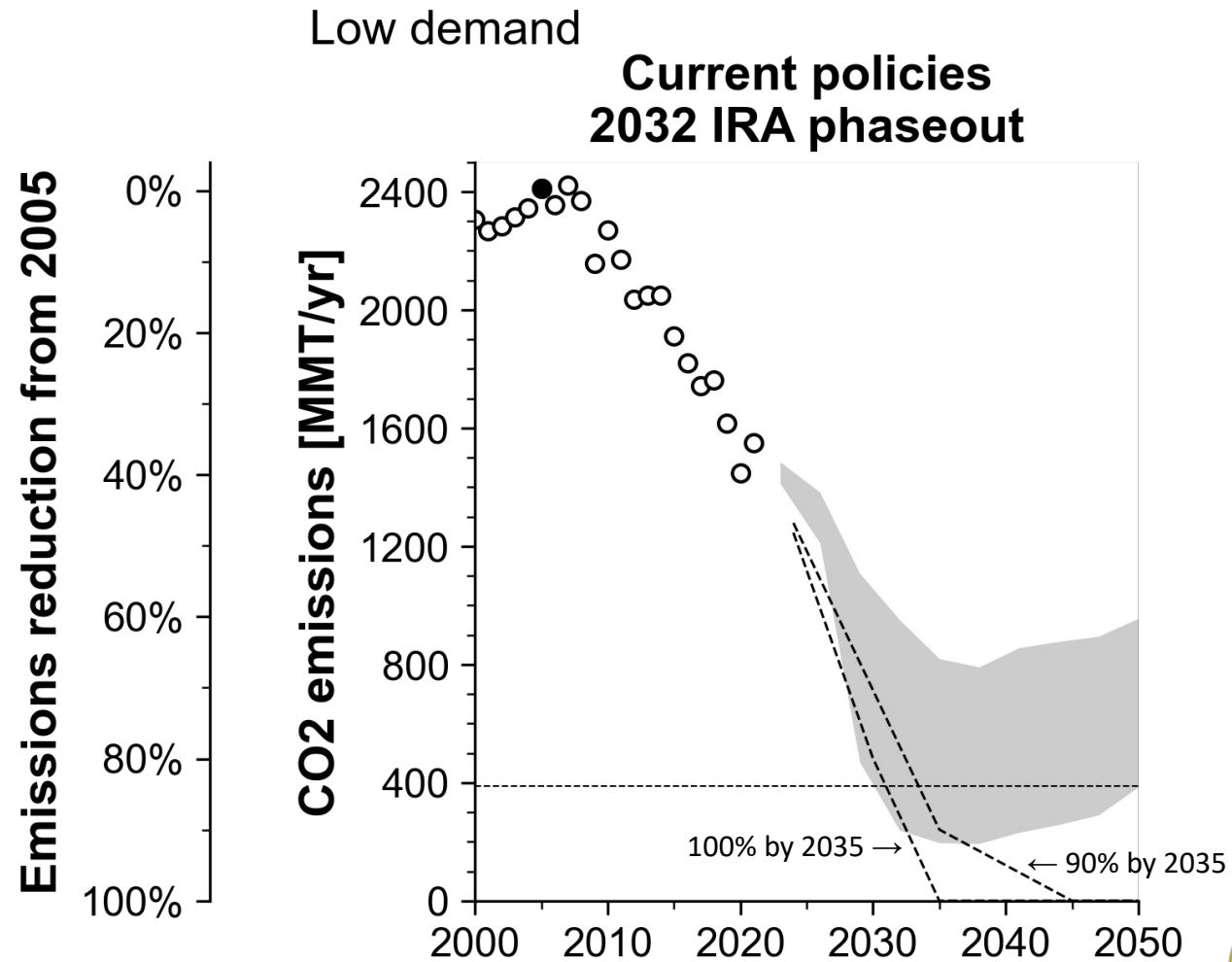






Example Outputs for Comparing Scenarios

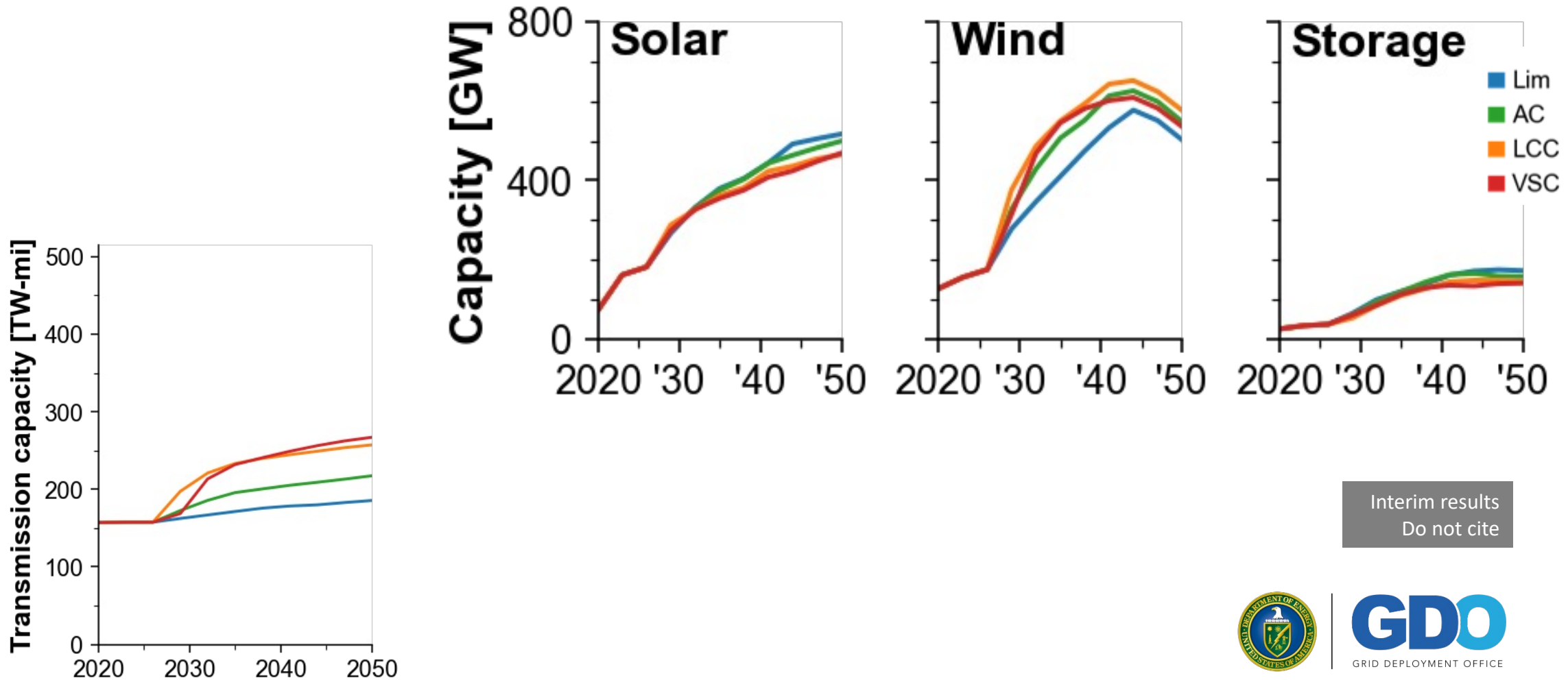
Carbon Emissions



Interim results
Do not cite



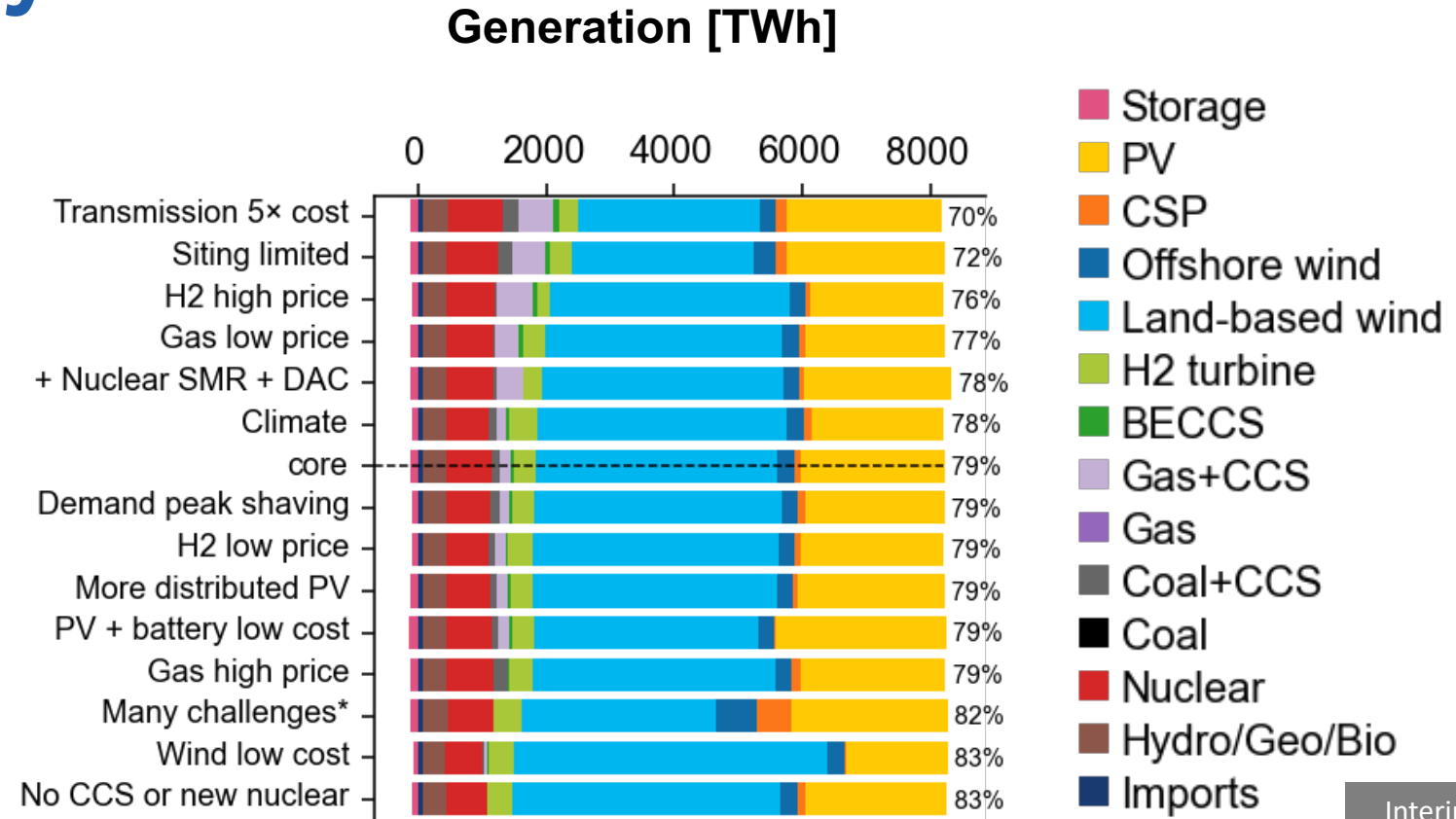
Transmission and Resource capacities by type



Interim results
Do not cite



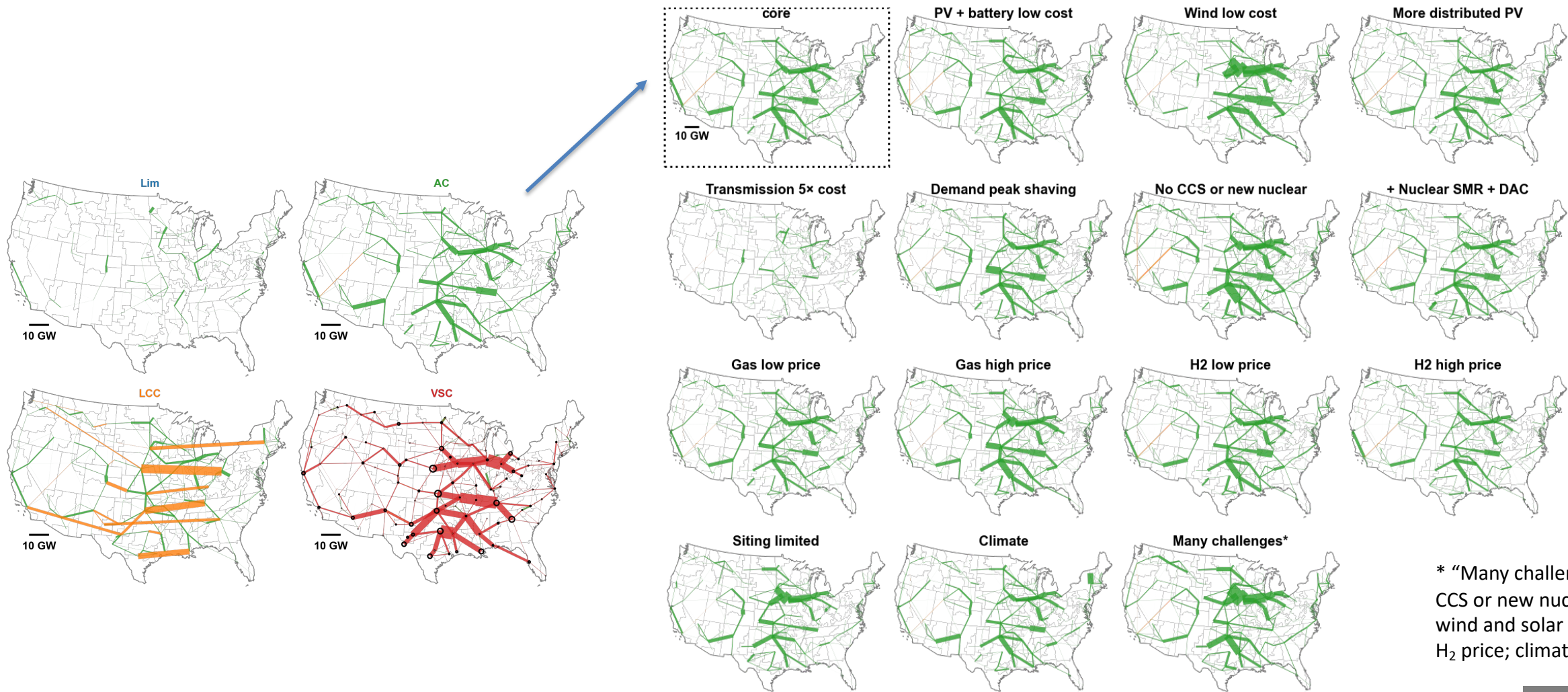
Annual Energy mixes



Interim results
Do not cite

Percent wind+solar energy

Geographic Representation of TX Expansion



* "Many challenges" = No CCS or new nuclear; limited wind and solar siting; high H₂ price; climate