U.S. DEPARTMENT OF
ENERGY
Office of Electricity

National Transmission Planning Study

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Building a Better Grid Initiative

Engagement and collaboration

- States
- Tribal nations
- Stakeholders

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 Grant Program ($3B)
- Grid resilience grants for states, Tribes, and utilities ($10+B)
- Loan guarantee programs

Transmission permitting process

- Streamline of permitting with federal agencies
- Public private partnerships
- Designation of corridors

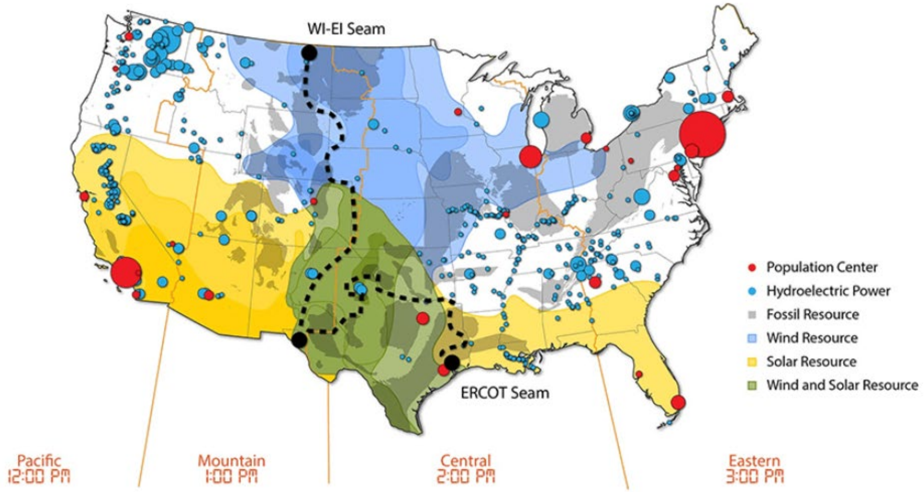
Transmission-related R&D

- "Next generation" electricity delivery technologies
- Supporting activities

Project team

This study is being 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



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North American Energy Resilience Model

Objectives of the study

1. Identify **interregional and national strategies** to accelerate cost-effective **decarbonization** while maintaining system reliability

2. Inform regional and interregional transmission planning processes, particularly by **engaging stakeholders** in dialogue

3. Identify **viable and efficient** transmission options that will provide broad-scale benefits to electric customers

Desired outcomes of the study

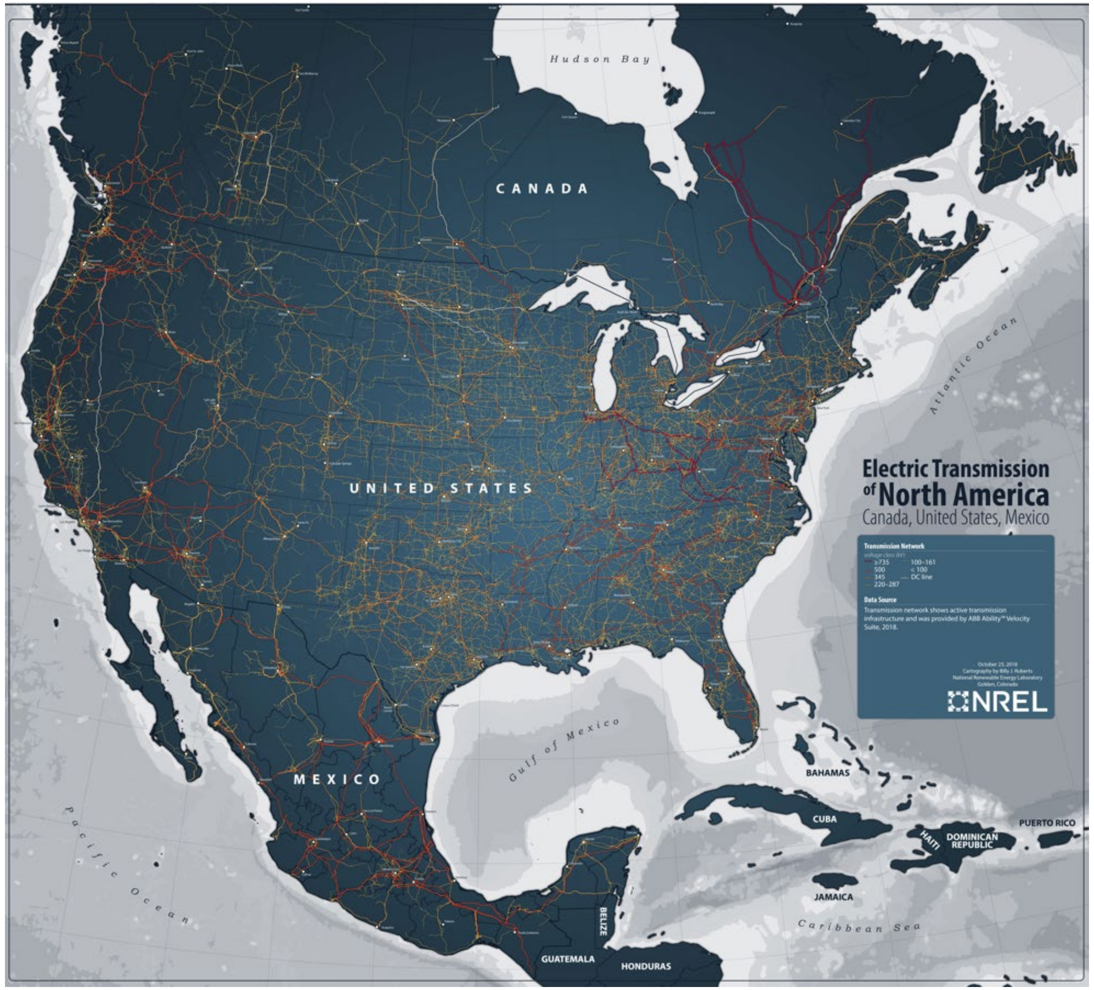
- Results help **prioritize future DOE funding** for transmission infrastructure support
- Results help **fill existing gaps** within interregional transmission planning
- Study provides a framework for stakeholders to discuss **desired grid outcomes** and **address barriers** to achieving them

National Transmission Planning Study Scope

- Baseline analysis
- Scenario analysis
- Public engagement

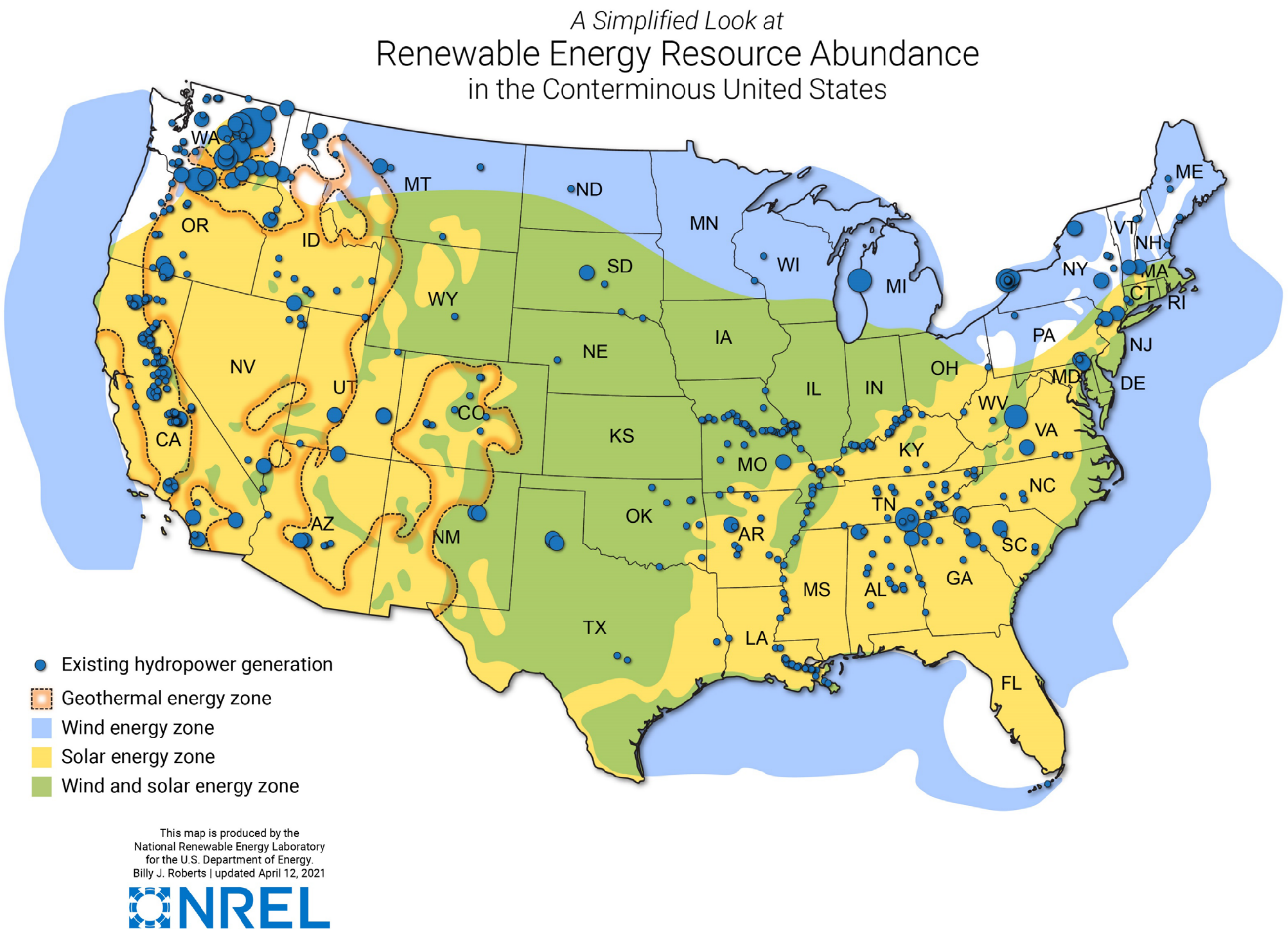
Baseline Analysis: Key Tasks

- Develop database of large, high-probability **transmission projects** likely to be in place by 2030
- Develop a database of power **generation projects** likely to be in operation in 2030
- From the above develop a transmission and power generation **nodal base case**
- Use the nodal base case to **conduct power flow and production cost modeling** for the grid in 2030
- **Answer the question**: How close does the currently-planned 2030 system get to meeting the Administration's 2035 decarbonization goal?



Baseline Analysis: Incorporating Additional Renewables

- Start from Baseline 2030 system
- Add renewable generation to more fully utilize planned 2030 transmission
- **Answer the question**: How close does the currently-planned 2030 system + additional renewables get to meeting the country's 2035 decarbonization goal?



From DOE EERE *Renewable Energy Resource Assessment Information for the United States* (March 2022)

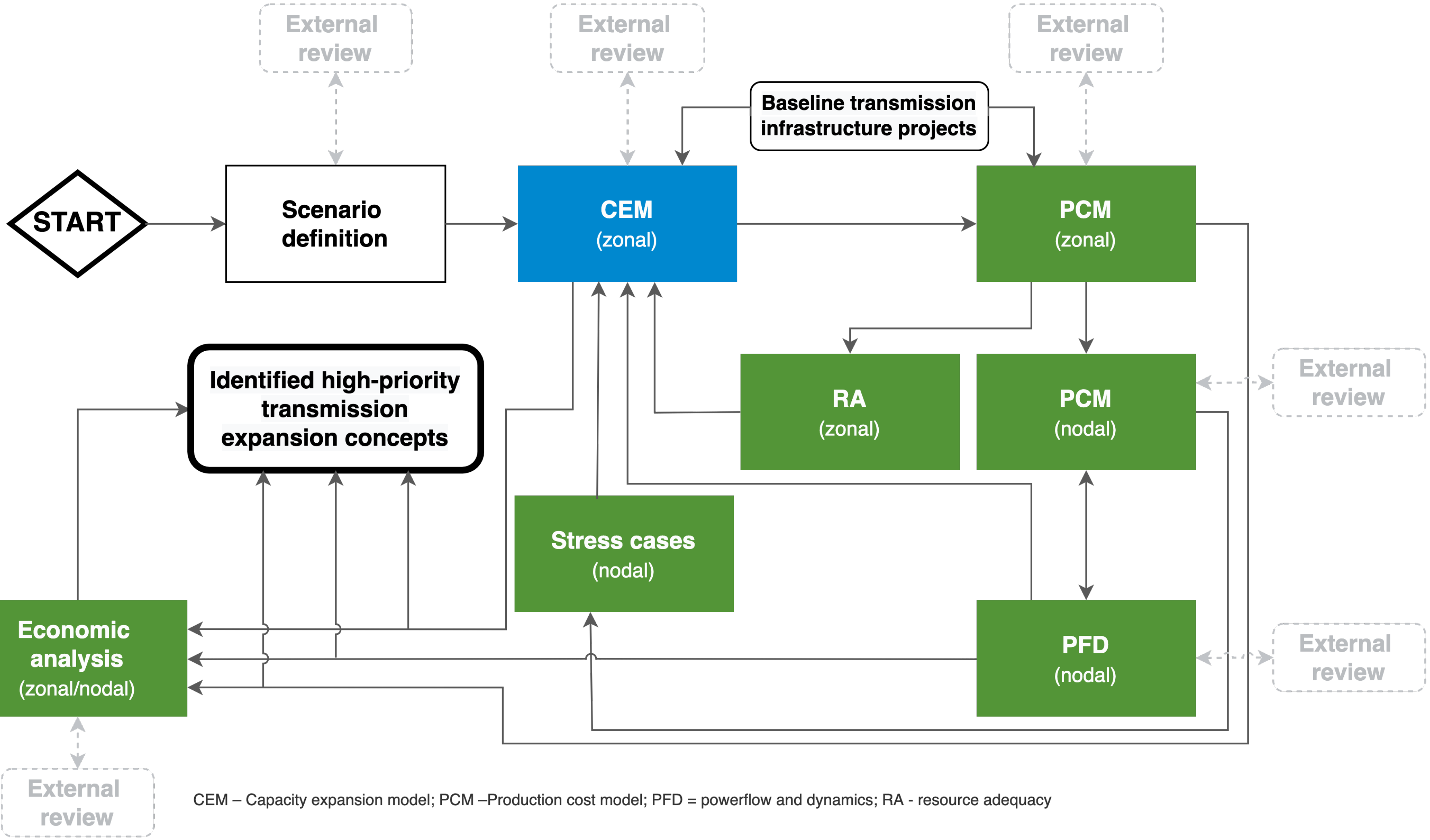
Scenario Analysis: Key Tasks

Define different **scenarios or storylines** to identify potential future generation resources and transmission expansion options

- Conduct **capacity expansion modeling**
  - Independently, identify potential **interregional renewable energy zones**
- Conduct **production cost modeling**
- Conduct **AC power flow** and **dynamic reliability analysis**
- Conduct **economic analysis**
- Conduct **stress case** and **resource adequacy** analysis

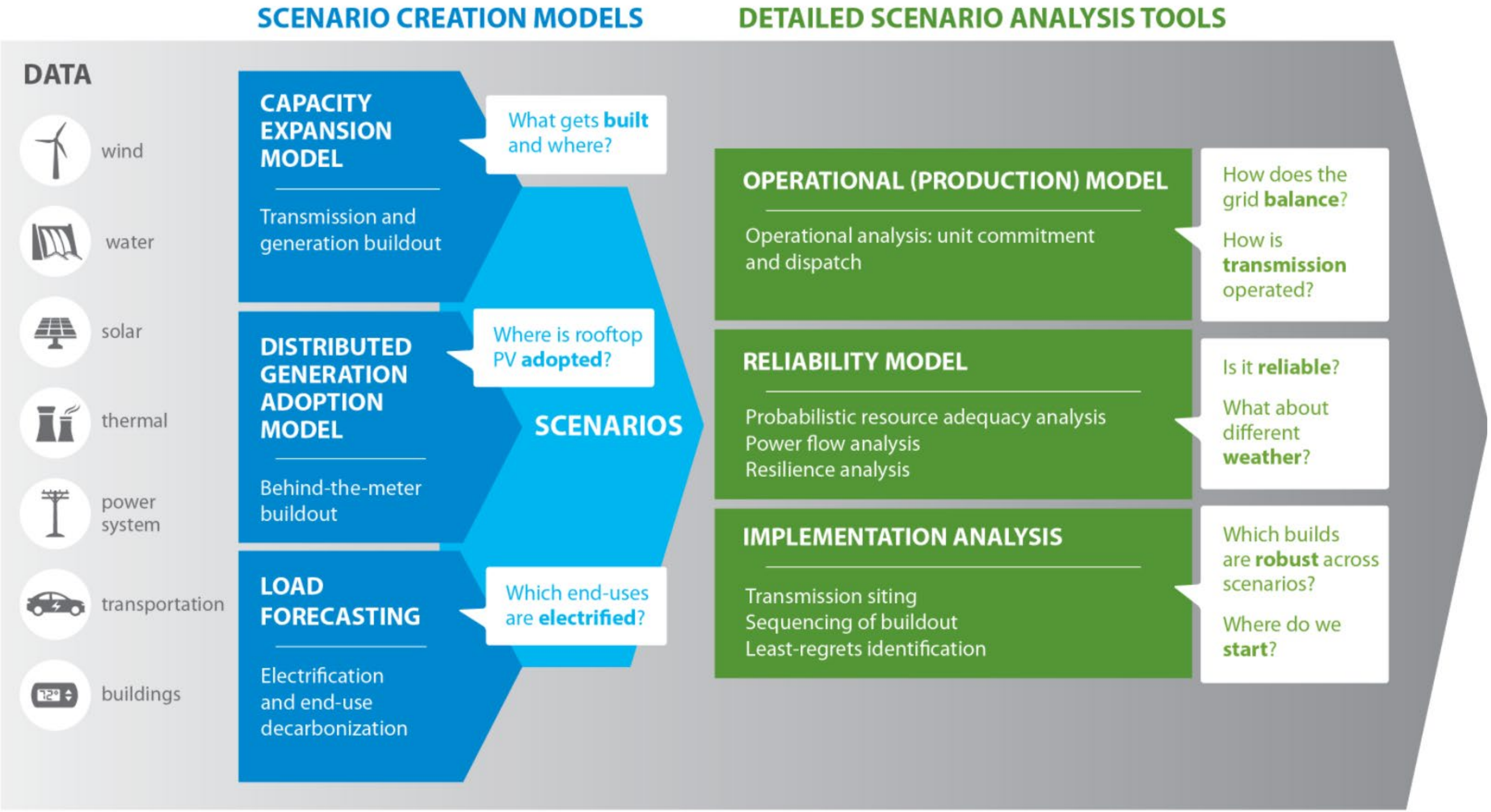
Identify a portfolio of potential transmission options

Scenario Analysis: Key Tasks cont'd



CEM – Capacity expansion model; PCM –Production cost model; PFD = powerflow and dynamics; RA - resource adequacy

Scenario Analysis: Study Plan



Public Engagement: Four Aspects

Public Workshops and Input

- Introduce project and provide updates
- Share interim and final results
- Provide opportunities for public feedback via website

Existing Convenor Groups

- Validate data and input assumptions
- Discuss consistency with groups' existing efforts
- Share project updates and interim results

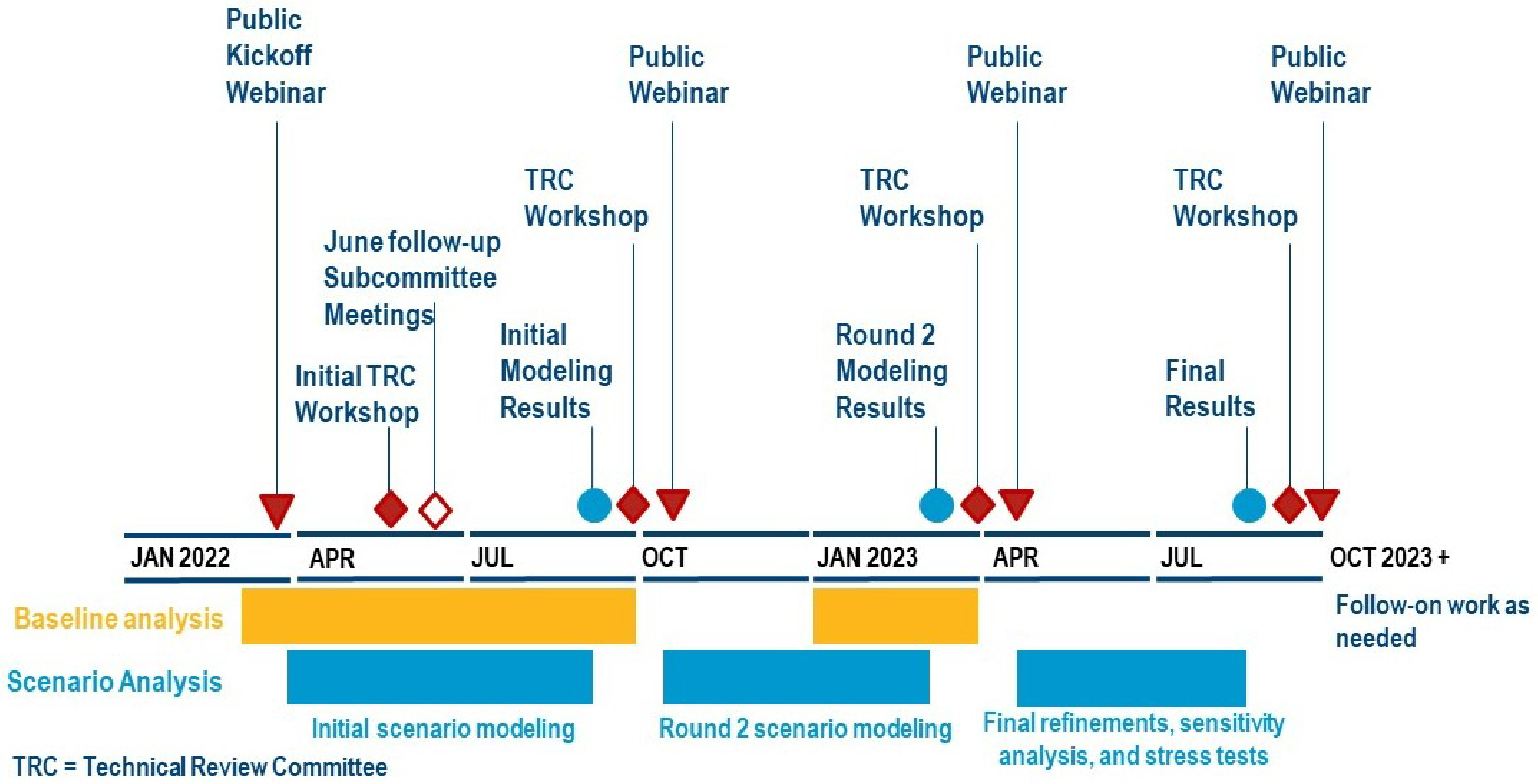
Technical Review Committee

- Provide project input
- Suggest project course corrections
- Review interim results

Tribal Outreach

- Initiate broad outreach to all Tribes
- Invite statements of interest
- Incorporate Tribal input into analysis

Public Engagement: Timeline



A Closer Look

Proposed Scenario Framework

4 transmission topologies

x

9 emissions variants = 3 grid decarbonization X 3 electrification

+

14 sensitivities = 2 emissions variants X 7 other drivers

+

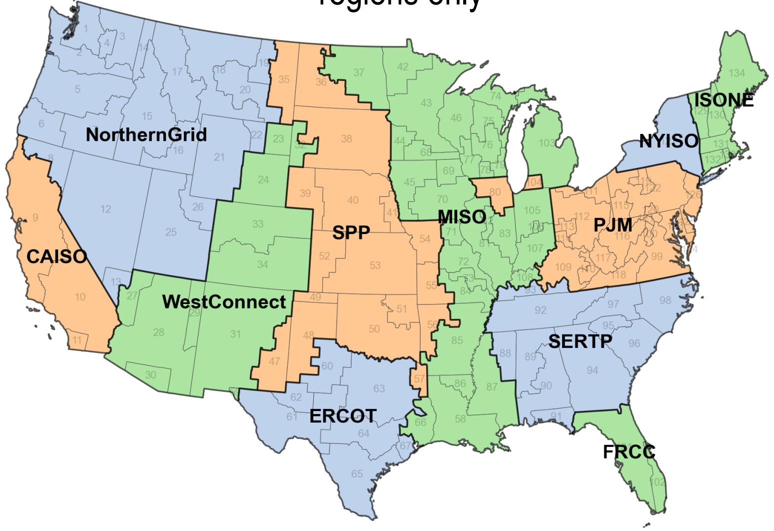
model formulation sensitivities

=

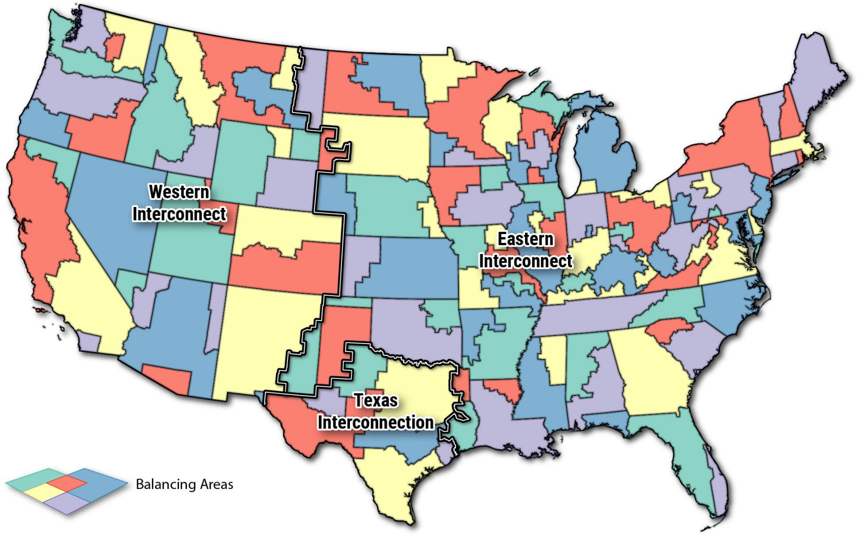
~100 total sensitivities from CEM

4 transmission topologies

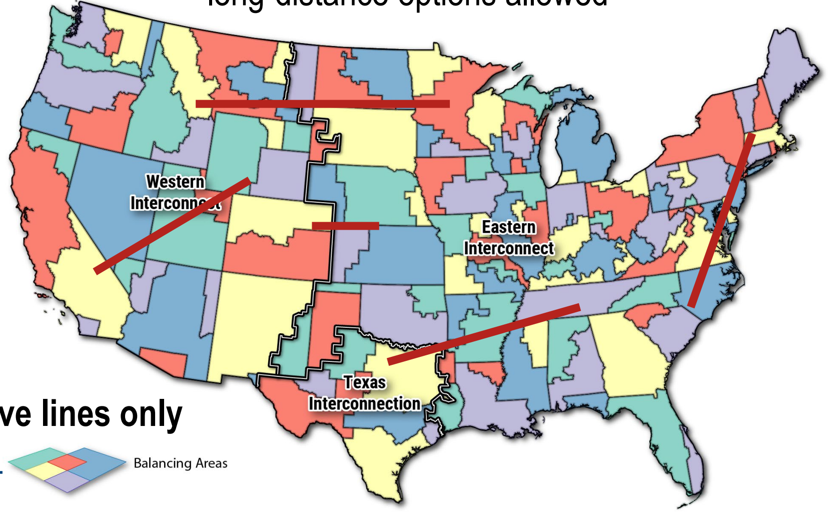
Intra-regional: expansion within 11 transmission planning regions only



Intra-interconnection: expansion between 134 model zones

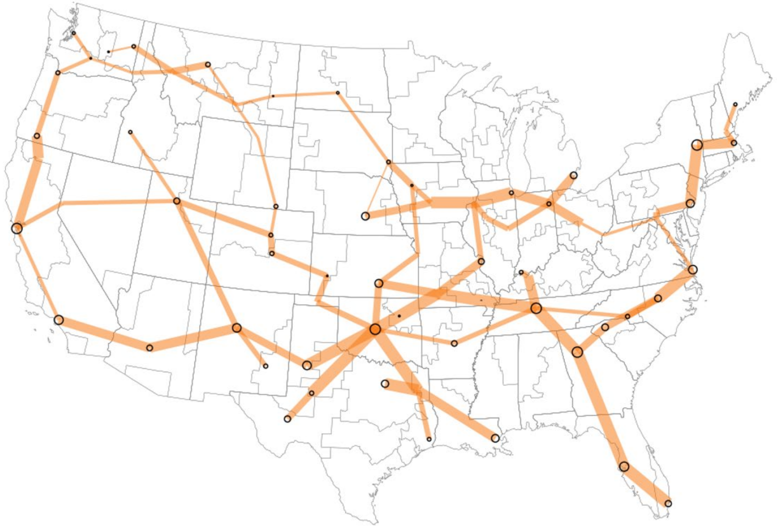


Inter-interconnection: back-to-back DC ties & other long-distance options allowed



Illustrative lines only

Macrogrid: multi-terminal HVDC-VSC



9 emissions variants

Reductions in national electric sector emissions (from 2005 levels =2,400 MMT-CO2)

	Low electrification	**Medium** electrification	**High** electrification
Current Policies Only	X	X	X
80% by 2035, 100% by 2050	X	X	X
80% by 2030, **100% by 2035**	X	X	X

The 7 other drivers

1. **High transmission costs → 2–10x default assumptions**
2. **High distributed PV adoption → 170 GW in 2035 (default = 93 GW)**
3. **Low solar & storage costs → ATB Advanced**
4. **Low wind costs → ATB Advanced**

Default = ATB Moderate (applies to items 3 and 4)

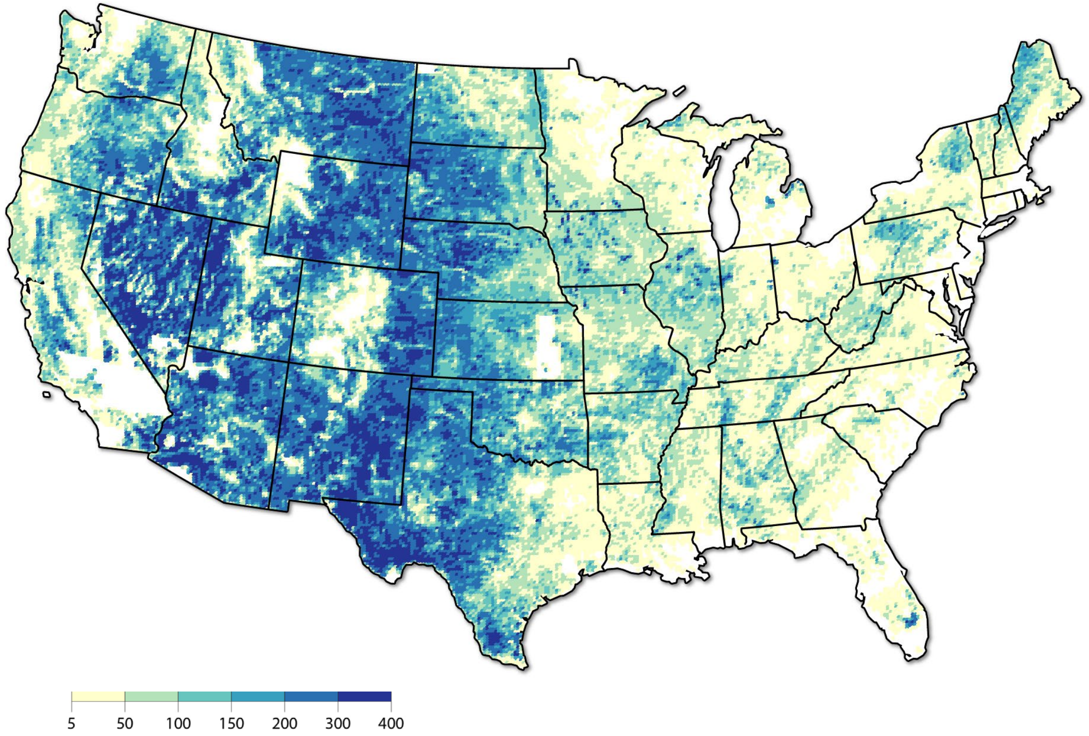
5. **Constrained renewable energy siting → Limited Access *(see next slide)***

…

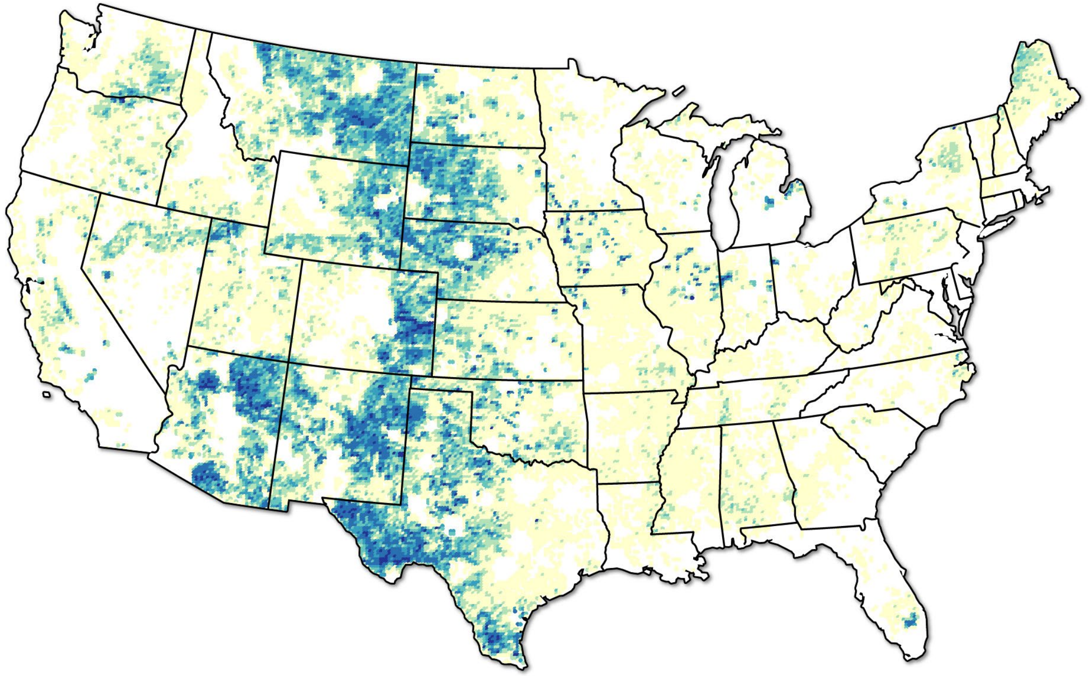
Constrained renewable energy siting

Developable wind resource potential

Default: Reference Access (6.7 TW)



Constrained: Limited Access (2.1 TW)



Standard exclusions: federal, state, and local restrictions; complex terrain; radar, shadow flicker; setbacks to infrastructure (1.1x max tip-height to buildings, roads, railroads, transmission lines); others

Key difference between Constrained and Default is the setback: 3x max tip-height.

The 7 other drivers

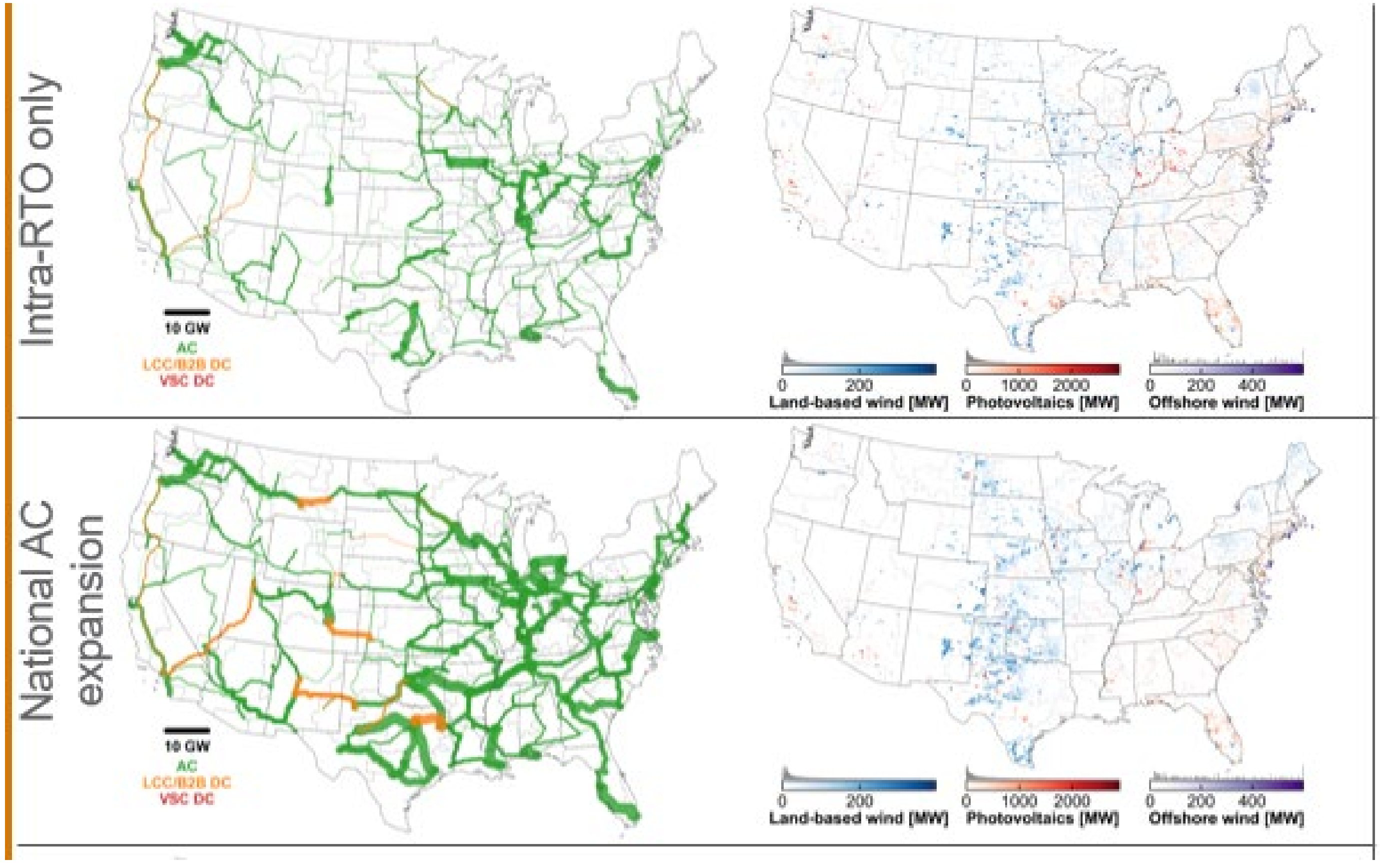
1. High transmission costs → 2–10x default assumptions
2. High distributed PV adoption → 170 GW in 2035 (default = 93 GW)
3. Low solar & storage costs → ATB Advanced
4. Low wind costs → ATB Advanced

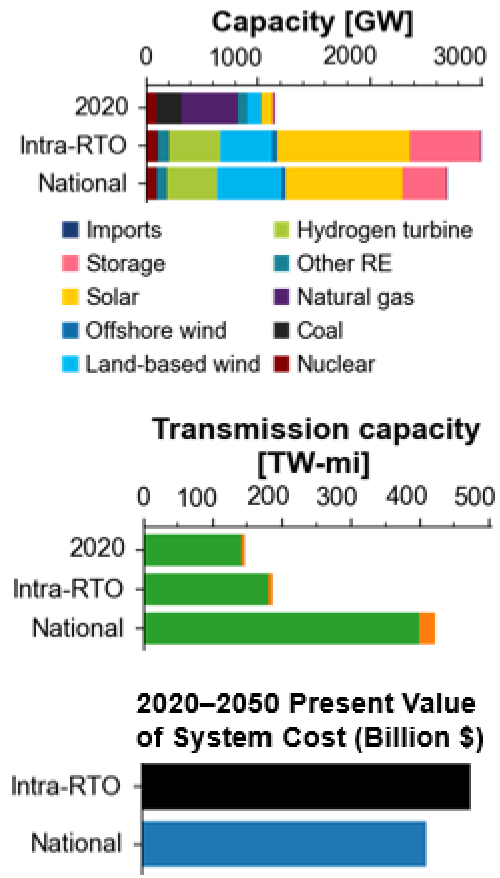
   Default = ATB Moderate (items 3–4)

5. Constrained renewable energy siting → Limited Access *(see next slide)*
6. Limited non-RE techs → no CCS, no new nuclear
7. Expanded non-RE techs → incl. CO_2 removal, nuclear-SMR

   Default allows new fossil CCS and conventional nuclear (items 6–7)

Illustrative examples of how drivers can impact outcomes

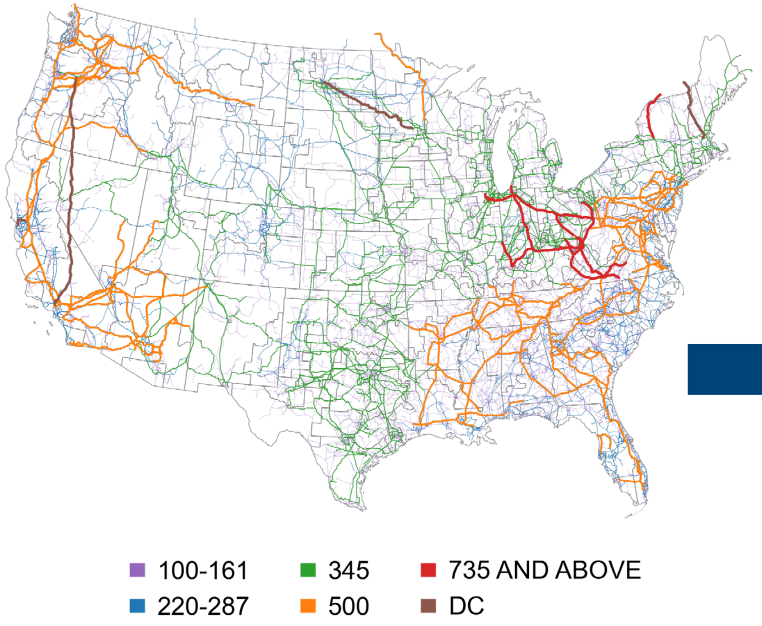




Illustrative modeling results only – do not cite

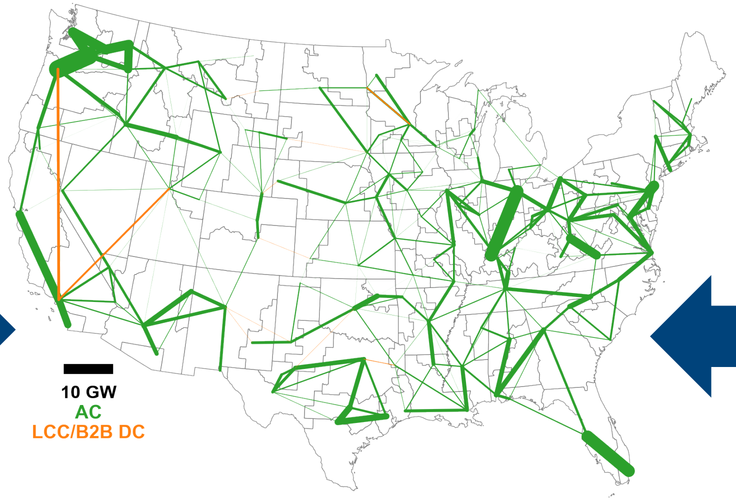
Zonal to Nodal (and vice versa)

Nodal (PCM, PFD)
(industry planning cases with initial transmission infrastructure incl. augmentation)



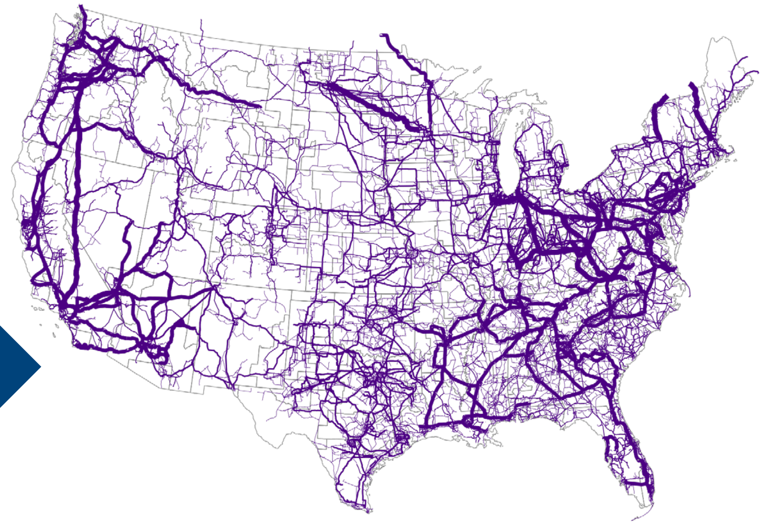
≅**124 000** nodes*
≅**122 000** branches
≅**12 600** generators

Zonal (CEM, RA)
(lines represent transfer capacities between zones)



134 zones
314 branches
≅**8 000** proxy generator technologies

Nodal (PCM, PFD, stress cases)
(expanded transmission infrastructure)



≥**124 000** nodes
≥**122 000** branches
≥**12 600** generators

[1] ≅93,300 nodes in Eastern Interconnection, ≅23,700 nodes in Western Interconnection, ≅7,000 nodes in ERCOT
Information on how zonal representation has been established can be found in Capacity Expansion Modeling in ReEDS. Sources: NREL; EPA eGRID

Discussion

- Does the proposed scenario framework capture the main drivers?
- Recommendations on how to execute zonal to nodal translation?
- Recommendations on how to make actionable findings:
  - What should outputs look like?
  - How can we make the findings understandable by varied audiences?