National Transmission Planning Study

Modeling Subcommittee Meeting

June 7, 2022

Project Overview

Objectives of the study

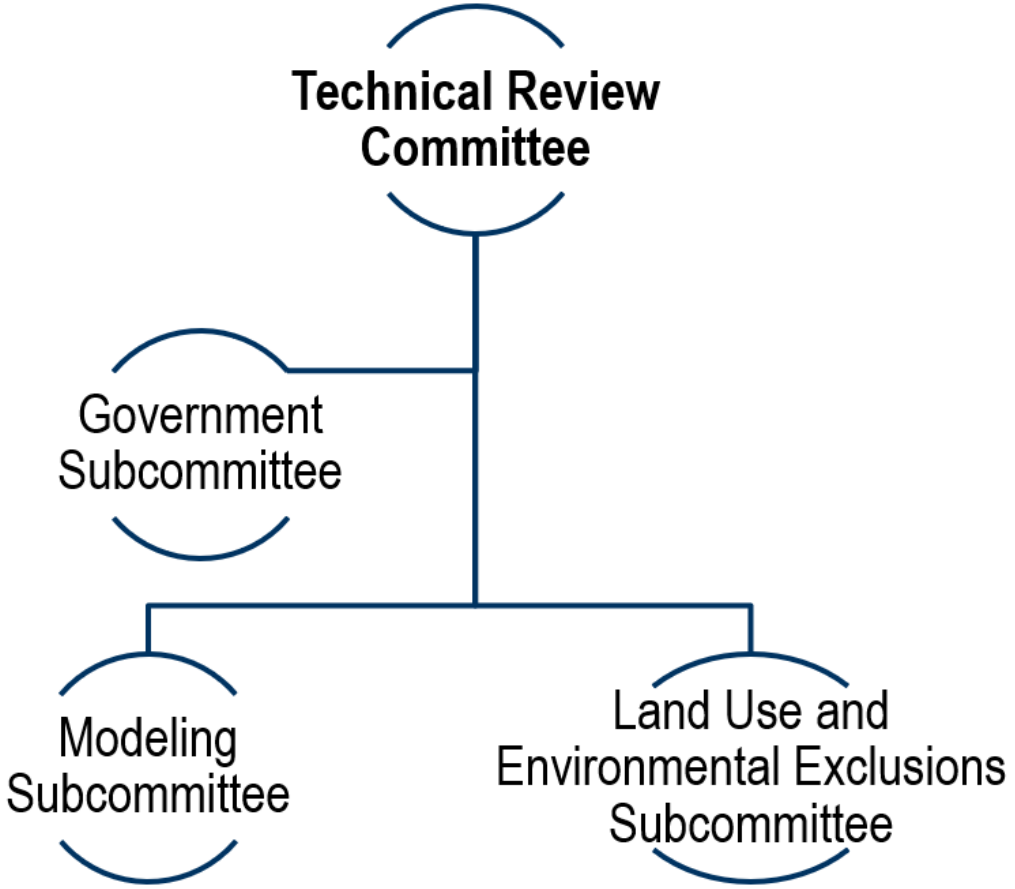
1. Identify interregional and national strategies to accelerate cost-effective decarbonization while maintaining system reliability

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

Technical Review Committee

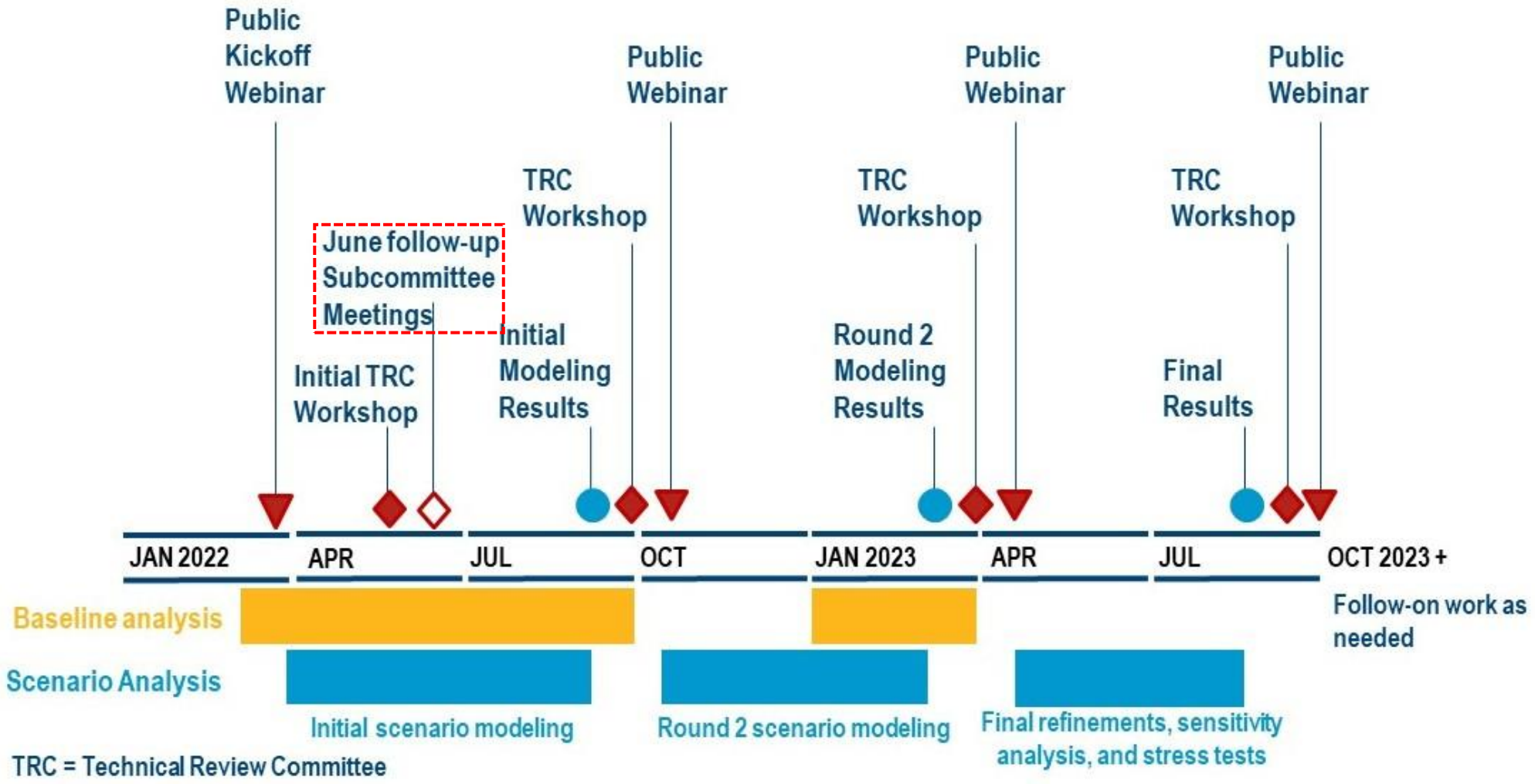
- **Technical Review Committee** (TRC) will constructively scrutinize and review the overall project and, where needed, will provide a forum for integrating input from all three subcommittees.
- **Government Subcommittee** will provide feedback on how to reflect federal and state policy and regulatory issues in the analysis.
- **Modeling Subcommittee** will provide technical feedback on assumptions, modeling, and data.
- **Land Use and Environmental Exclusions Subcommittee** will provide feedback on generalized issues related to constraints on locating new transmission and generation.



Follow-up June subcommittee meetings

- Follow-up June subcommittee meetings will provide an opportunity for smaller-group dialogue and questions based on material presented during the May 20 TRC meeting
  - **Modeling Subcommittee** – today
  - **Government Subcommittee** – June 10th from 12:00 to 2:00 p.m. Eastern
  - **Land Use and Environmental Exclusions Subcommittee** – June 24th from 12:00 to 2:00 p.m. Eastern
- Future TRC meeting information will be posted on the public project website: https://www.energy.gov/oe/national-transmission-planning-study

Public Engagement: Timeline



Baseline

Approach for Developing Baseline Cases

Cases	Name	Description
Case 1	Industry Planning Case	WECC 2030 ADS/ MMWG 2031
Case 2	Baseline Transmission Case	Industry Planning Case + new base Transmission Lines
Case 3	High Renewables Industry Case	Case 1 + New Renewables • Identify substations with large retirements • Use queue information to identify regions with high developer interest • Use transmission loading results from Case 1 to identify underutilized transmission
Case 4a	High Renewables only using Baseline Transmission	Case 2 + Renewable additions maximizing the use of new base transmission • Use information from developers about any proposed wind and solar capacity to be added associated with the line • Use transmission loading results from Case 2 to identify additional capacity to utilize baseline projects. This case will show us the additional achievable decarbonization due to the new base transmission lines
Case 4b	High Renewables using Baseline Transmission +High Renewables Industry Case	Case 4a + Case 3 This case will show us the highest potential achievable decarbonization

Select items from TRC feedback received to date

Data sets to be used

Baseline Transmission Criteria

- Line length and voltage requirement
- Criteria for Advanced Development Stage
- Power flow / dynamic data availability

Approach

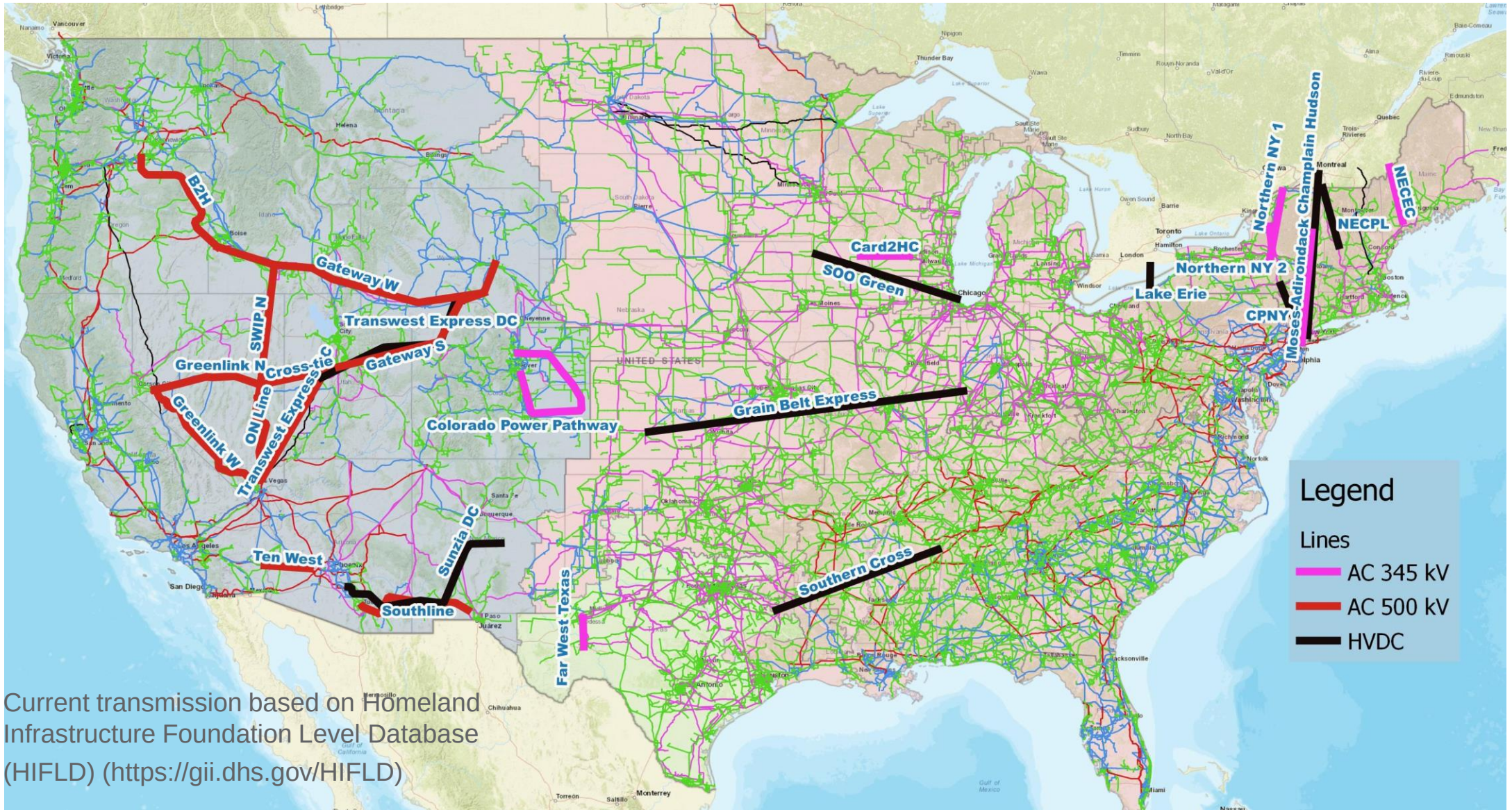
- Methods for new wind and solar additions
- Solar vs. Hybrid solar+storage project

Open discussion for other feedback

TRC Feedback: Baseline Transmission - Selection Criteria

- We only considered large transmission projects that are 345KV or above and at least 70 miles in length
- Projects were screened based on meeting **two** or more of the following criteria:
  1. New Line construction or rebuild of an existing line is underway. (multi-phase/segments projects), starting in one segment, does not guarantee the build of the second segment)
  2. New line developers are in active communications with FERC Order 1000 entities and are providing transmission line visibility/impact studies and PFM data.
  3. Developers actively / successfully acquiring federal and/or state permits
  4. Developers actively / successfully securing power purchaser commitment for proposed lines (load-serving entities, power trade in RTO, state energy commission approvals for Regulated utilities)
  5. Developers actively / successfully engaging public to address concerns and gain acceptance
- Availability of lines Power Flow data and dynamic data for HVDC is a must, we are not developing such models from scratch

Baseline transmission projects at advanced development stage



Current transmission based on Homeland Infrastructure Foundation Level Database (HIFLD) (https://gii.dhs.gov/HIFLD)

Most of them have the objective of connecting renewable resources with load centers

TRC Feedback: Methodology for how much RE will be added

- Reliability-limited: Requires contingency analysis to test for line overloading in case of new transmission line outage
- Economically-limited: which may be a tighter constraint than is reliability constraint.
  - ***Criterion***: if wind/solar capacity - last added - is curtailed above a threshold of potential annual generation. We suggest threshold to be set to 5%-20%
- Question:
  - What is a plausible threshold for curtailment at which wind/solar capacity becomes uneconomical?

TRC Stated: “It makes sense if extensive storage is added along with new wind and solar” in the Baseline

- Yes, recently new solar capacity (bulkpower-sized) has energy storage with 50% of the solar nameplate with energy duration of up to 4 hour
- Rather than adding more sensitivity analyses to the Baseline, we feel that such sensitivity analysis is more meaningful to be added to the Scenario Analysis, when we are looking at zero-carbon generation mix.

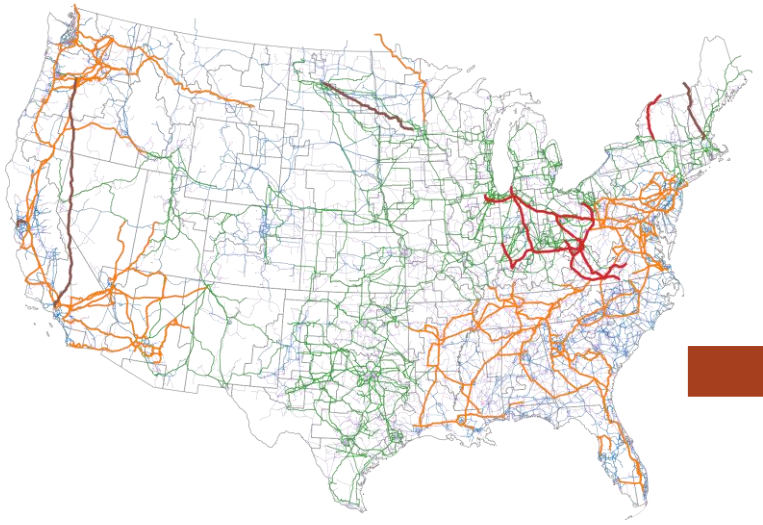
Model Linkages

If the reasons/drivers for zonal to nodal translation are not sufficiently comprehensive and clear, can you provide others?

Zonal to nodal (and vice versa) - What are the benefits and drawbacks?

Nodal (PCM, PFD)

(industry planning cases with initial transmission infrastructure incl. augmentation)



100-161 345 735 AND ABOVE
220-287 500 DC

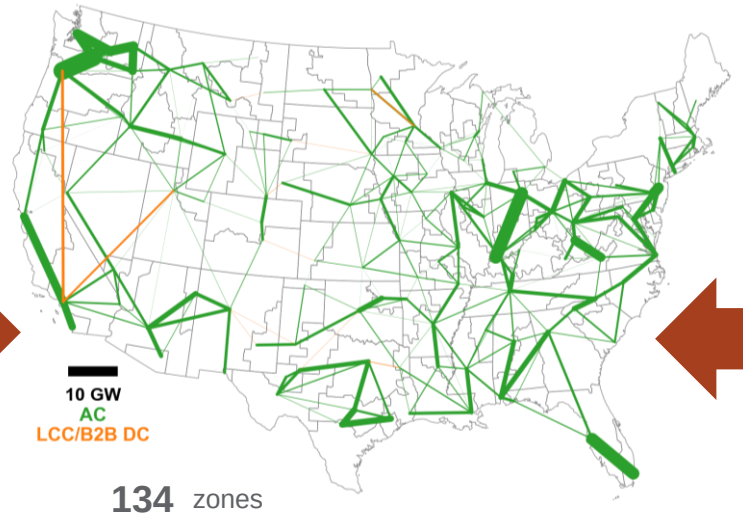
≅109 000 nodes*

≅137 000 branches

≅12 600 generators

Zonal (CEM, RA)

(lines represent transfer capacities between zones)



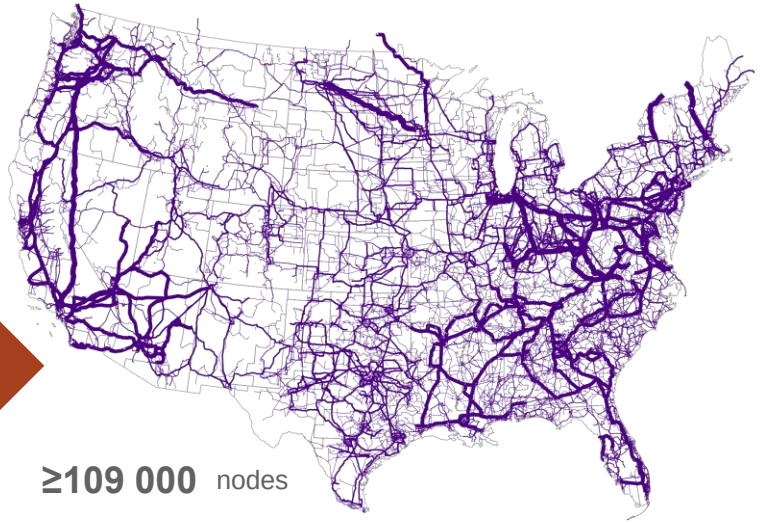
134 zones

314 branches

≅8 000 proxy generator technologies

Nodal (PCM, PFD, stress cases)

(expanded transmission infrastructure)



≥109 000 nodes

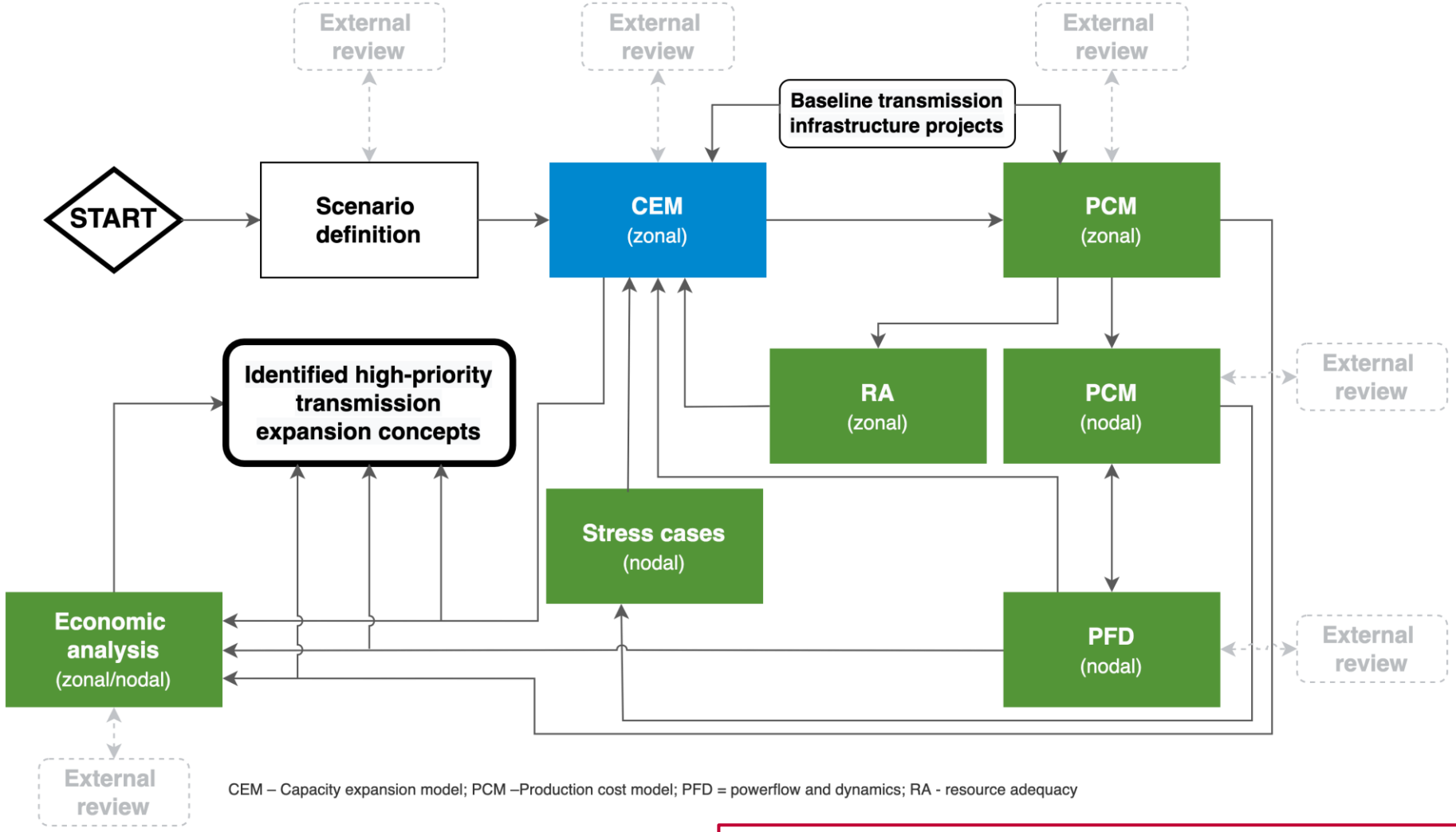
≥137 000 branches

>12 600 generators

- **Increased model fidelity and insights**
- **Inter-zonal transmission congestion and expansion needs (incl. transit)**
- **Intra-zonal transmission congestion and potential investments/upgrades**
- **Enabling more seamless dataflow between models (PCM and PFD)**

[1] Eastern Interconnection: ≅78.6k nodes & ≅99.2k branches, Western Interconnection: ≅23.7k nodes & ≅29.2k branches, ERCOT: ≅7k nodes and ≅9k branches; Information on how zonal representation has been established can be found in Capacity Expansion Modeling in ReEDS. Sources: NREL; EPA eGRID; HIFLD

NTPS workflow links a range of data, models and methods with periodic review



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

What further linkages between models are important to consider?

What additional data/information for zonal to nodal conversion would be necessary or useful (other categories, other items)?

What can be utilized from zonal to nodal translations?

Item	Data source	(S)tatic/(D)ynamic*
Economic		
Investment and operations costs	NREL ATB	D
Losses estimation	CEM/PCM/PFD	D
Demographic		
Population density	EFS	S
Electrification level	EFS	D
DER adoption	dGen	D
Siting		
Nodal export capacity	PCM/PFD (nodal), heuristics	D
Environmental constraints[1]	Numerous	S
RE specific: Resource availability, locations	NSRDB/WIND (reVX)	D
Thermals: Efficiency, fuel availability, decommissioning (technology)	EIA	(except decom.) S
Technical/Engineering		
Topology	NARIS/MMWG/ADS	D
Voltage level	NARIS/MMWG/ADS	S
Utilisation metrics and thresholds[2]	PCM (nodal)	D
Known and new critical contingencies (thermal limits, stability limits)	PFD (nodal)	D
Operational constraints from powerflow/dynamics[3]	PFD (nodal)	D

* (S)tatic/(D)ynamic – indicates unchanging/changing across scenarios

[1] Land-use, protected areas, urban settlements, existing infrastructure; [2] Lines/corridors, transformation capacity); [3] At increased RE penetration levels.

A list of acronyms and abbreviations is available at the end of the presentation.

Selected items from TRC feedback – Model linkages

Zonal to nodal drivers

- More industry trust/confidence in findings
- Increased granularity on specific transmission metrics (utilization, congestion)
- Transmission contingency/stability requires nodal

Model linkages

- Ideal - All modelling domains nodal
- Note on integrated modelling frameworks to avoid risk of model translation/data processing inefficiencies and errors
- Forward looking climate-based stress cases (not just historical events) and integration with PFD
- Potentially feedback newly identified transmission expansion concepts into CEM
- Suggestion to focus on end-points (100% clean electricity) for nodal
- Inclusion/consideration of distribution networks

Data/information between models

- Skepticism of heuristics - parametrization of key input variables to capture uncertainty
- Use of zonal risk metrics to inform when/where to undertake further nodal analysis (CONUS vs regional focus)
- Methodology for the zonal-to-nodal translation process
- Visualisation of outcomes for interpretation and sharing
- Further elaboration and detailed listing of “Environmental constraints”
- EJ screen overlay e.g. EPA EJ Screen

Scenario Framework

Clarifications

- Transmission, generation, storage are co-optimized.
  - Transmission is an output of the model. Topologies represent constraints applied to transmission (e.g., inter-regional or not)
  - Onshore and offshore wind deployment levels are outputs of the model
- Carbon constraints and electrification levels are not forecasts
- CEM is zonal (134 zones) only, but zonal-to-nodal linkage process is part of the study.
- Grid-enhancing technologies are not part of CEM but will be considered in the study
- Retirements: announced, age, and economic
- Demand assumptions and coordination with other studies (AOWTS)

Capacity expansion modeling: 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

=

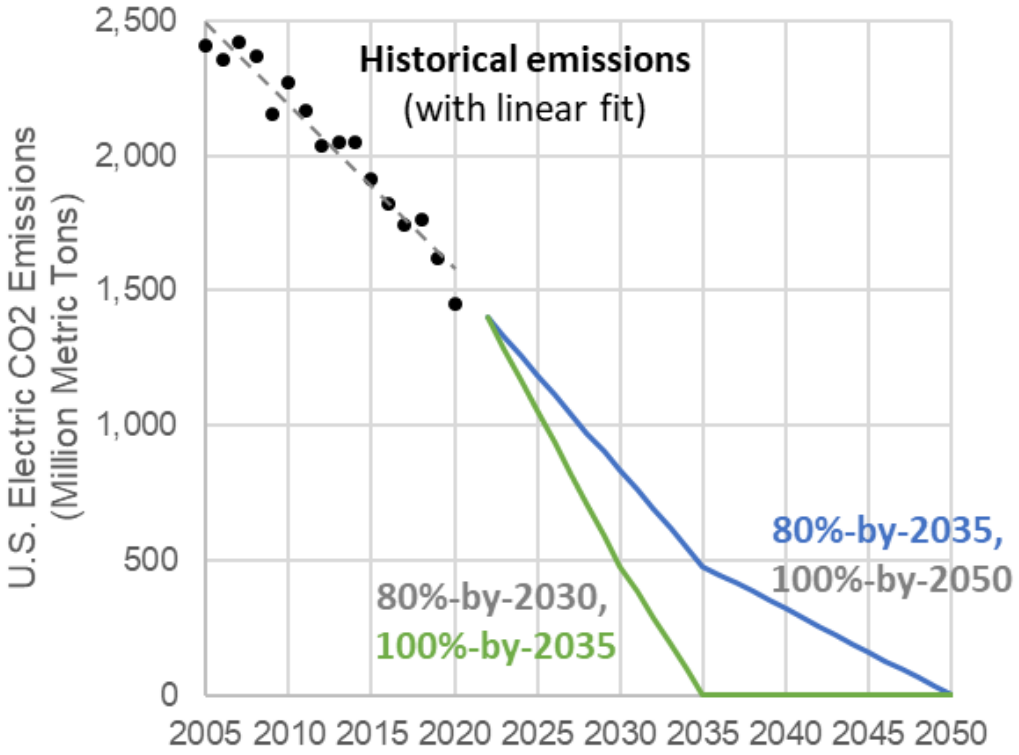
~100 total sensitivities from CEM

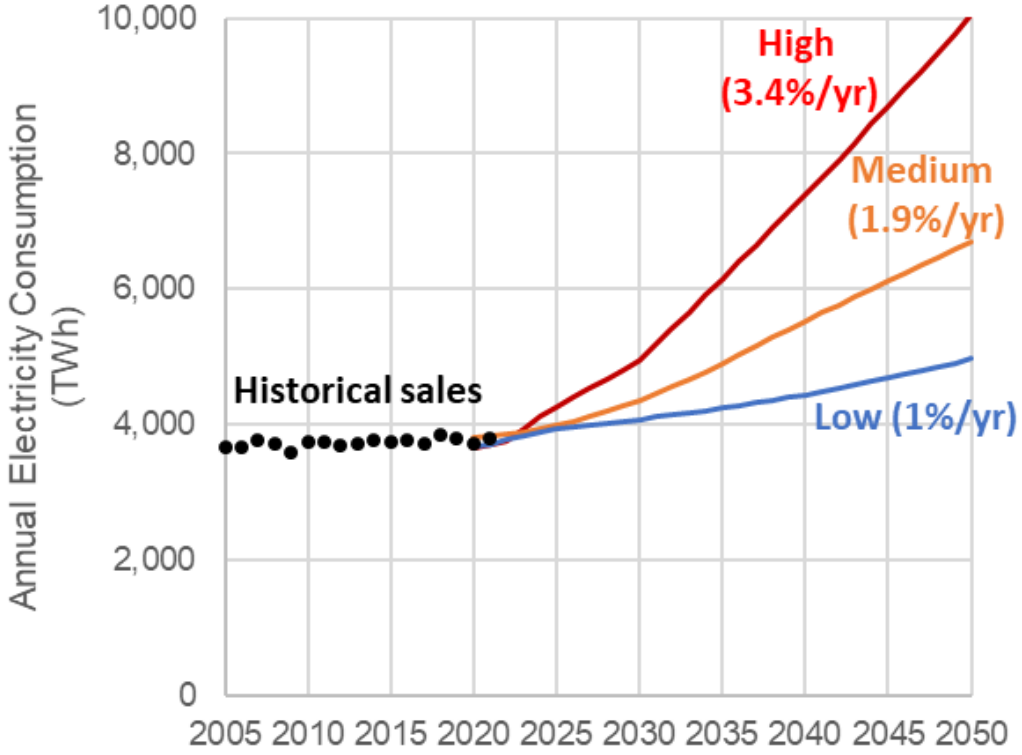
1. High transmission costs → 2–10x default assumptions
2. High distributed PV adoption → 170 GW in 2035 (default = 93 GW)
3. Low solar & storage costs → ATB Advanced
4. Low wind costs → ATB Advanced
5. Constrained renewable energy siting → Limited Access *(see next slide)*
6. Limited non-RE techs → no CCS, no new nuclear
7. Expanded non-RE techs → incl. CO_2 removal, nuclear-SMR

Does the proposed scenario framework capture the main drivers relevant for national transmission planning? Are there any missing or extraneous drivers?

9 emissions variants = 3 grid decarbonization X 3 electrification

Emissions and electrification assumptions



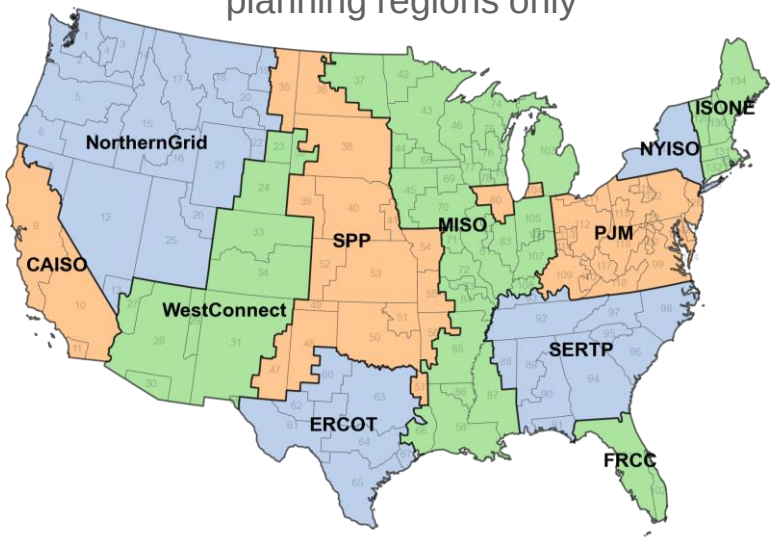


Do the range of assumptions appropriately bound expectations - especially within the lens of decarbonization? Reactions to the electrification and demand growth assumptions would be most helpful.

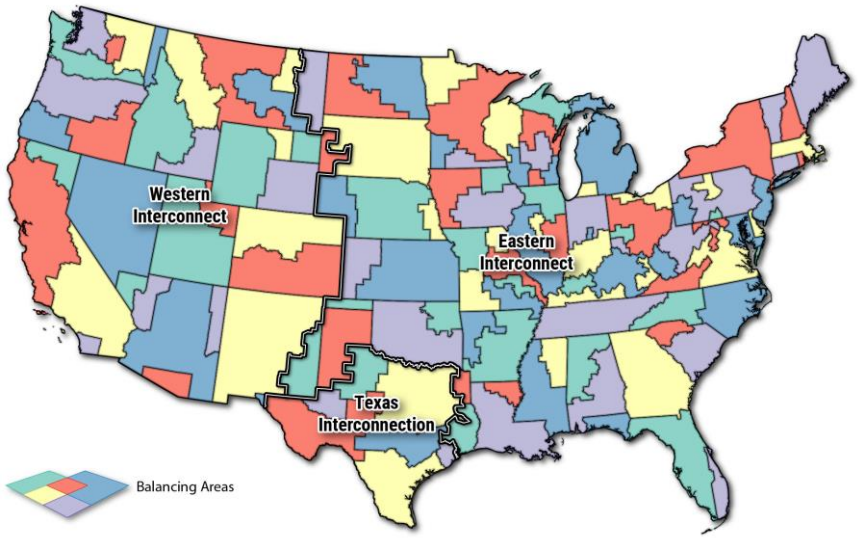
4 transmission topologies

Are there specific variations to the transmission topologies that should be prioritized?

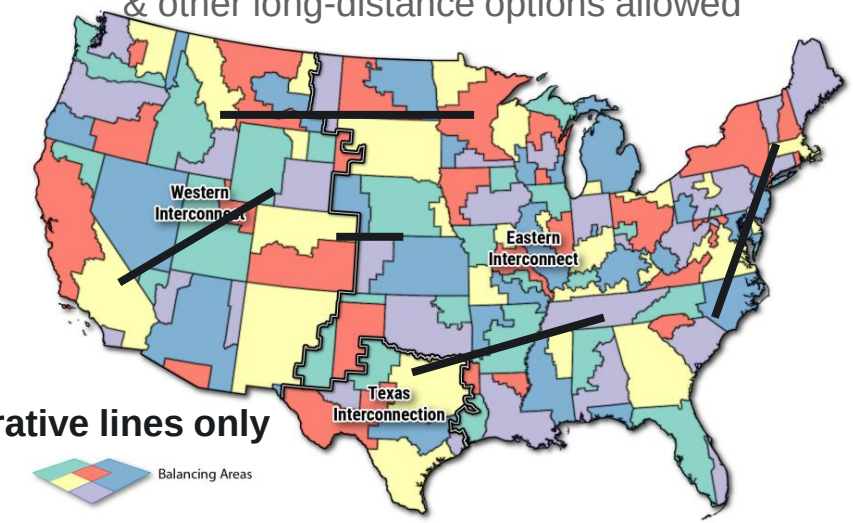
Intra-regional: expansion within 11 transmission planning regions only



Intra-interconnection: expansion between 134 model zones

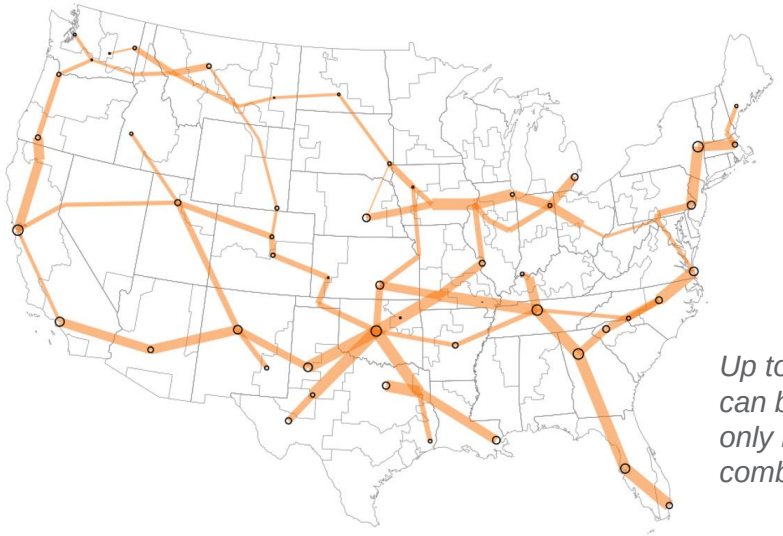


Inter-interconnection: back-to-back DC ties & other long-distance options allowed



Illustrative lines only

Macrogrid: multi-terminal HVDC-VSC



Up to 3 additional variations can be tested, but plan to only run ~4 across the full combinations of scenarios

Select items from TRC feedback received to date

Scenarios and sensitivities

- Demand-side flexibility and distributed resources
- Reserve margin and extreme weather
- Fuel price variations
- Energy justice (generator and transmission siting)
- Clean gas
- Low-cost storage
- Constraints on new transmission due to siting and environmental challenges

Range of parameters

- 100% by 2035 and high electrification may be ambitious

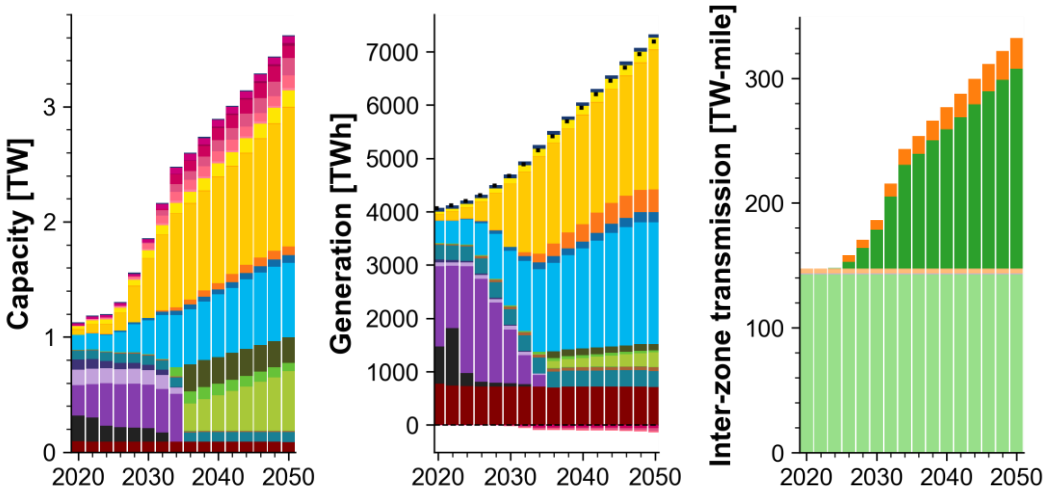
Transmission topologies

- More constraints on intra-regional expansions
- Trade-offs between inter- vs. intra-regional transmission
- Prioritize inter-interconnection and macrogrid, less interest in intra-interconnection one

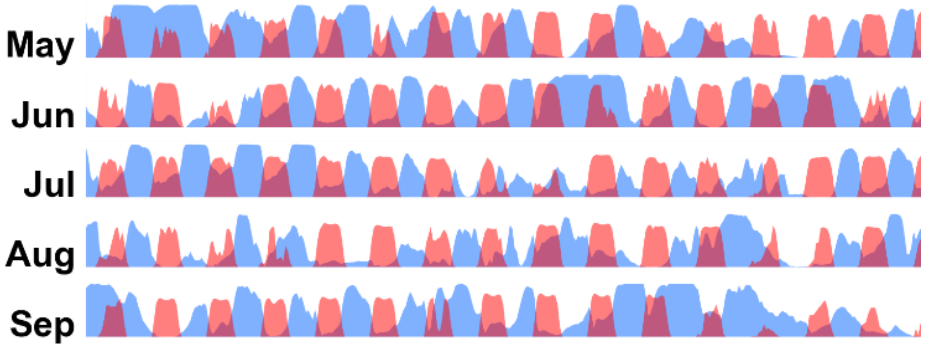
Capacity Expansion Modeling

ReEDS: Key Takeaways

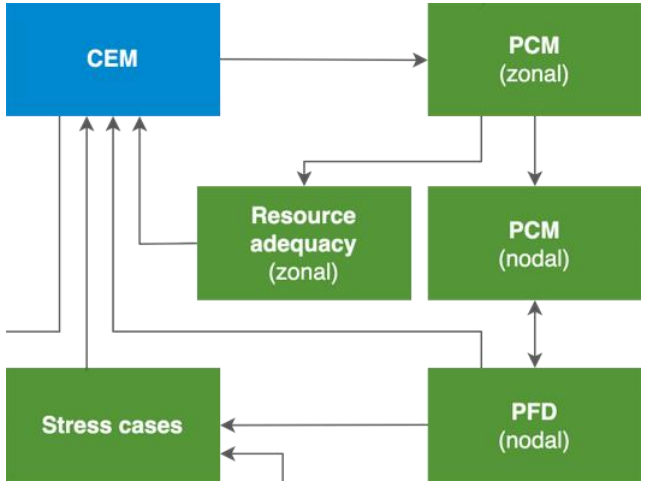
Co-optimizes generation, storage, and transmission capacity nationwide over the next 3+ decades



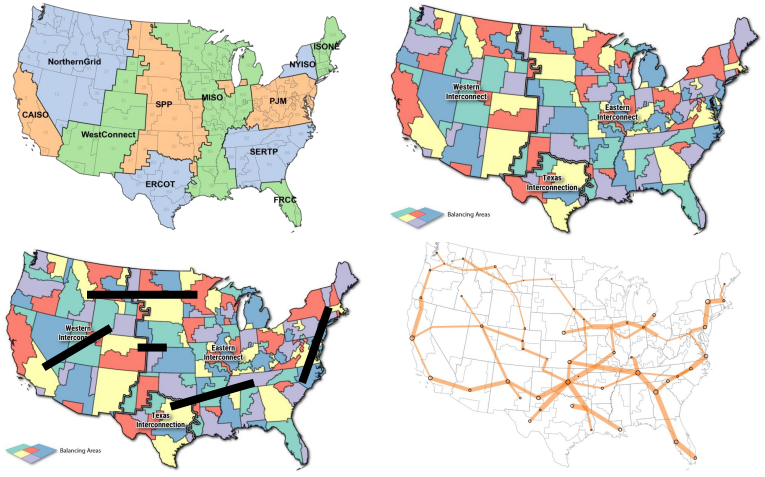
Explicit treatment of issues related to **VRE and storage**; flexible tradeoff of spatial vs. temporal resolution



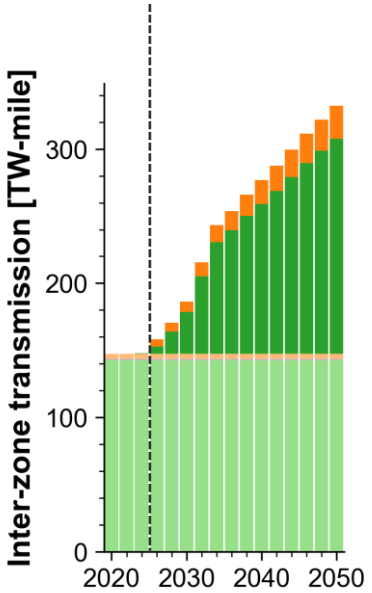
Provides **starting point** for more detailed operational models



Capable of covering a **broad range** of scenario designs & transmission frameworks

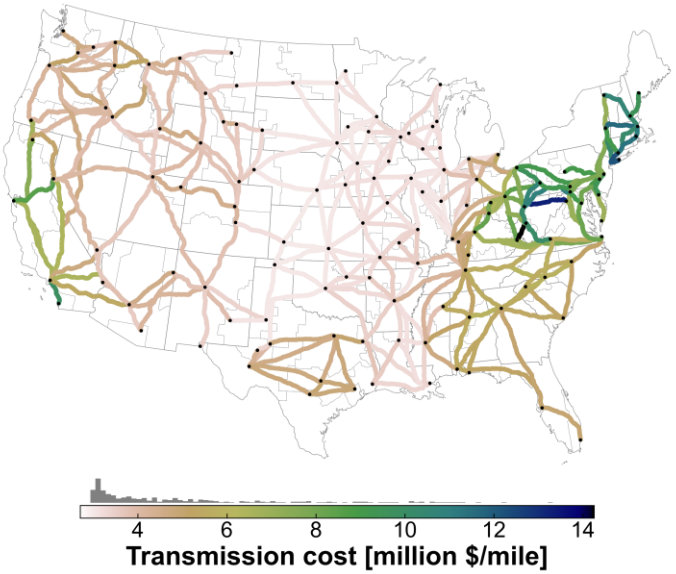


Key capacity-expansion questions for the TRC



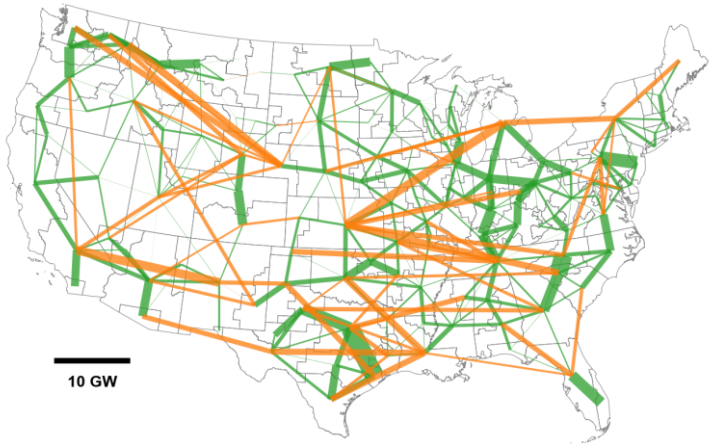
1. In what year should new, **currently unplanned** transmission capacity additions start to be allowed?

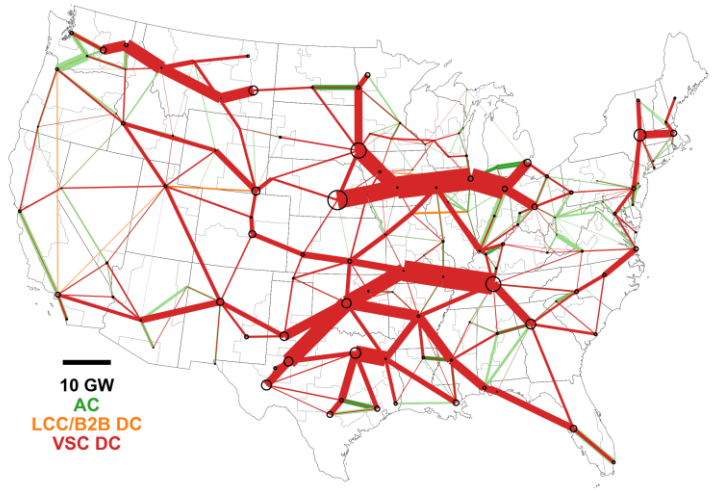
Should it depend on technology, location, or other factors?



2. Are the assumed **cost and performance** characteristics appropriate?

Are there other characteristics that should be considered?





3. Is it worthwhile to consider both **LCC** and **VSC** DC, or other high-capacity options?

4. **What geographic resolution** for transmission construction is needed for actionable findings? (Total TW-miles, inter-region capacities, individual lines…?)

Select items from TRC feedback received to date

First year for new transmission builds

- 2026 is too early, 2028 is aggressive, 2030s is more realistic (consistent feedback but not uniform)
- Depends on multiple factors

Transmission costs

- How do costs differ with different voltages and associated land requirements?
- Can ROW costs be considered
- Reasonable process and assumptions, though some specific regions may differ

LCC vs. VSC, geographic resolution

- Mixed on whether LCC vs. VSC should be studied—more input from HVDC vendors?
- Mixed on individual lines vs. inter-regional

General project, TRC, and timeline Q&A

Next Steps


Pacific Northwest
NATIONAL LABORATORY
NREL
NATIONAL RENEWABLE ENERGY LABORATORY
U.S. DEPARTMENT OF
ENERGY

Next Steps

- TRC members complete and submit the feedback form provided by June 14th
- Next subcommittee meetings
  - **Government Subcommittee** – June 10th
  - **Land Use and Environmental Exclusions Subcommittee** – June 24th
  - **Modeling Subcommittee** – July
- Lab team will
  - Continue conducting the baseline and scenario analyses
  - Develop methodology for interregional renewable energy zones (IREZs), present draft methodology to Land Use and Environmental Exclusions Subcommittee June 24th
  - Explore energy justice tools and modeling with DOE Office of EJ Policy and Analysis
- Next TRC meeting - September
- Next public webinar will be in October 2022 to share interim results

https://www.energy.gov/oe/national-transmission-planning-study

- Overview of NTP Study goals and objectives
- Project news and milestone results
- Webinar presentations
- NTP Study mailing list
- TRC meeting schedules and presentation materials
- **Public comment form**