Evaluating transmission's role in resource adequacy

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IEEE Resource Adequacy Working Group

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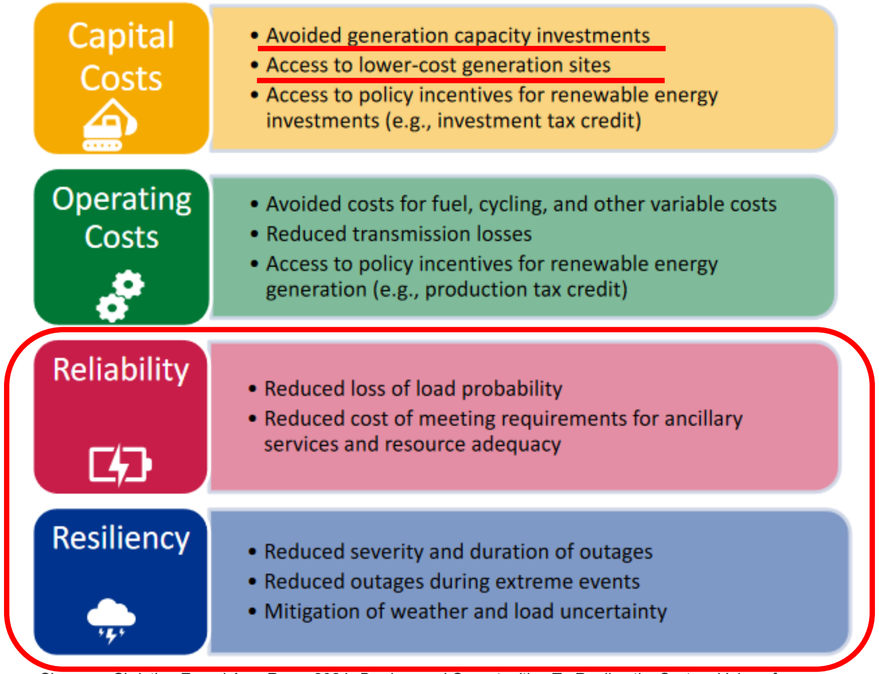
Resource adequacy is one of many potential benefit streams for transmission



Simeone, Christina E. and Amy Rose. 2024. *Barriers and Opportunities To Realize the System Value of Interregional Transmission*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A40-89363. https://www.nrel.gov/docs/fy24osti/89363.pdf.

Capturing the benefits and tradeoffs of transmission for resource adequacy requires:

- **integrated planning** of generation and transmission
- **linkage** between portfolio planning tools and resource adequacy analysis

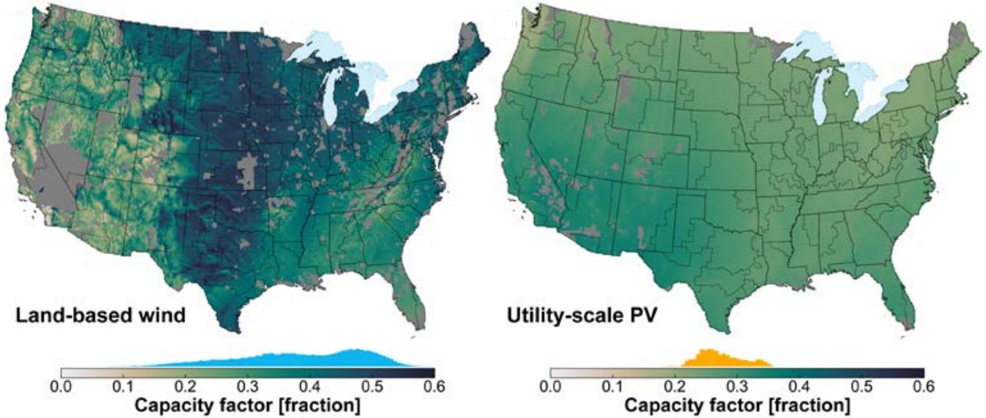
What are the mechanisms for transmission to provide resource adequacy value?

Mechanisms

- Load and resource diversity
- Access more resources to contribute to stressful conditions at different times and locations

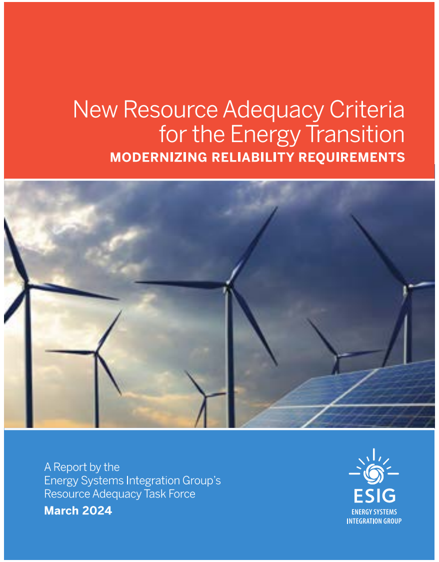
Planning / Economic Value

- **Retire higher cost resources**
- **Access lower cost resources**
- **Build fewer new resources overall**
- **Meet targets at lower cost**



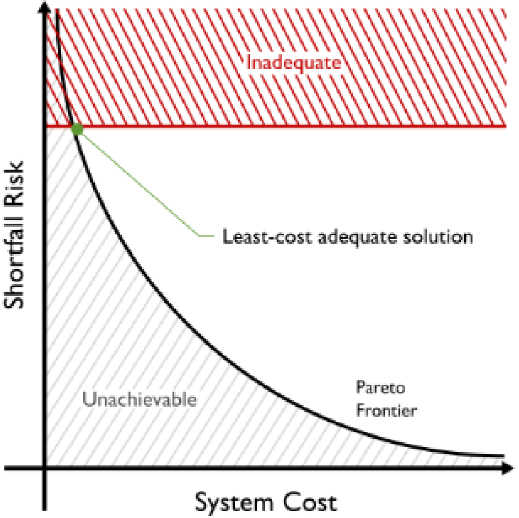
Transmission has resource adequacy value when it is the **least cost solution** to meeting resource adequacy needs

Transmission's contribution is not only about reliability…it's also about cost



"…resource adequacy should be viewed as a continuum in which the level of risk is dependent on the amount of resource investment.

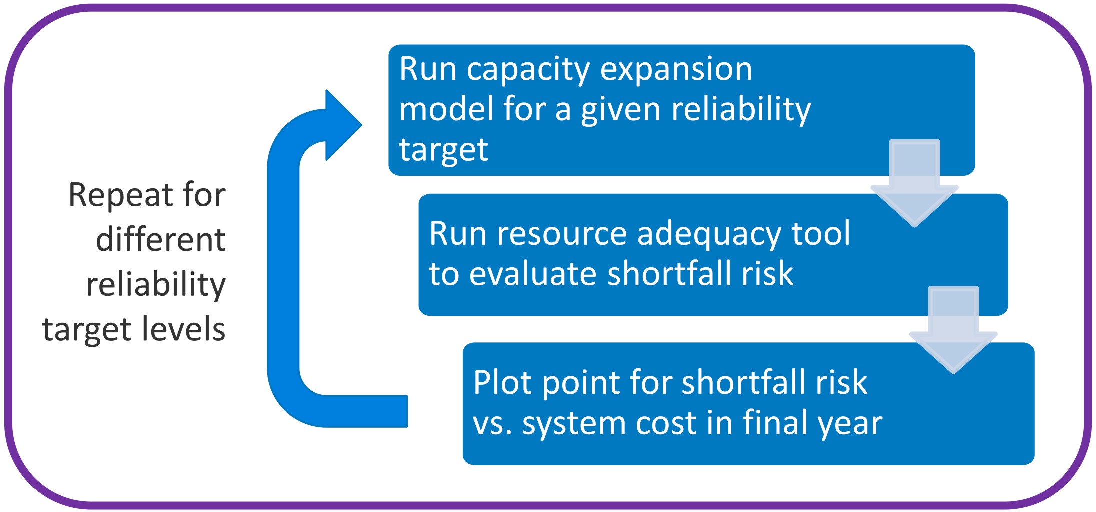
*The appropriate level of adequacy is determined by the **trade-off between what customers are willing to pay versus how much shortfall they are willing to tolerate**."*



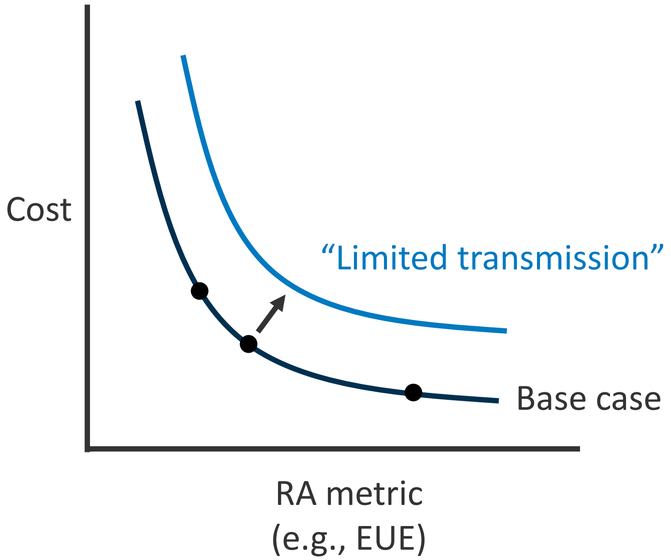
Kuna, Jess, Gord Stephen, and Trieu Mai. 2024. Beyond Capacity Credits: Adaptive Stress Period Planning for Evolving Power Systems. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A40-89386. https://www.nrel.gov/docs/fy24osti/89386.pdf.

Metrics might include ability to reduce shortfall risk (e.g., expected unserved energy) or to lower the cost to meet a risk target (e.g., total investment cost)

Using capacity expansion modeling to understand transmission and the cost/reliability tradeoff



Repeat entire process for different transmission scenarios to evaluate impact on the frontier



Testing the framework using the ReEDS model

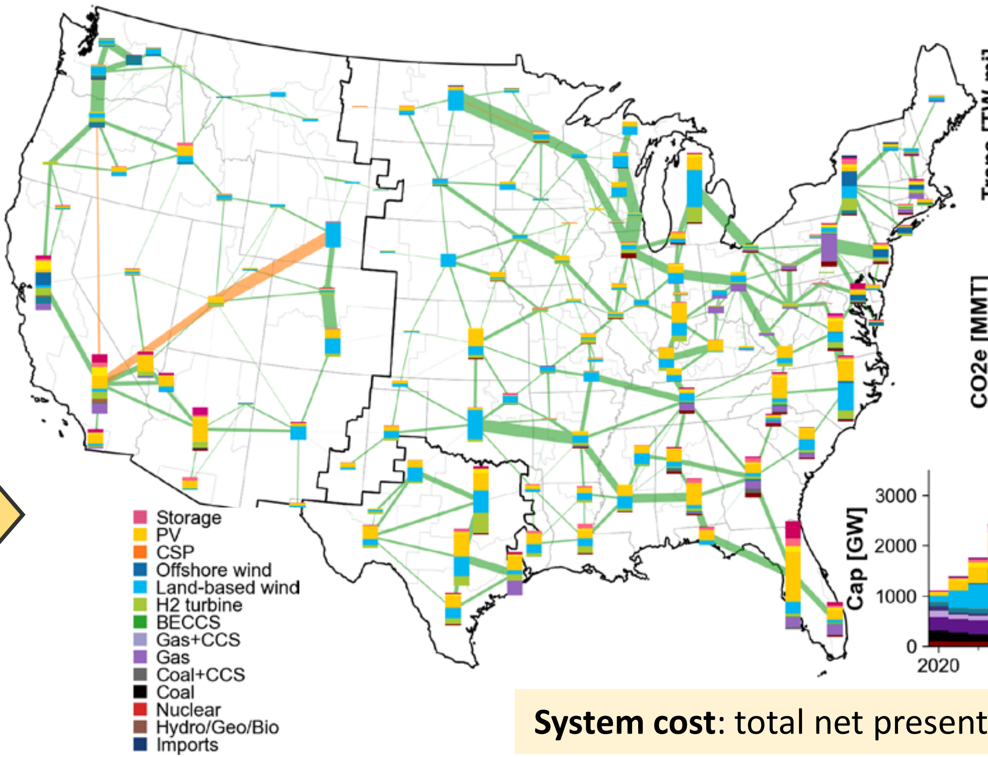
Co-optimizes generation, transmission, and storage **capacity & operations** to meet demand at **least possible cost** under a range of policy and physical **constraints**

Inputs

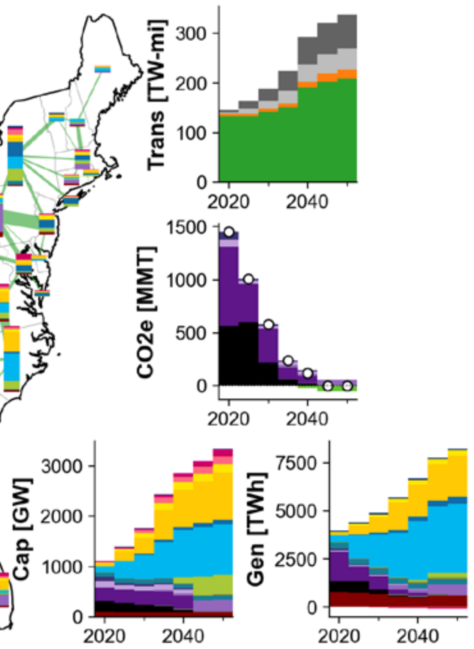
- **Existing & planned** capacity
- Variable renewable energy (**VRE**) availability (spatial and temporal)
- State & federal **policies**
- **Demand** (hourly) projections
- **Cost** projections
- **Technology** availability

ReEDS

Regional Energy Deployment System (ReEDS): https://www.nrel.gov/analysis/reeds/



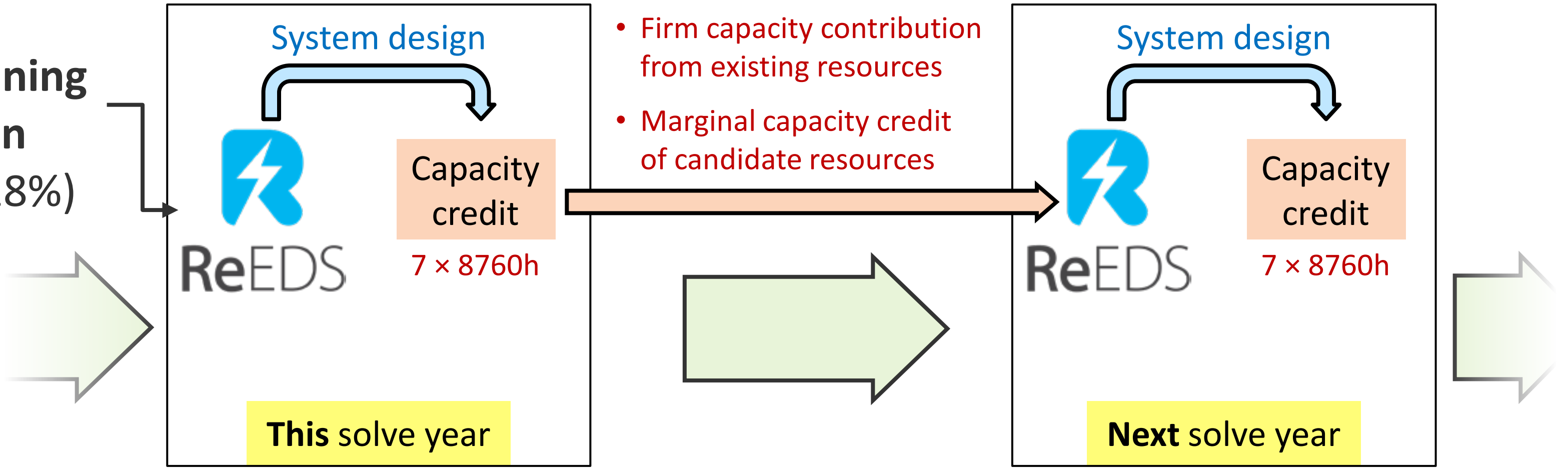
Outputs



System cost: total net present value [$ billion]

The ReEDS capacity credit approach to resource adequacy

Exogenously specified **planning reserve margin** (typically 12-18%)



Run resource adequacy assessment on final system

PRAS

Probabilistic Resource Adequacy Suite (PRAS): https://www.nrel.gov/analysis/pras.html

Reliability metrics: expected unserved energy (EUE, MWh), normalized expected unserved energy (NEUE, parts per million), loss-of-load probability, etc.

Patrick Brown, Luke Lavin, Surya Dhulipala, Jess Kuna, Trieu Mai. "Stress period" resource adequacy formulation. ReEDS User Group Meeting 2023.

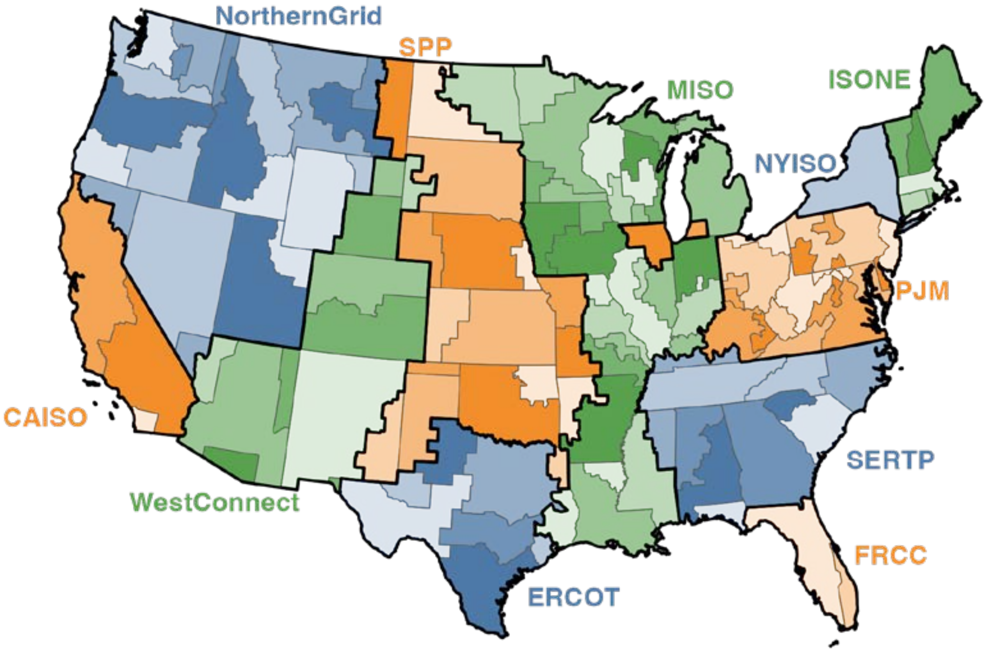
Scenario design for estimating Pareto frontiers

Transmission

- All new builds allowed
- No new interregional
- No new transmission

Emissions

- Business as usual (BAU)
- Zero carbon by 2050



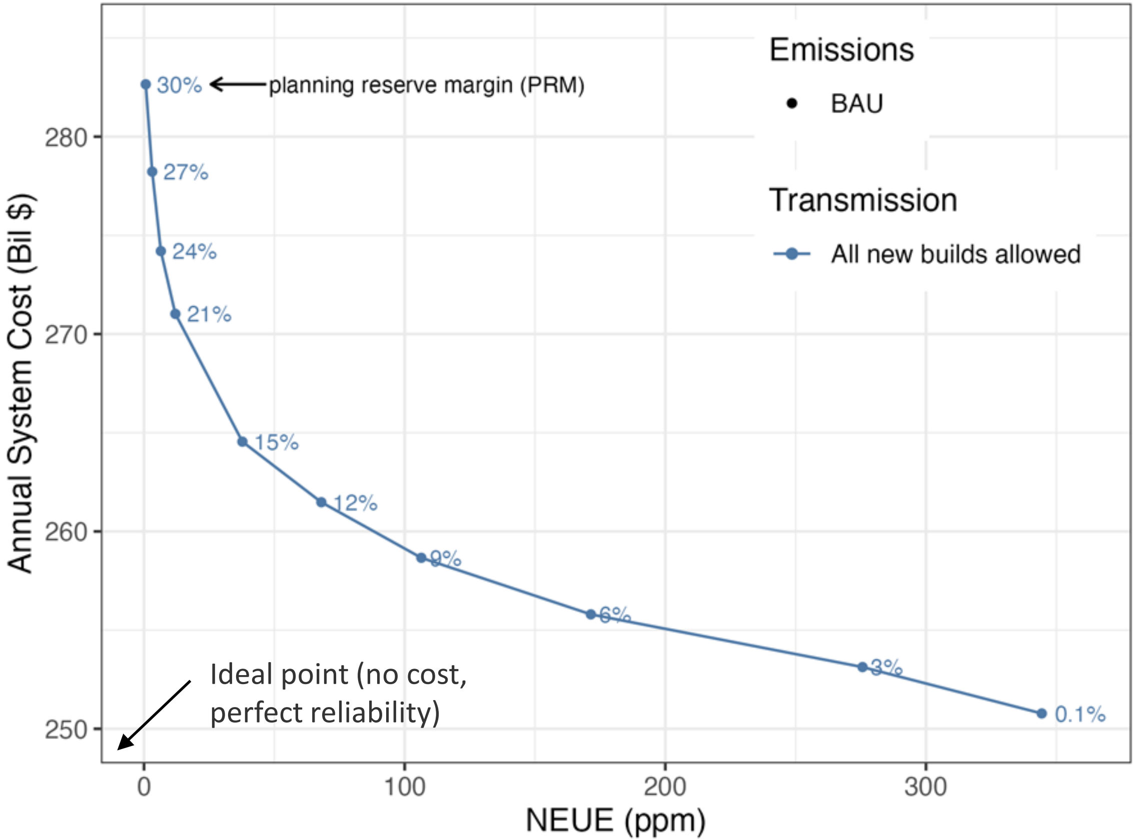
PRM target set for in transmission planning region (colored)

Initial Pareto frontier results

Baseline transmission and emissions assumptions

Results shown for 2050 model year

Annual system cost includes annualized capital expenditures + operating costs



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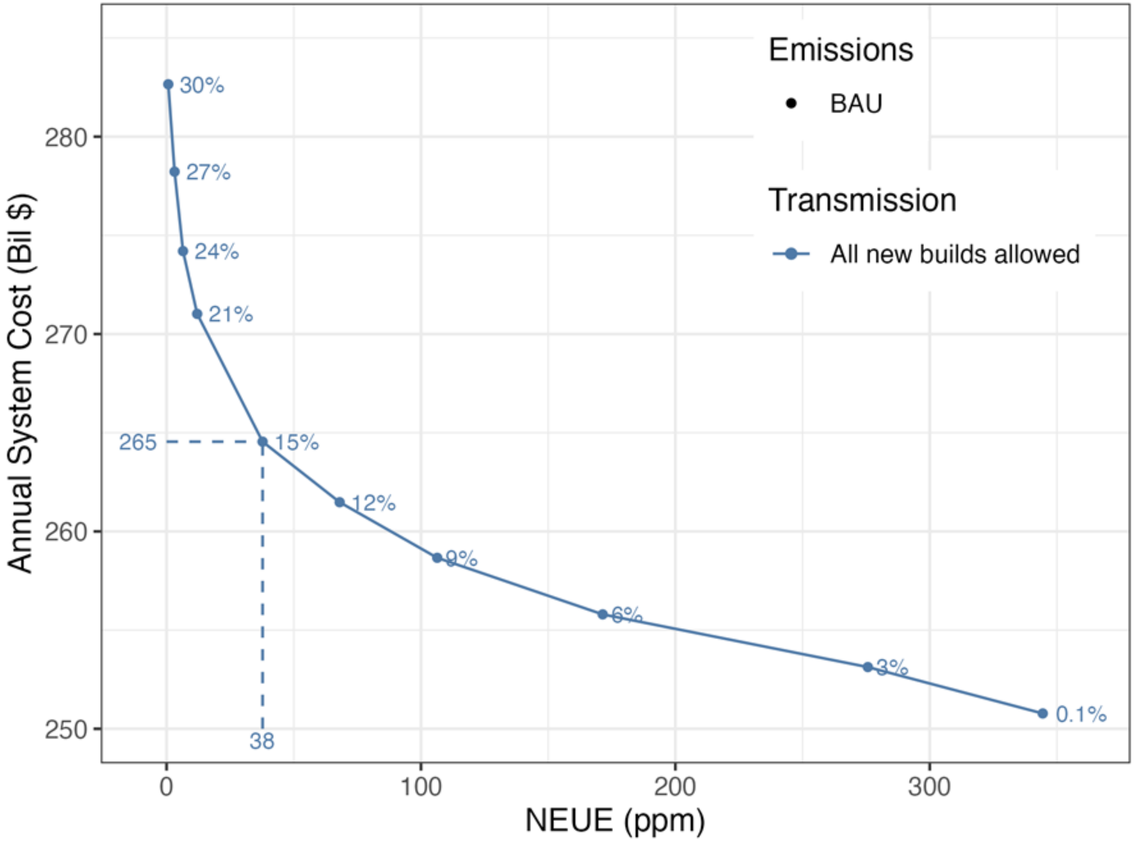
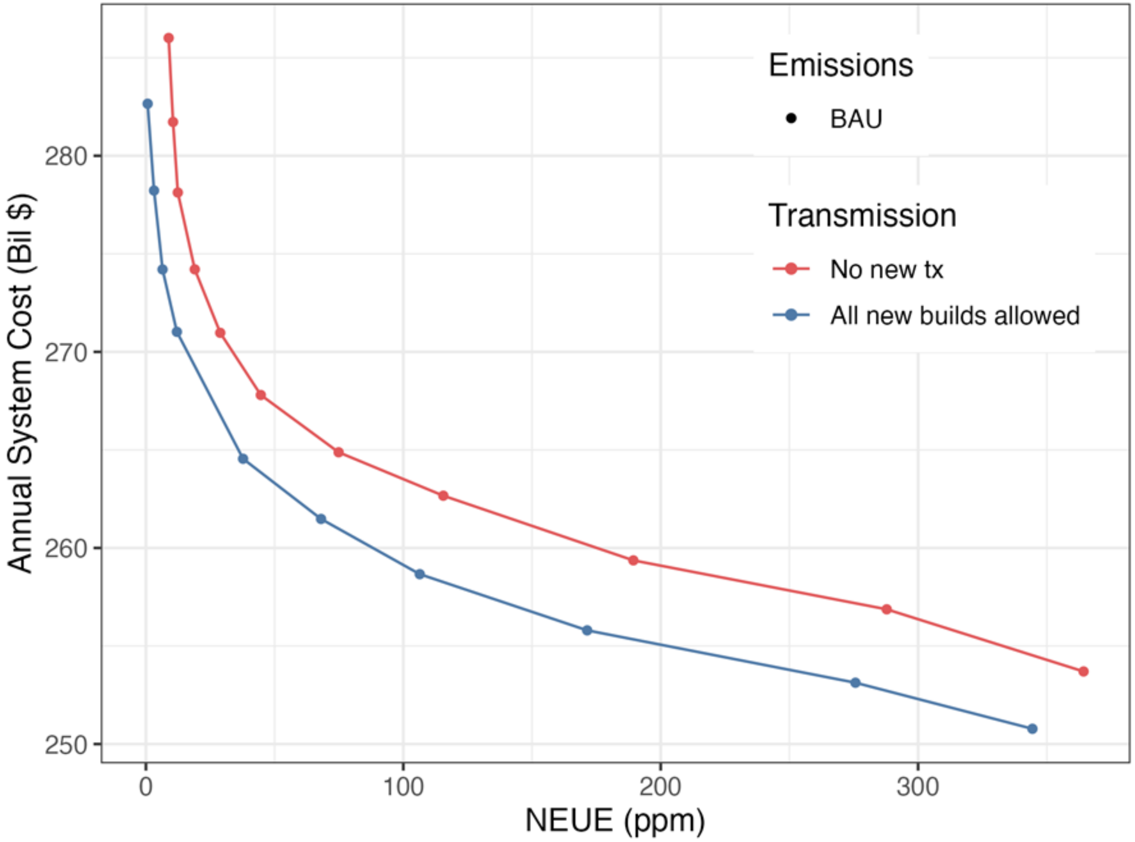


Restricting transmission investment moves the Pareto frontier further from the ideal



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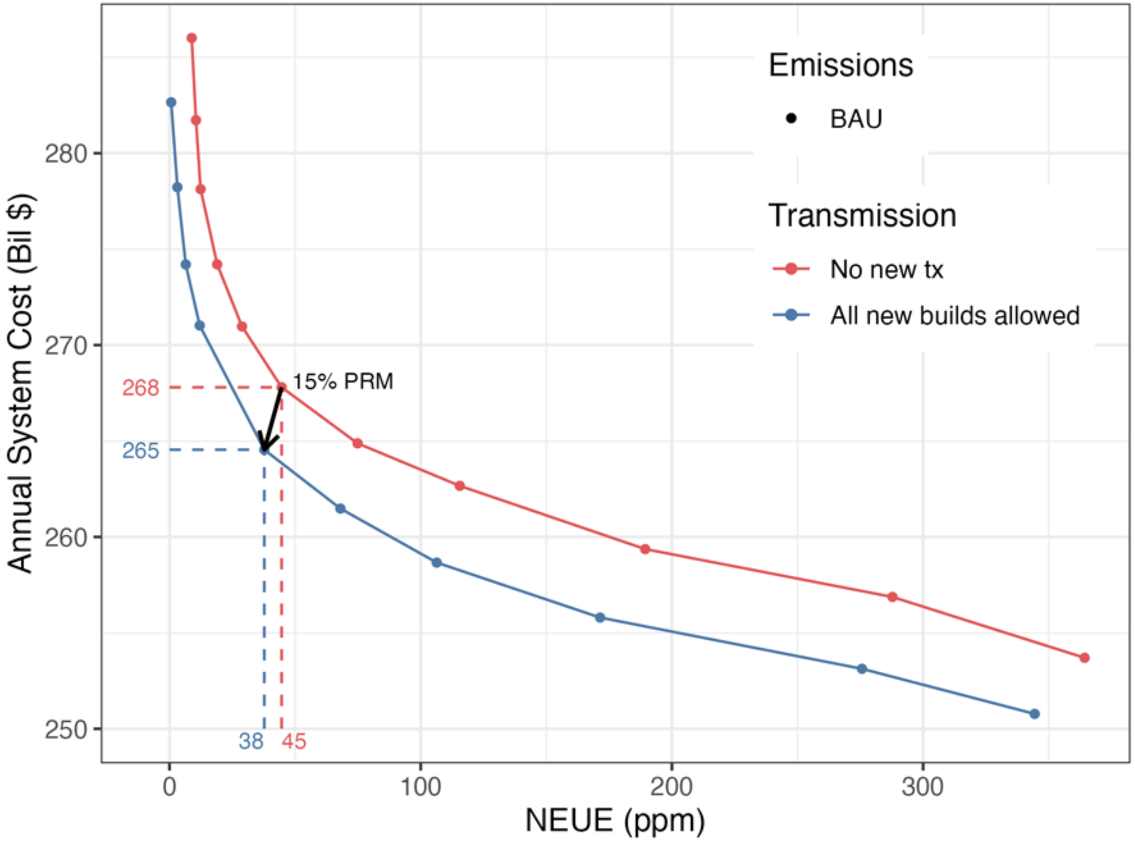

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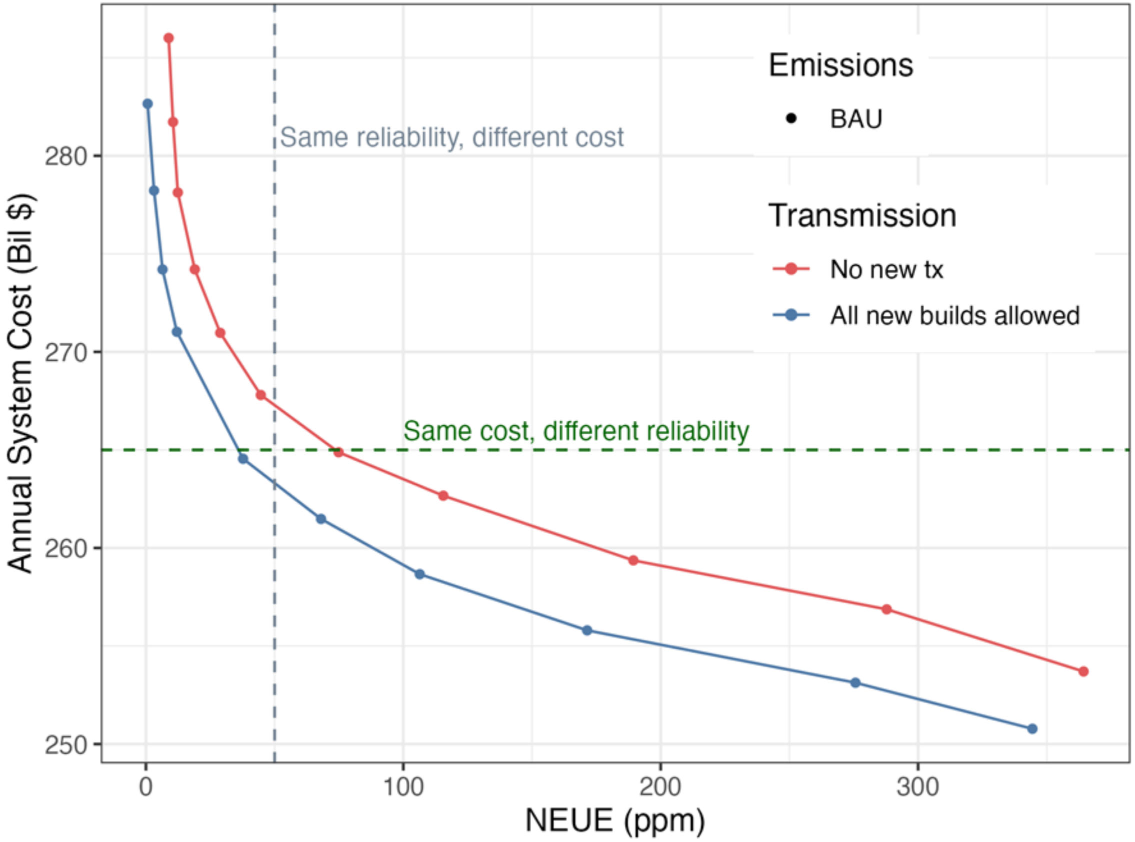
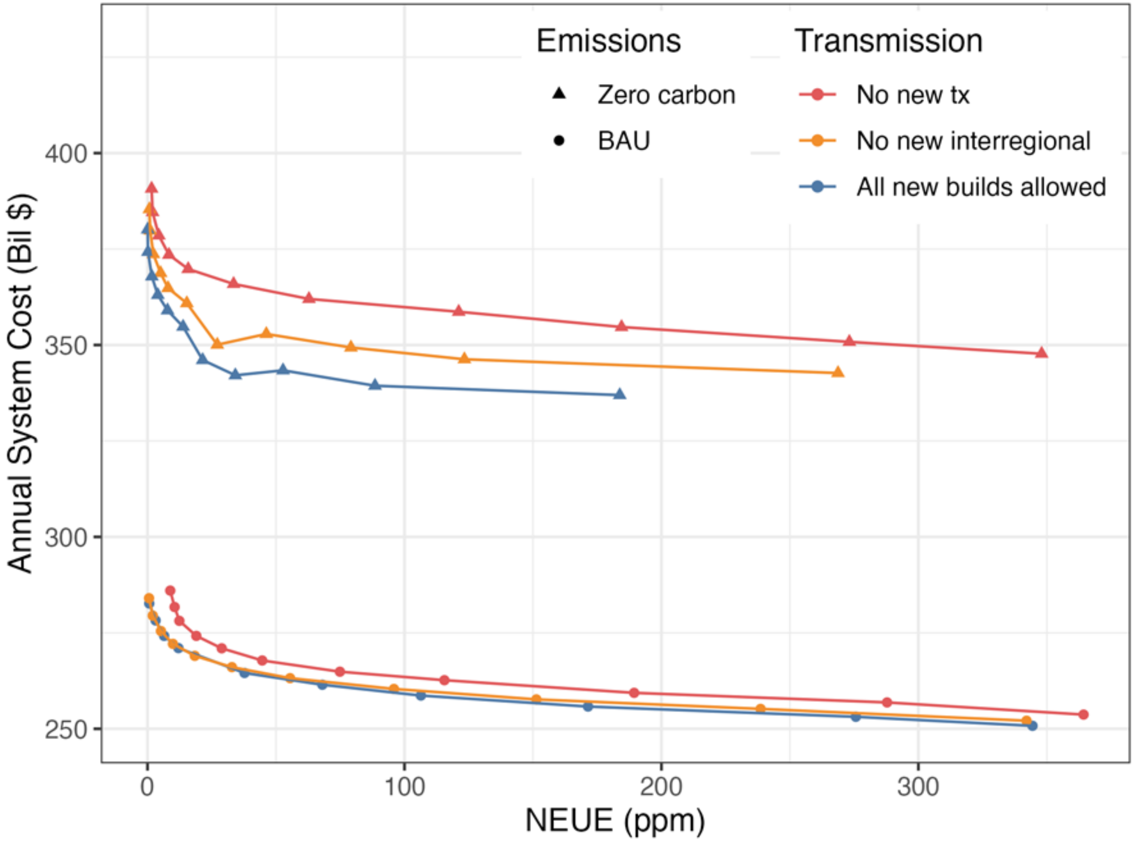


Transmission constraints have larger impact on tradeoffs under decarbonization scenarios



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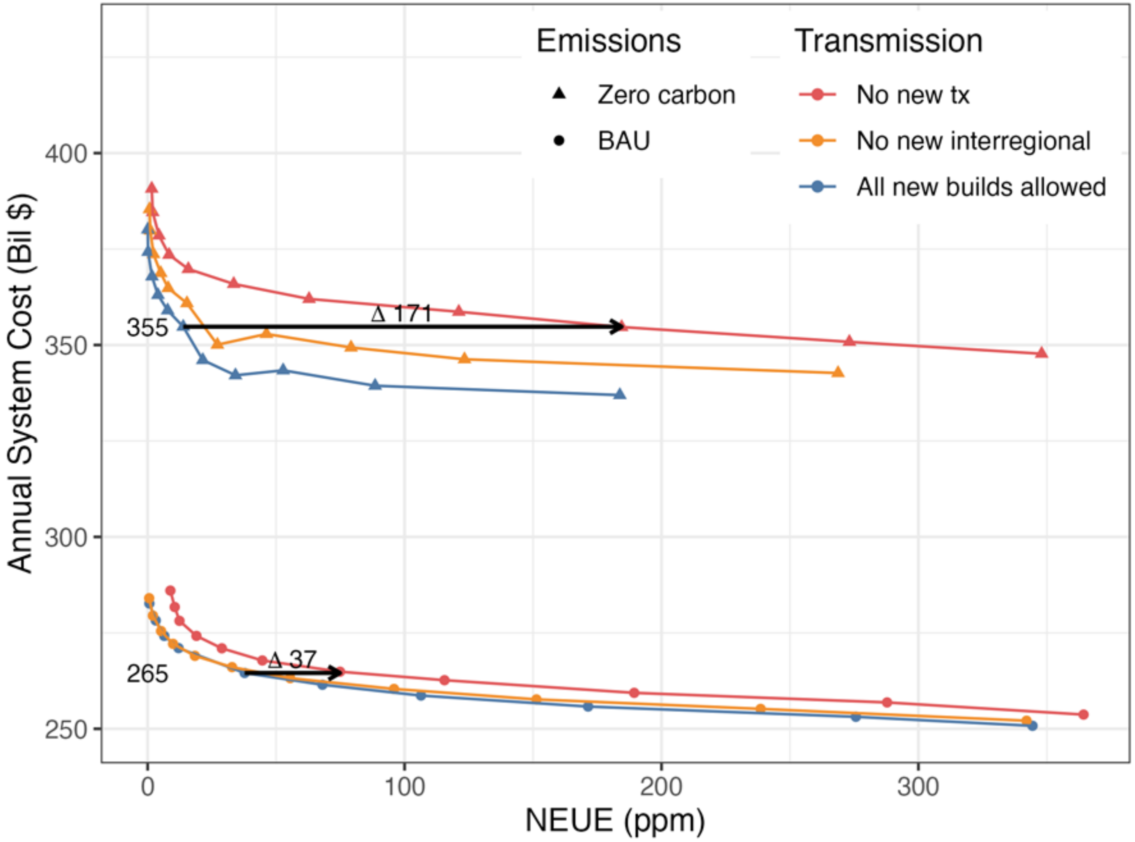

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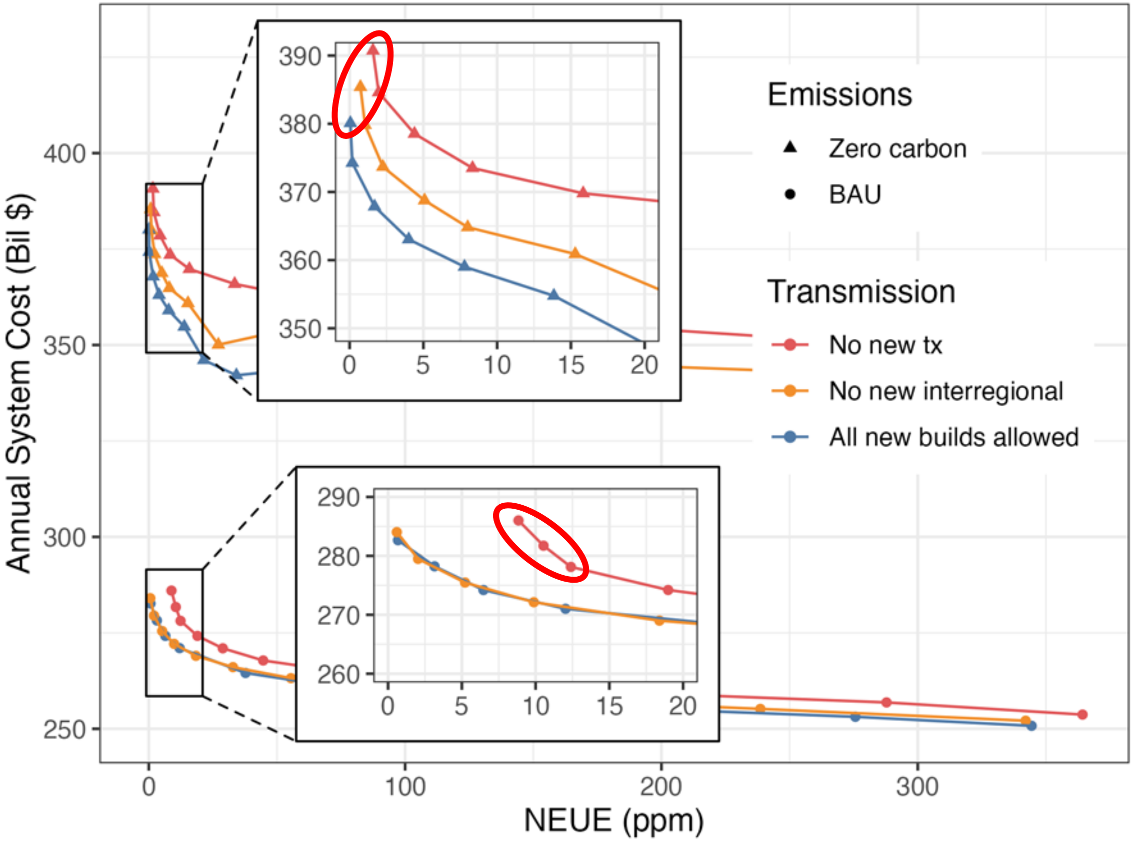
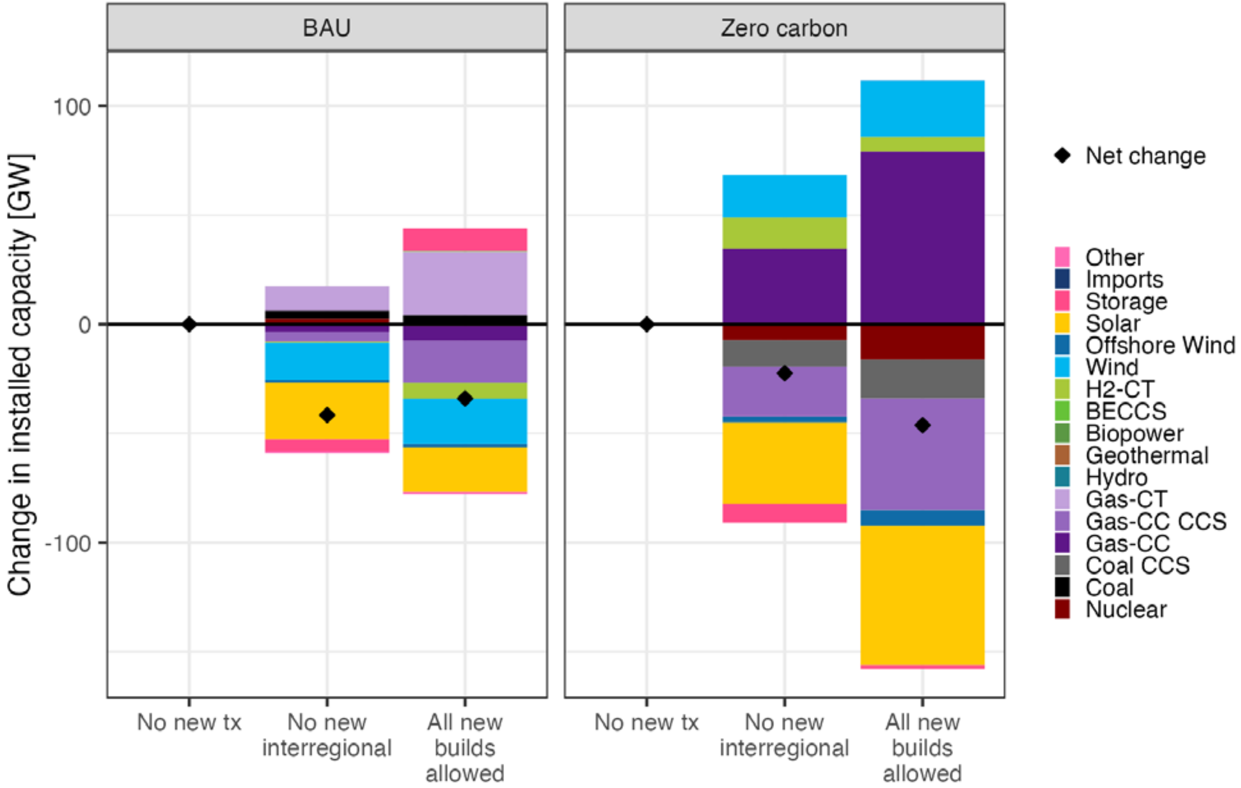


Context for cost savings:

- $180 billion annually in capital expenditures by IOUs (EEI)
- $20-25 billion annually in transmission expenditures (Brattle)

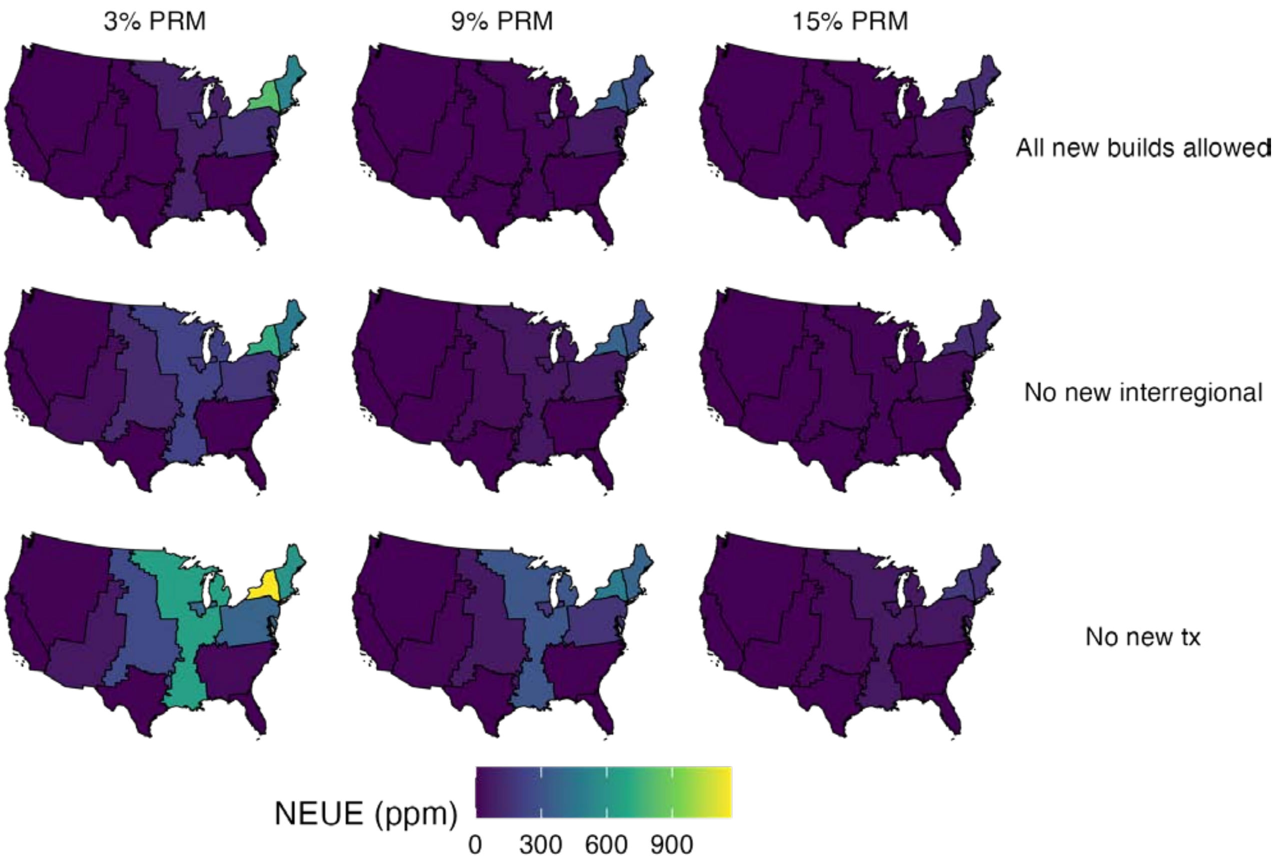
EEI: https://www.eei.org/en/resources-and-media/industry-data
Brattle: https://www.brattle.com/wp-content/uploads/2023/07/Annual-US-Transmission-Investments-1996%E2%80%932023.pdf

Ability to build new transmission changes what types of resources are deployed



Results shown in 2050 for a 15% PRM

Where does unserved energy occur when transmission buildouts are limited?



Results shown in 2050 for the zero carbon scenario

Limitations of the capacity credit approach for transmission and resource adequacy

In ReEDS we've historically calculated **capacity credit** using **net load** within 11 "planning regions" approximating FERC Order 1000 regions plus ERCOT

1. Capacity credit is assessed in the planning region where a resource is **sited**, even if it is used to meet RA needs in a **different** planning region

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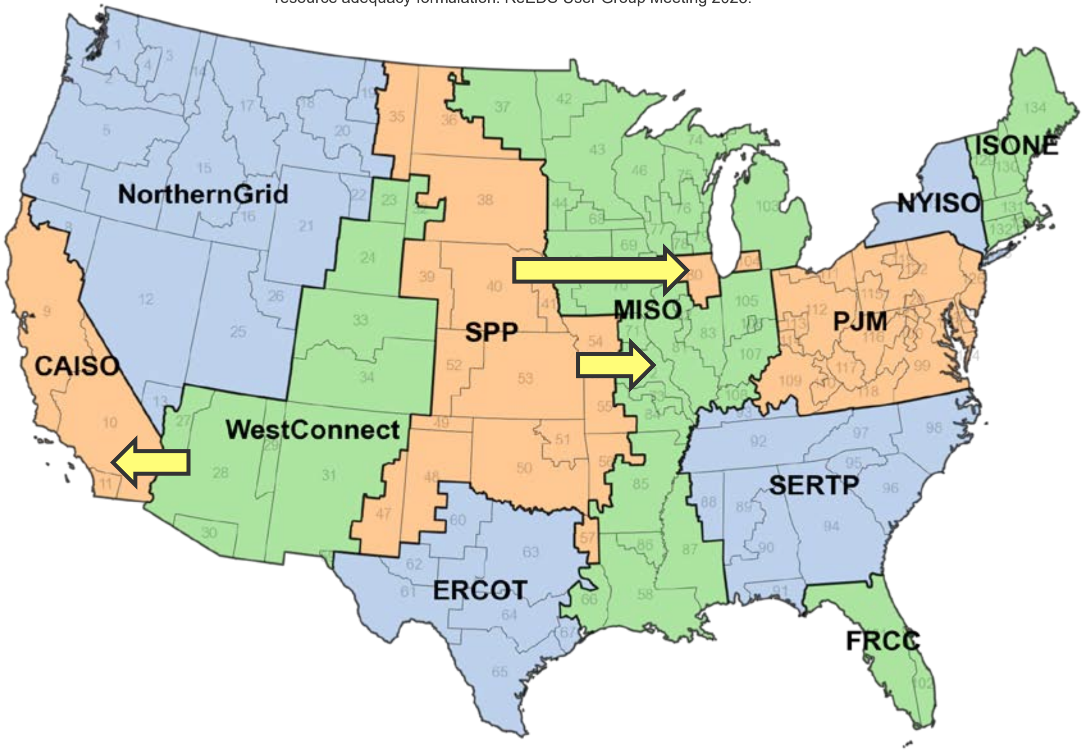

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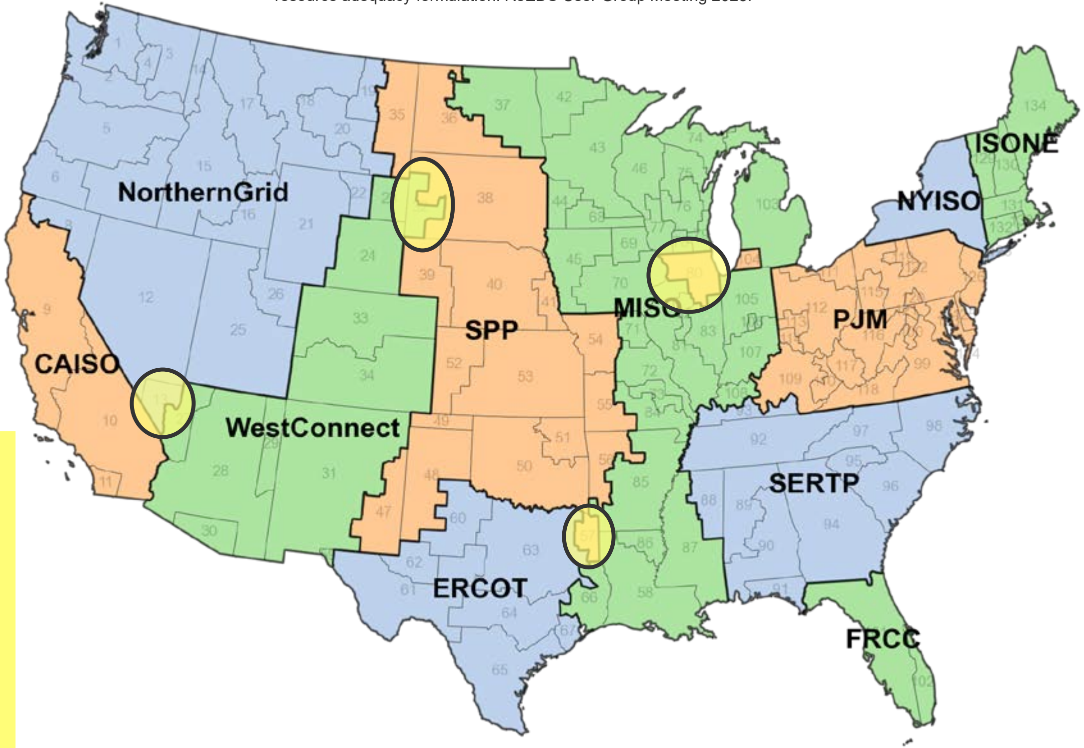

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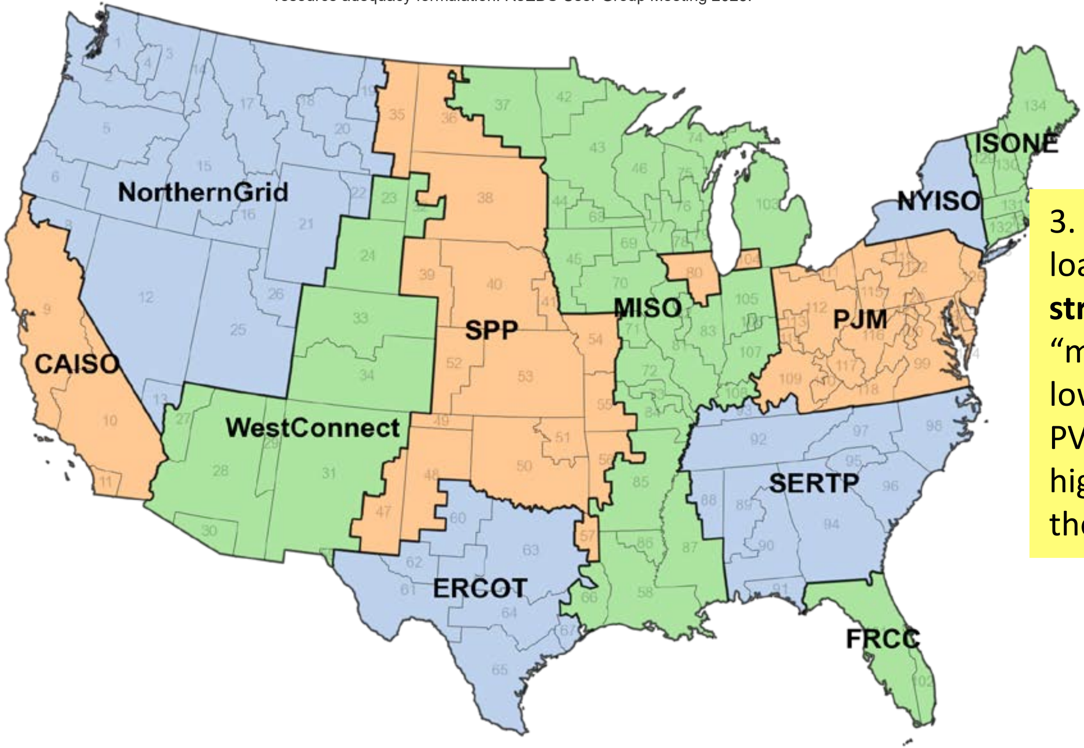

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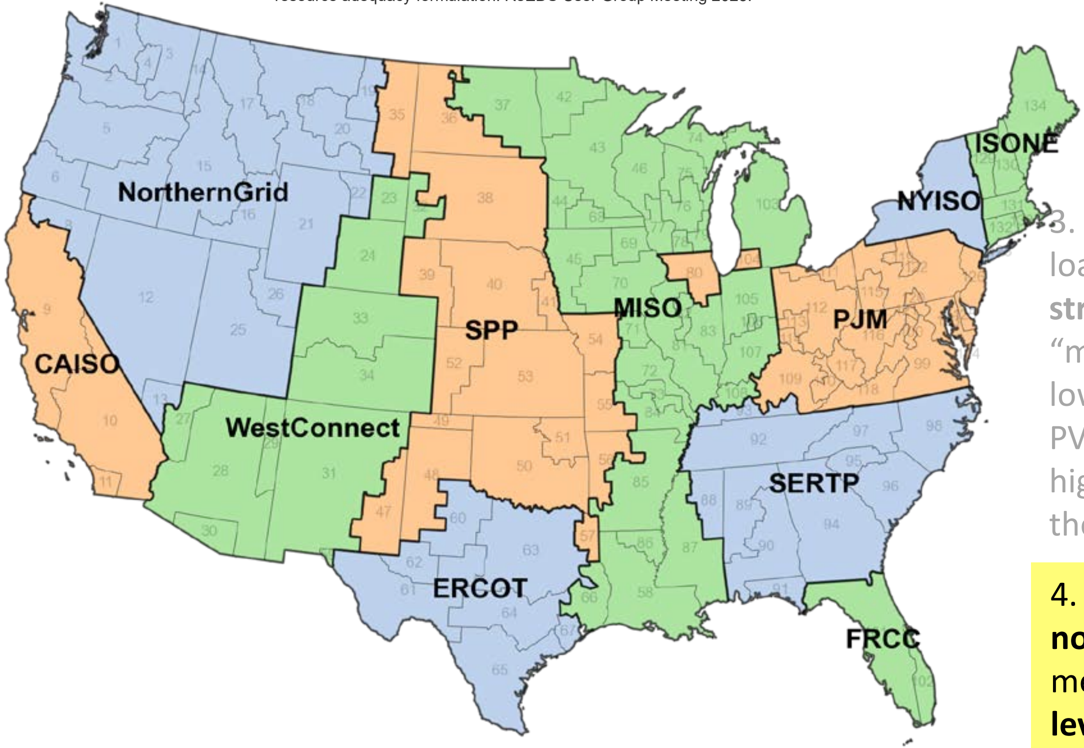

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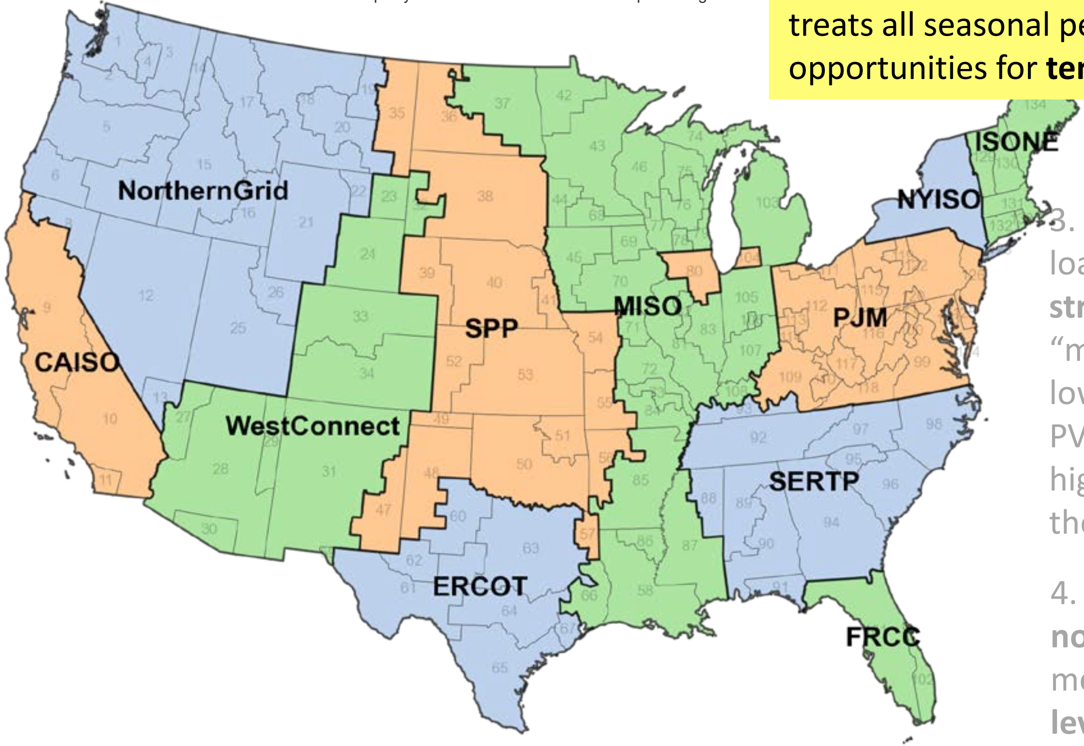

5. Our PRM + capacity credit representation treats all seasonal peaks as coincident, missing opportunities for **temporal complementarity**

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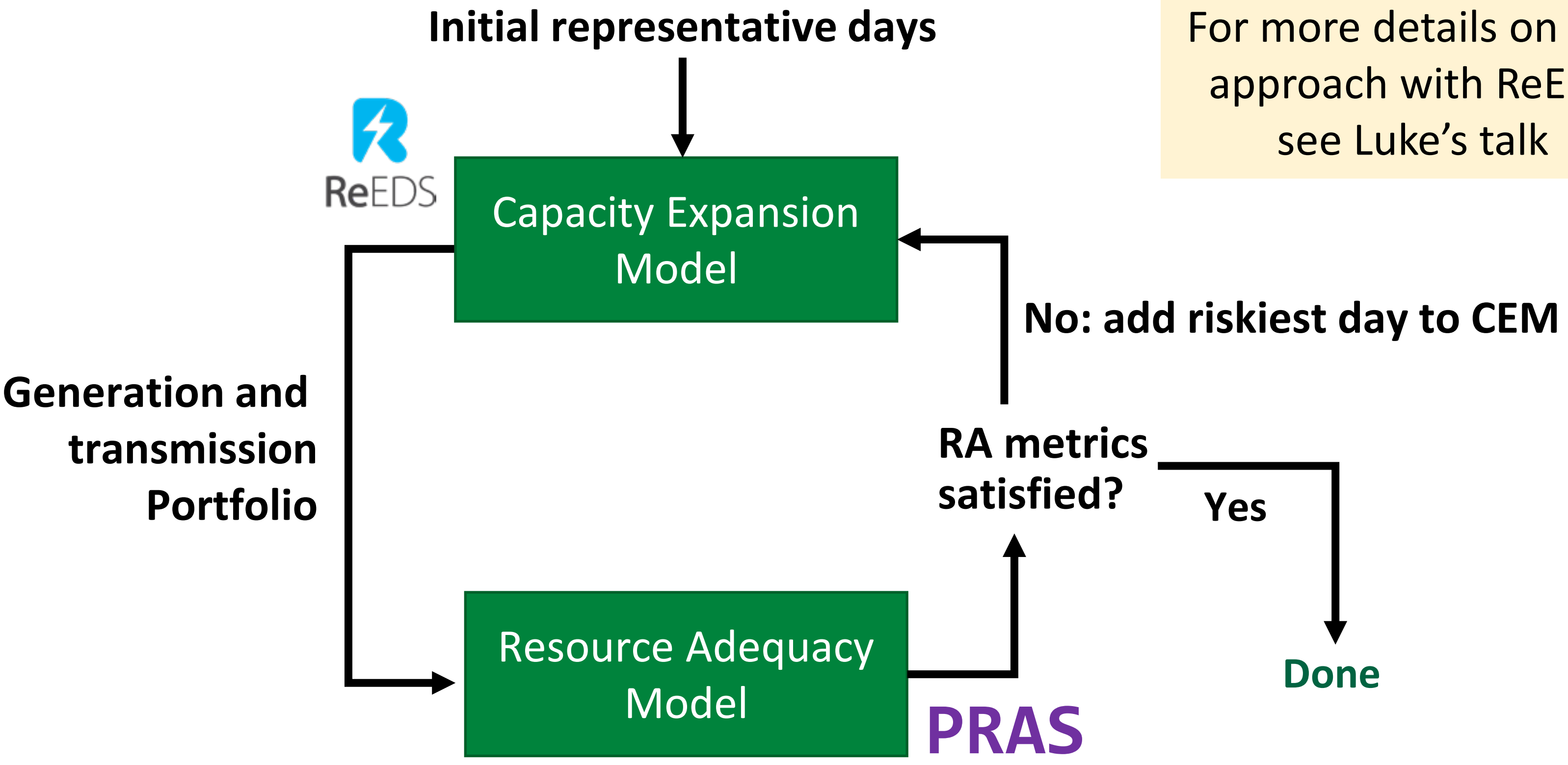
Integrating capacity expansion and resource adequacy models via “stress periods”

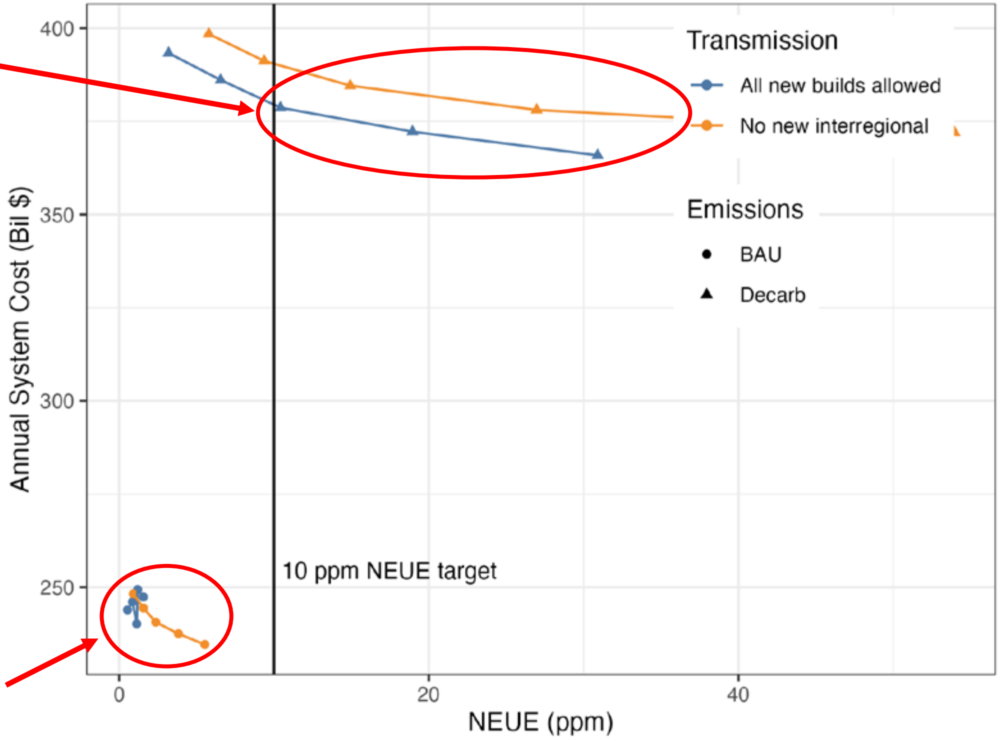
For more details on this approach with ReEDS see Luke’s talk



Stephen, Gord. 2023. Closing the Loop: Capturing Stress Periods in Planning Models via Dynamic Risk Period Identification. IEEE Power & Energy Society General Meeting.

Challenges for estimating Pareto frontiers using the stress periods approach

Cases where the CEM and RA models failed to hit the RA threshold after 10 iterations



NEUE threshold is a ceiling, so a system can "overbuild" and exceed the threshold, leading to different RA outcomes for similar cases

Planned efforts to further explore transmission's role in resource adequacy

- Apply the stress periods approach to estimating Pareto frontiers
  - Add a dynamic energy reserve margin to avoid overshooting reliability target
- Refine the model's representation of stress events
  - Incorporate correlated outages for thermal generators
  - More detailed representation of transmission outages
- Identification of conditions under which transmission is important for resource adequacy
  - One potential approach: take a future buildout, reduce interface capacity, evaluate shortfall impact in PRAS, and then repeat for each corridor under different scenarios

What other analyses or factors should we be considering?

Questions or suggestions? Reach out!

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