Pacific Northwest
NATIONAL LABORATORY

From Sea to Shining Sea: Offshore Wind Analysis and Action

ESIG Fall Meeting

T. Douville, PE

Providence, RI

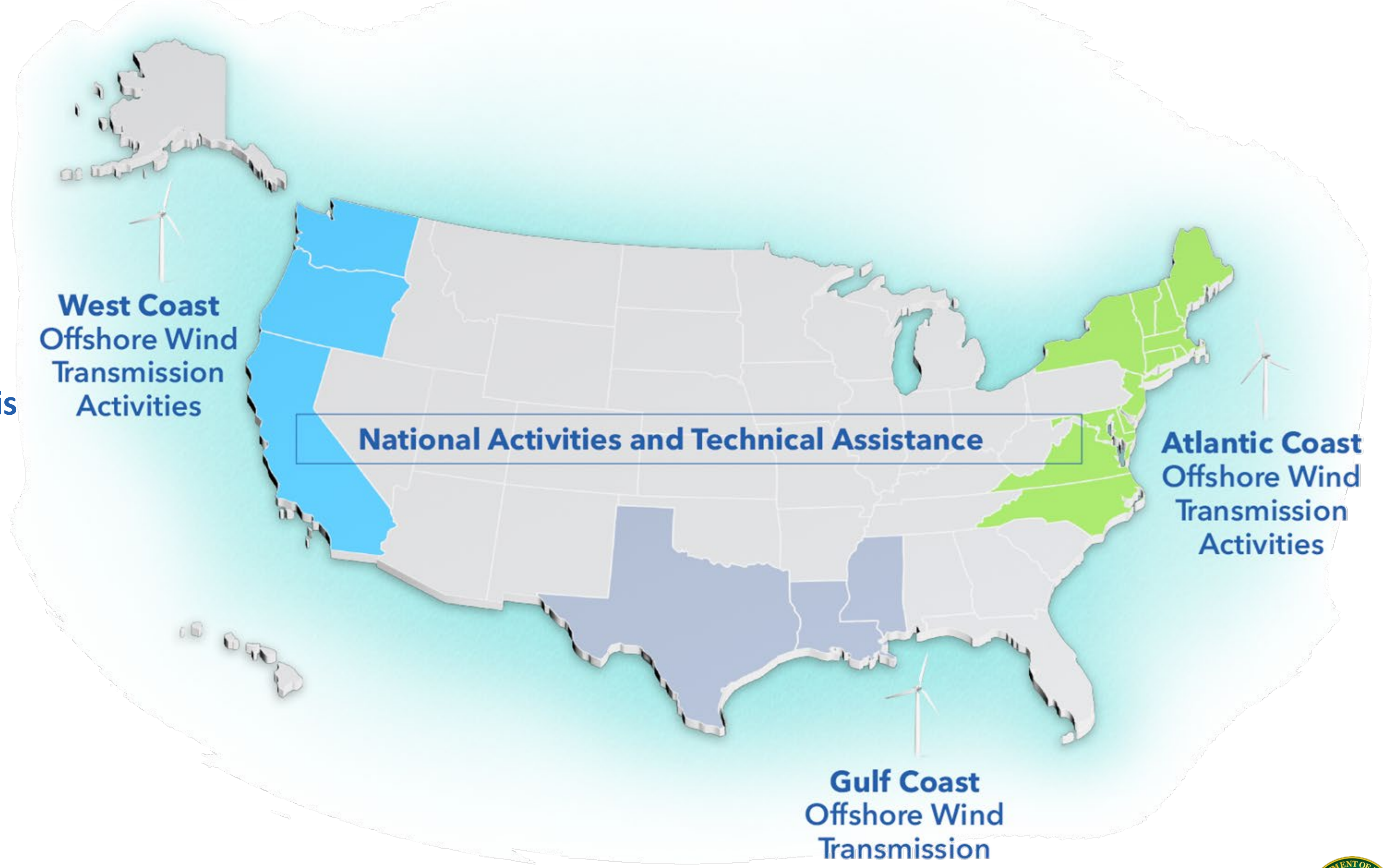
October 21, 2024

U.S. DEPARTMENT OF ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy

DOE Efforts on Offshore Wind Transmission

- Gaps Analysis
- Convening
- Study
- Actions



- Gaps Analysis
- Convening
- Study
- Actions

- Gaps Analysis

Atlantic Action Plan

Partnerships & Collaborations	Planning & Operations	Technologies & Standardization	Economics & Support Initiatives	Siting & Permitting

- 41 recommendations
- Spanning 2023-2050
- 5 Key Categories

- Co-drafted by DOE & BOEM
- Input provided by FERC, NOAA

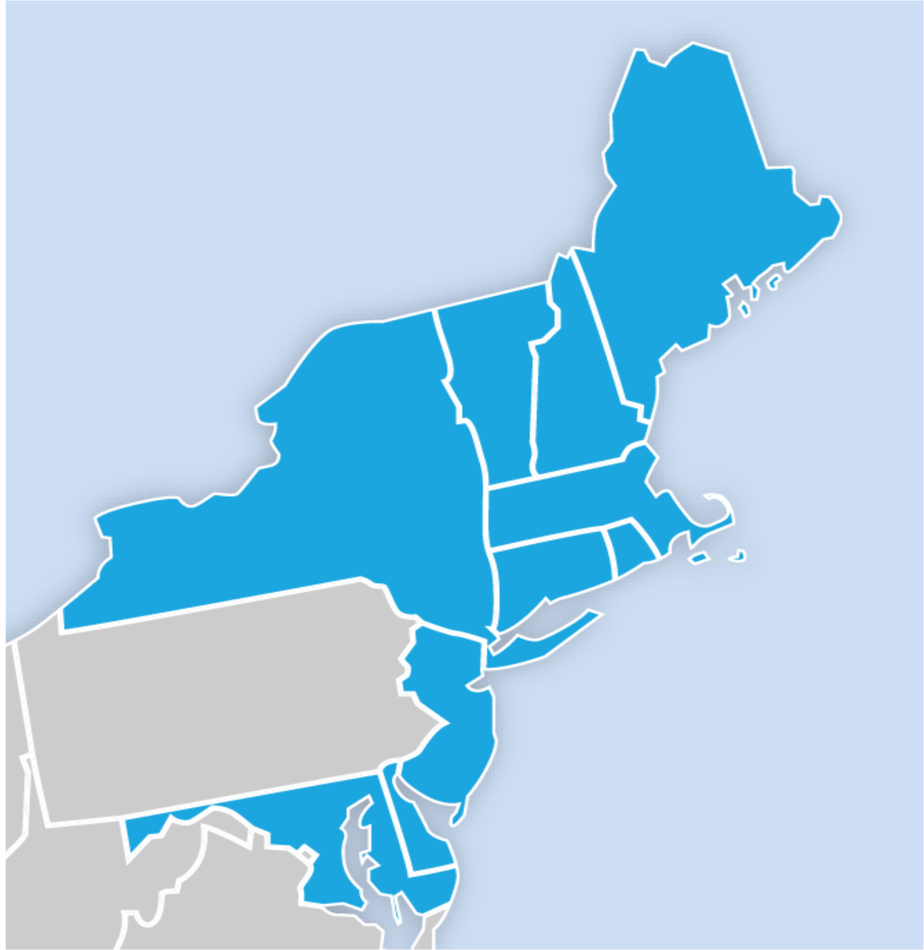
U.S. DEPARTMENT OF ENERGY

BOEM Bureau of Ocean Energy Management

Northeast States Collaborative on Interregional Transmission

Action Plan Recommendation 1.1.1

- Eight northeastern states sent a letter to DOE in June 2023 requesting support for interregional and offshore transmission planning efforts (2 more have joined since).
- Asked DOE to assist in forming a “Northeast States Collaborative on Interregional Transmission”
- The collaborative is working to:
  - identify barriers to economic planning and development of interregional transmission
  - identify potential multi-state projects that may be suitable for ISO/RTO study
  - develop a strategy for state cooperation on technical standards for OSW transmission equipment
- GDO is working with state members to explore how best to support their engagement in transmission planning and development activities to meet their energy policy goals.



MAINE

NEW HAMPSHIRE

VERMONT

NEW YORK

MASSACHUSETTS

RHODE ISLAND

CONNECTICUT

NEW JERSEY

DELAWARE

MARYLAND

U.S. DEPARTMENT OF ENERGY

OSWTransmission@hq.doe.gov

DOE's Investments in HVDC

- HVDC Standards & Workforce FOA
  - Functional requirements and standards development
  - HVDC curriculum for education and workforce training
- IDEAL-HVDC FOA
  - HVDC converter Innovative designs for increased power density and cost reduction

CORE Initiative Metrics 35% by '35

DOE Announces $1.25 Million Award Standardization for Interregional Offshore Wind Transmission

Goal: Form a consortium of technical experts to identify standardized offshore wind transmission equipment specifications and mesh-ready design to support coordinated procurement in the United States.

Timeline: DOE anticipates this project to occur over a 12-month period across FY24-FY25.

Eligibility: Specialized, independent experts, consultants, and academic entities. Principal Investigator must certify status as a U.S. domestic entity.

Scan the QR code to access the announcement page.

Add yourself to the teaming partner list to connect with others and build an application.

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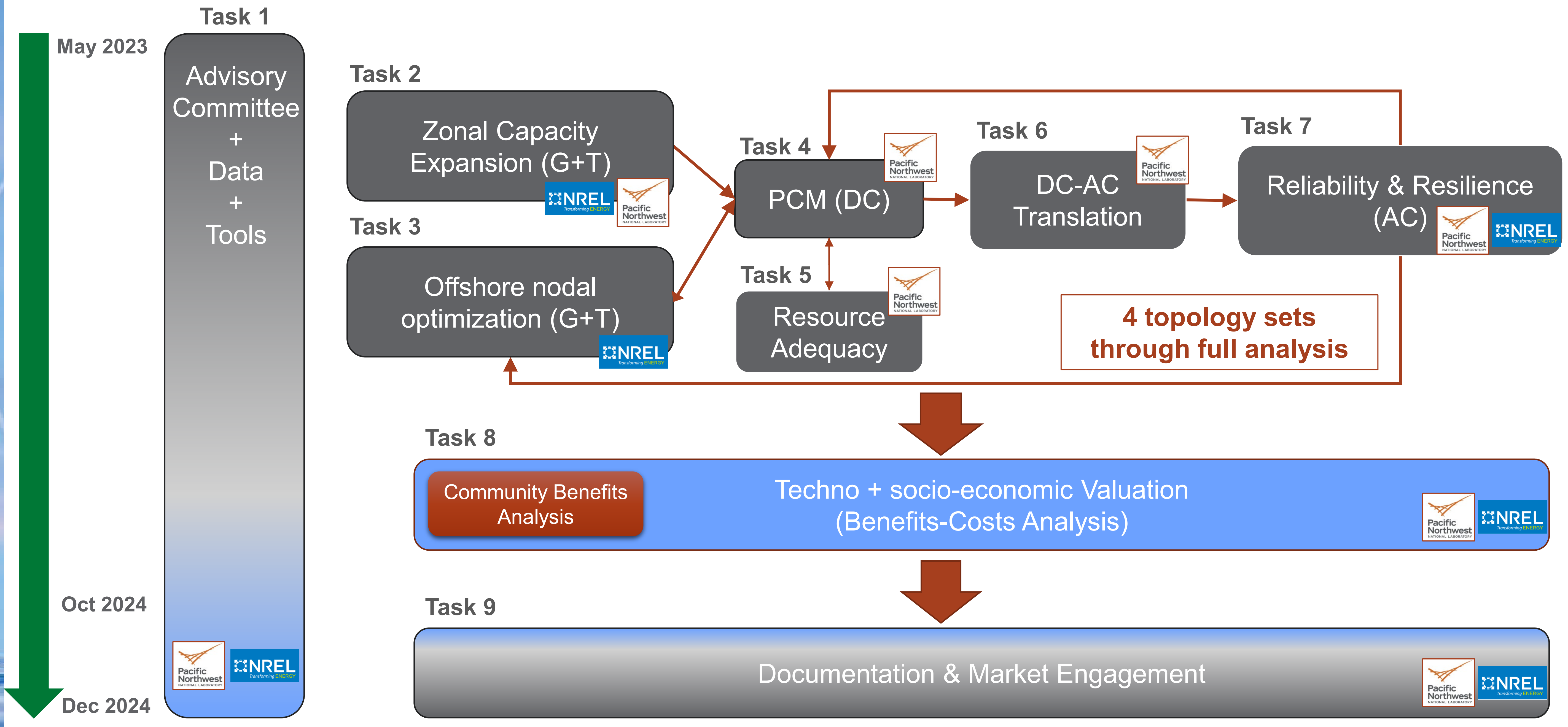
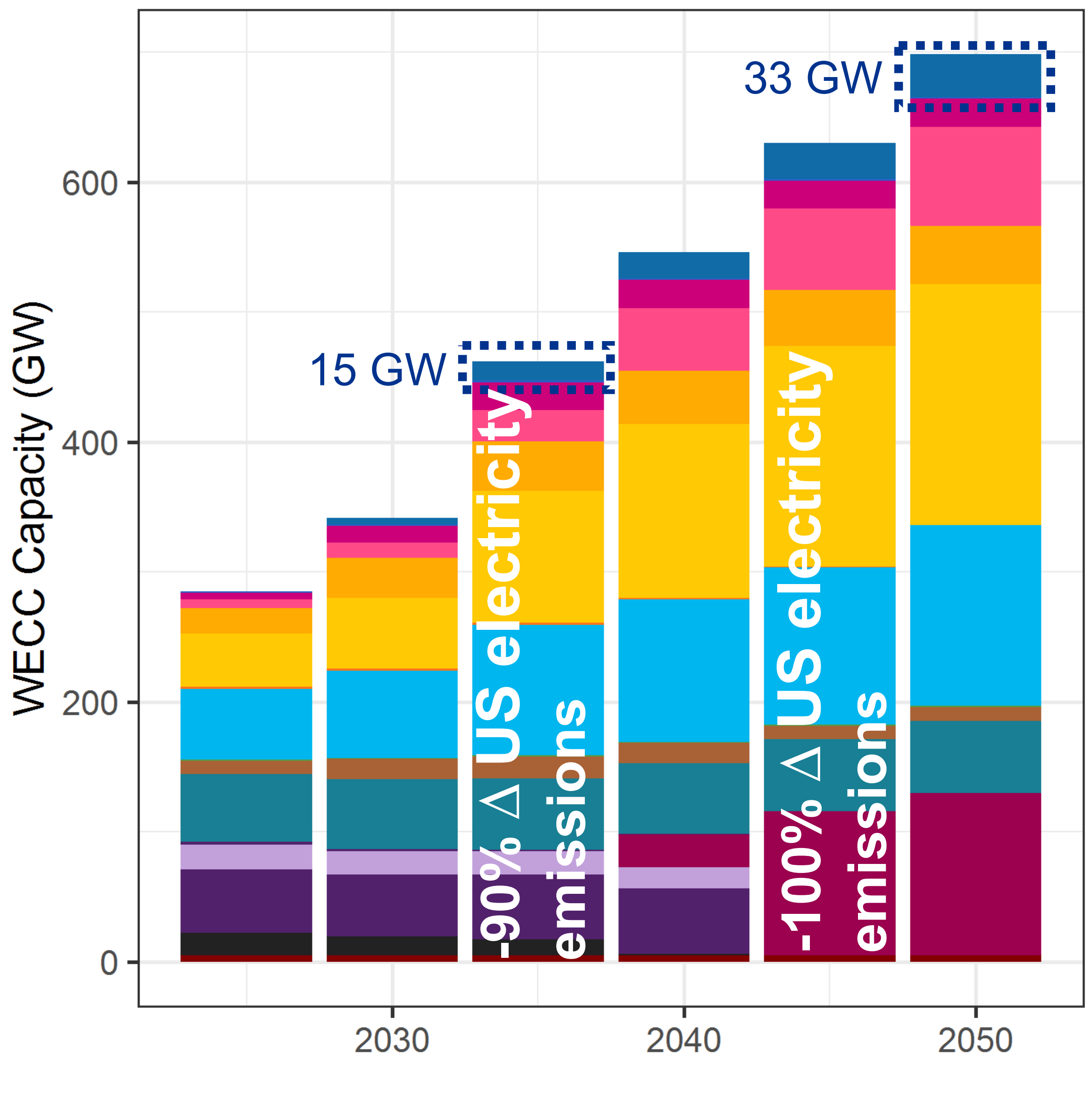
OSWTransmission@hq.doe.gov

West Coast OSW Transmission Study (WOW-TS)

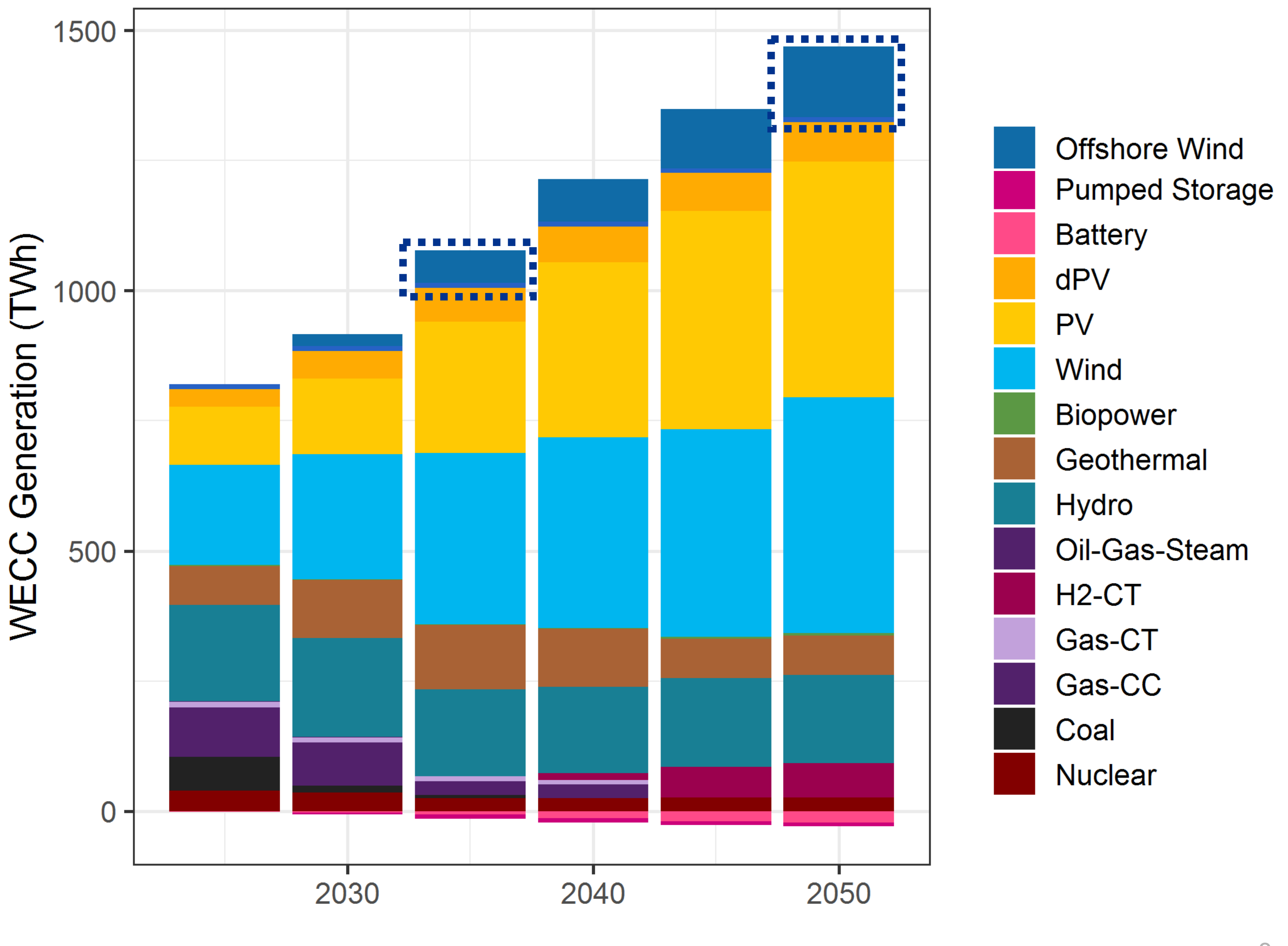


Capacity Expansion Results
All generation technologies (WECC)

Installed Capacity (GW)

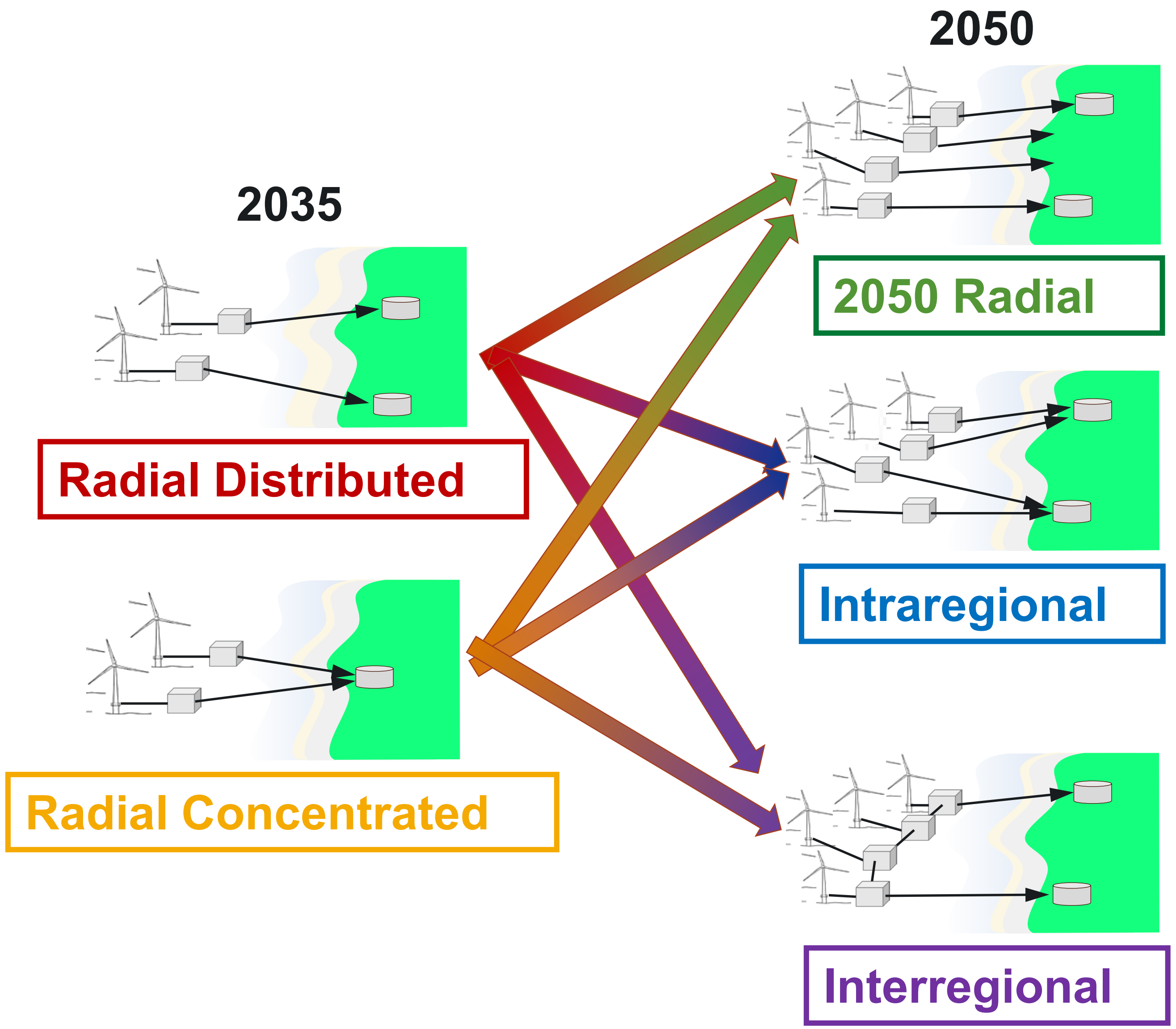


Annual Generation (TWh)



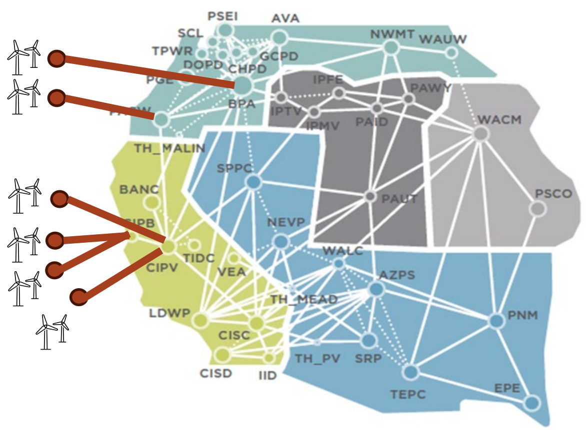
Topology Sets & Development Pathways

Topology Set	Year	OSW (GW)	No. of POIs
Radial, Distributed	2035	15	9
Radial, Concentrated	2035	15	5
Radial (Counterfactual)	2050	33	13
Intraregional	2050	33	13
Interregional	2050	33	13

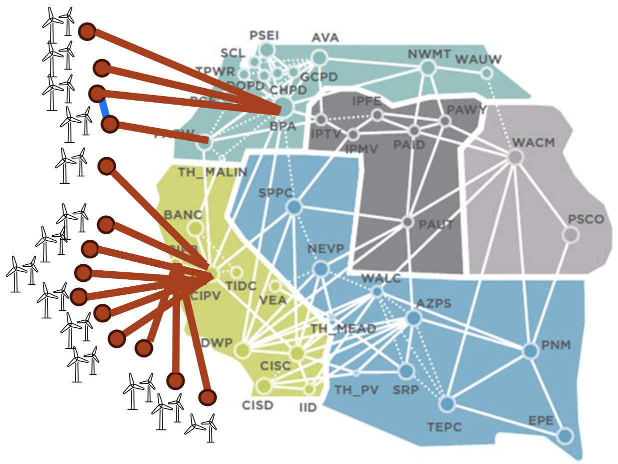


Resource Adequacy in GridPath RA Toolkit

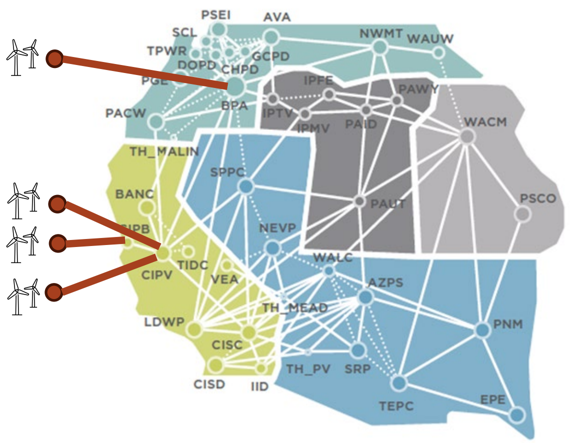
- 38 Zonal topology compatible with WECC Load Areas + Key Path Interfaces
- The transmission topology, line ratings, and path limits are synced to the PCM
- Forced outages are assumed for thermal generation.
- Weather-dependent generation de-rates are not modeled.
- Forced outages of transmission are not modeled.
- Hydro and energy storage dispatch assumes perfect foresight through 7-day subproblems



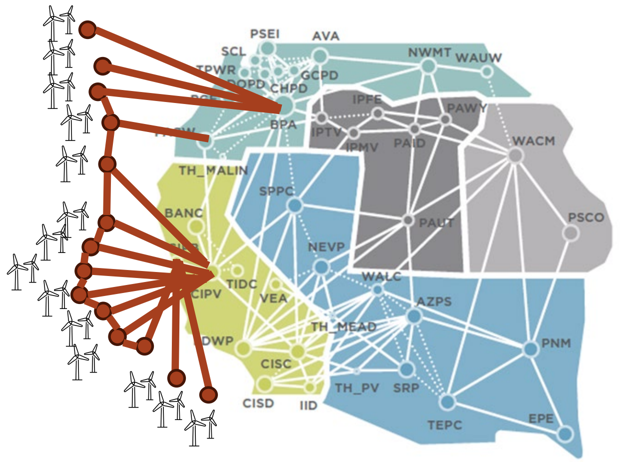
Radial Distributed



2050 Radial | Intraregional



Radial Concentrated



Interregional

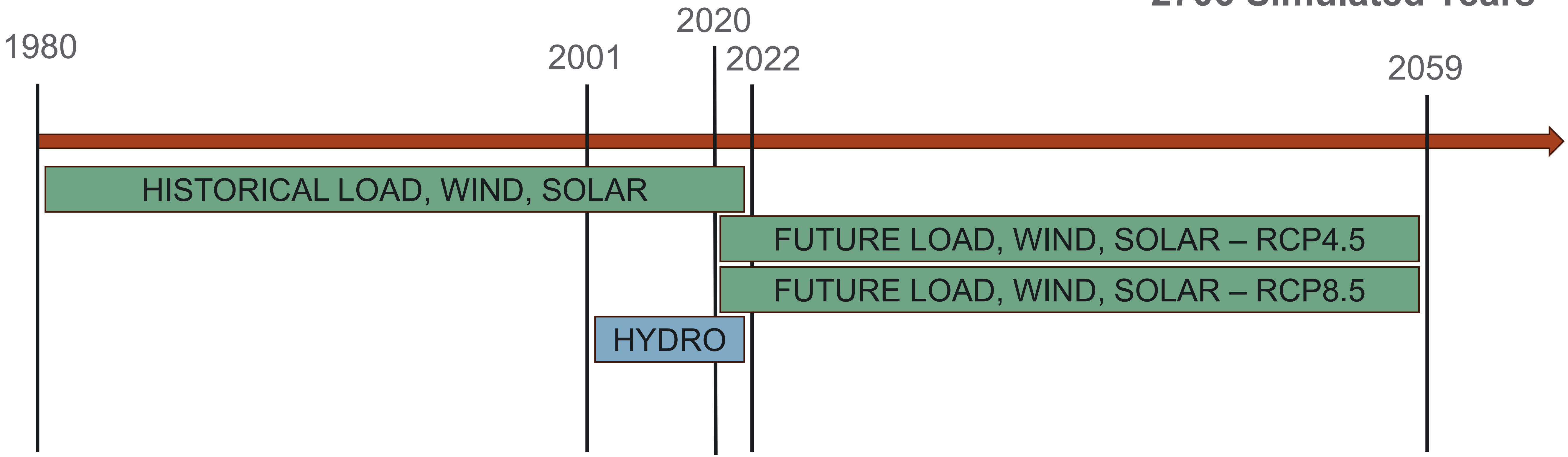
https://gridlab.org/wp-content/uploads/2022/10/GridLab_RA-Toolkit-Report-10-12-22.pdf

Weather-Synchronized Time Series

43 *Historical* Weather Years X 22 Hydro Years = 946 Simulated Historical Years

40 *Future* Weather Years X 22 Hydro Years X 2 Climate Pathways = 1760 Simulated Future Years

2706 Simulated Years

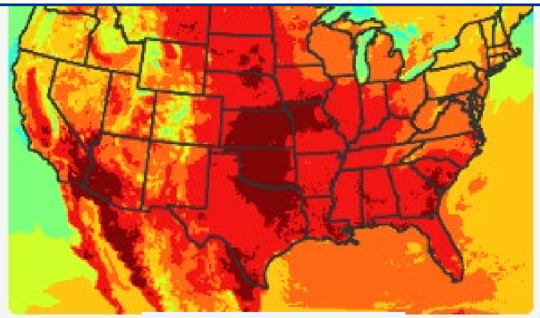


Time series: Coincident Meteorology

- **Meteorology**: IM3 Thermodynamic Global Warming (TGW) Numerical Weather Prediction model datasets, spanning 1980 – 2022
    - Future climate scenarios from historical weather repeated forward with Representative Climate Pathway 4.5, 8.5 (RCP4.5, RCP8.5), spanning 2020-2059

INTEGRATED MULTISECTOR MULTISCALE MODELING

Thermodynamic Global Warming WRF



12km/1hr

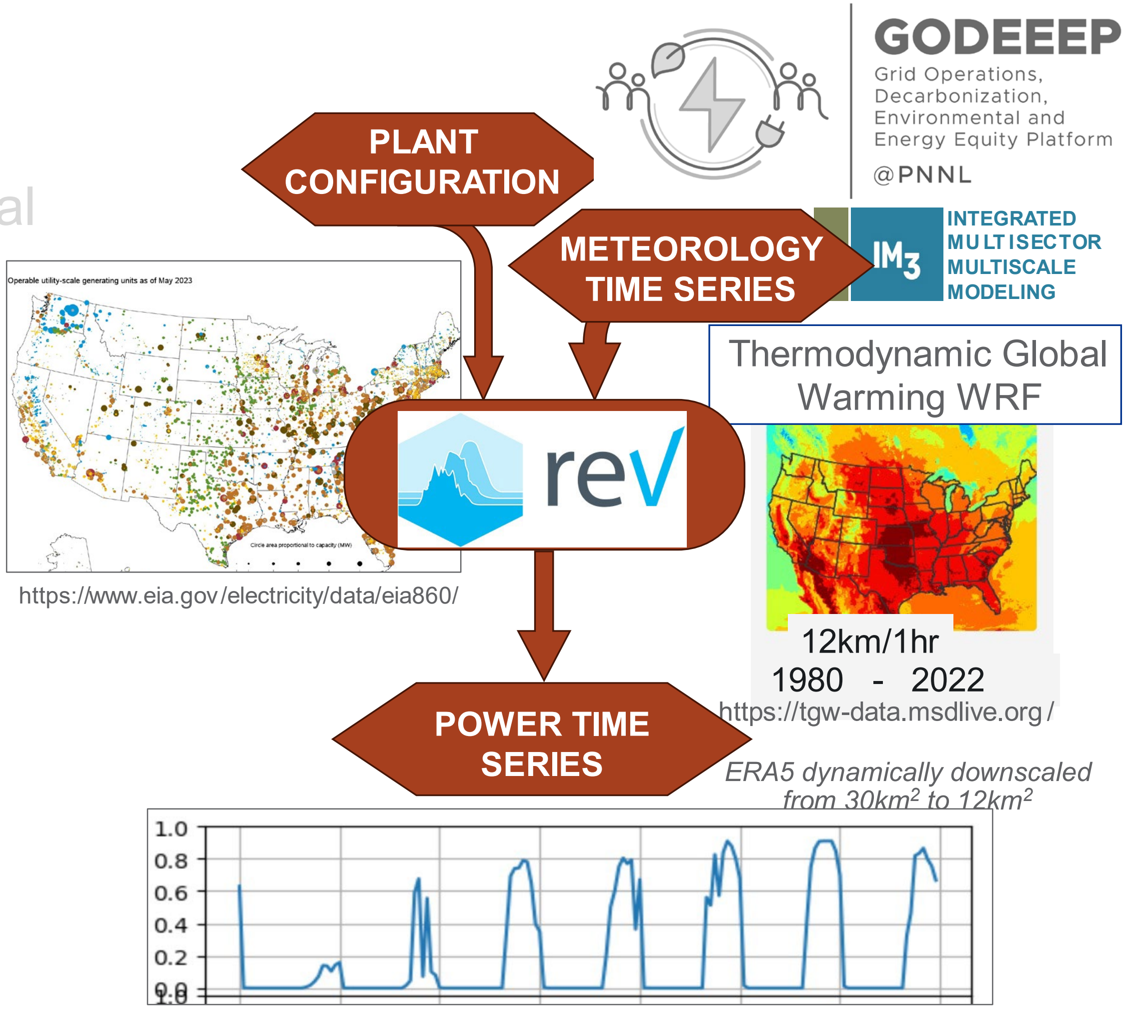
1980 - 2022

https://tgw-data.msdlive.org/

Climate data was developed with DOE Sc funding and is publicly available: https://data.msdlive.org/records/cnsy6-0y610

Time series: Hourly Wind + Solar (1980 – 2059)

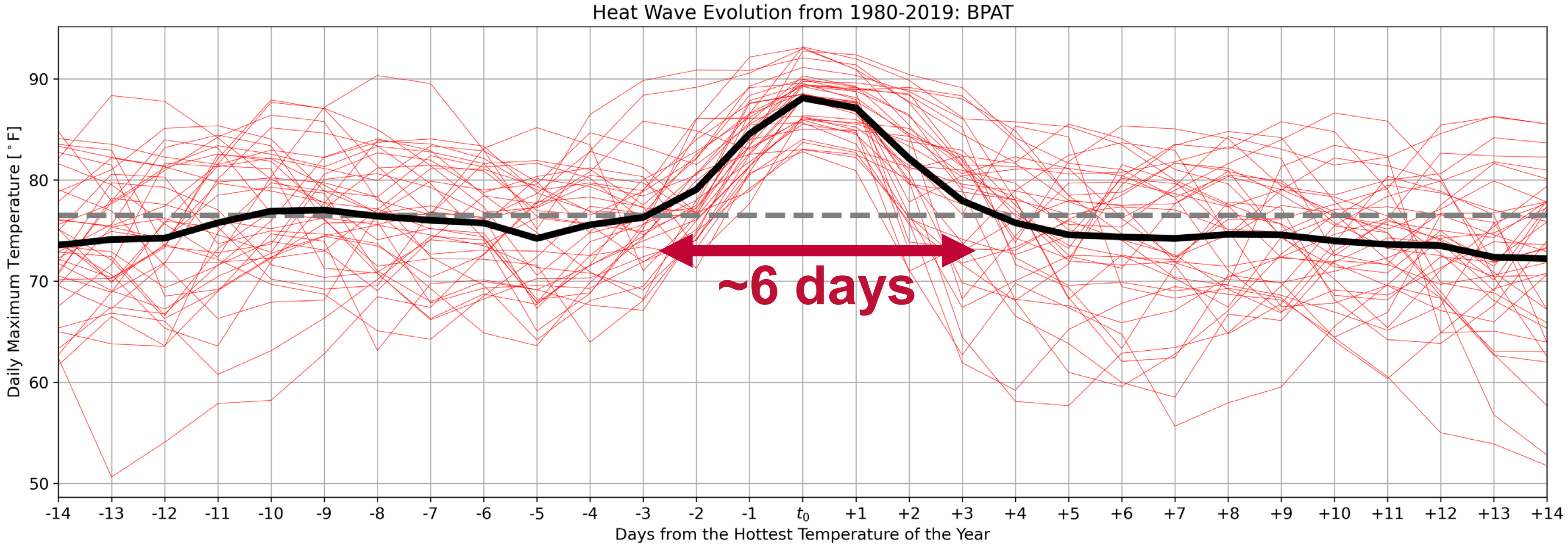
- Meteorology: IM3 Thermodynamic Global Warming (TGW) Numerical Weather Prediction model datasets, spanning 1980 – 2022
    - Future climate scenarios with Representative Climate Pathway 4.5, 8.5 (RCP4.5, RCP8.5), spanning 2020-2059
- **Wind + Solar Generation**: TGW + EIA 860 plant configurations

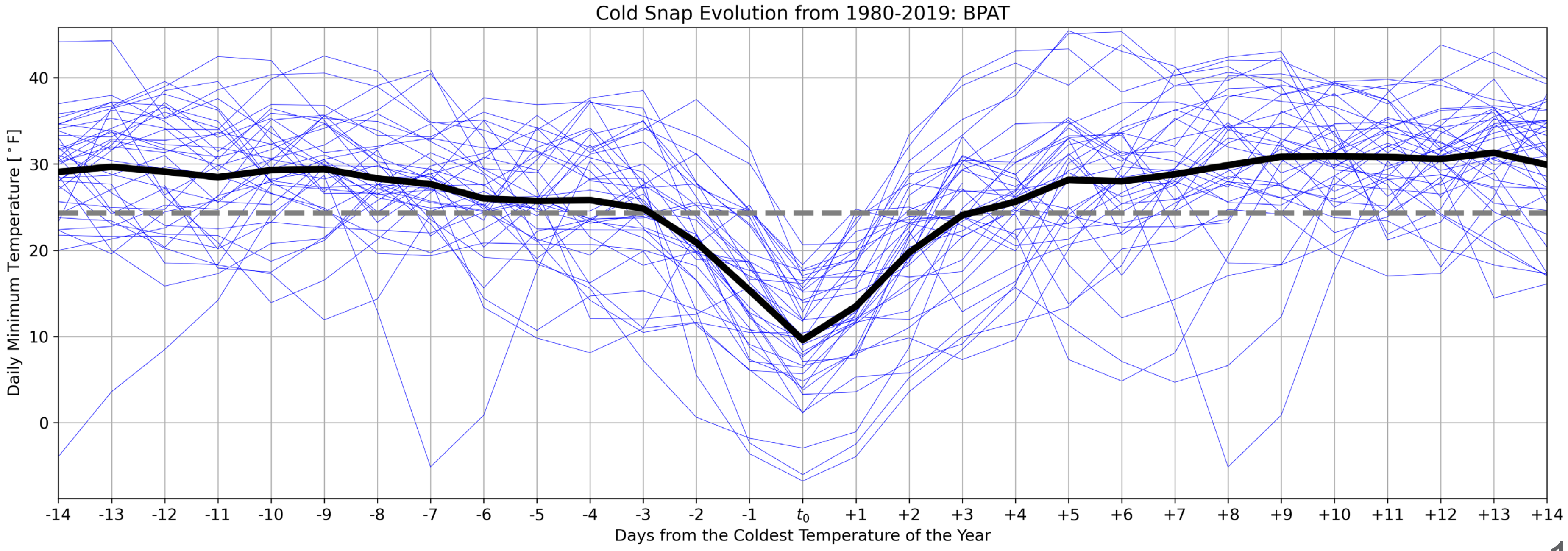


Historical Plant-Scale Hourly Solar and Wind for Lower 48 U.S. States
https://zenodo.org/records/8393319

Extreme Events: Heat Wave and Cold Snap Duration in BPAT

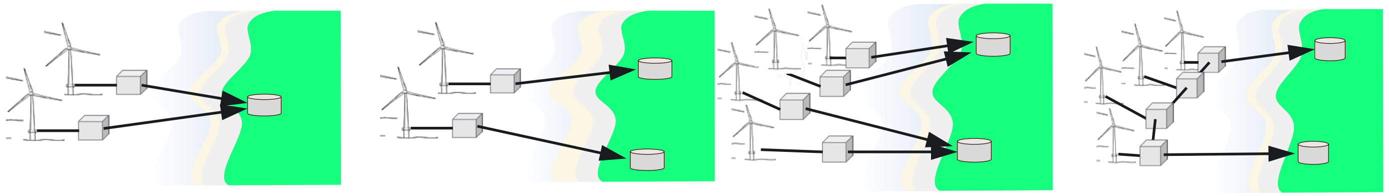
- Analyzed the hottest and coldest day of each year (1980-2019) in each BA in the WECC
- **Typical heat waves and cold snaps last ~6-7 days and are, on average, symmetric about the max/min temperature day**
- We use these event dates and meteorology time series to select extreme hot/cold events to study
- These patterns are consistent across BAs in the WECC in the historical record

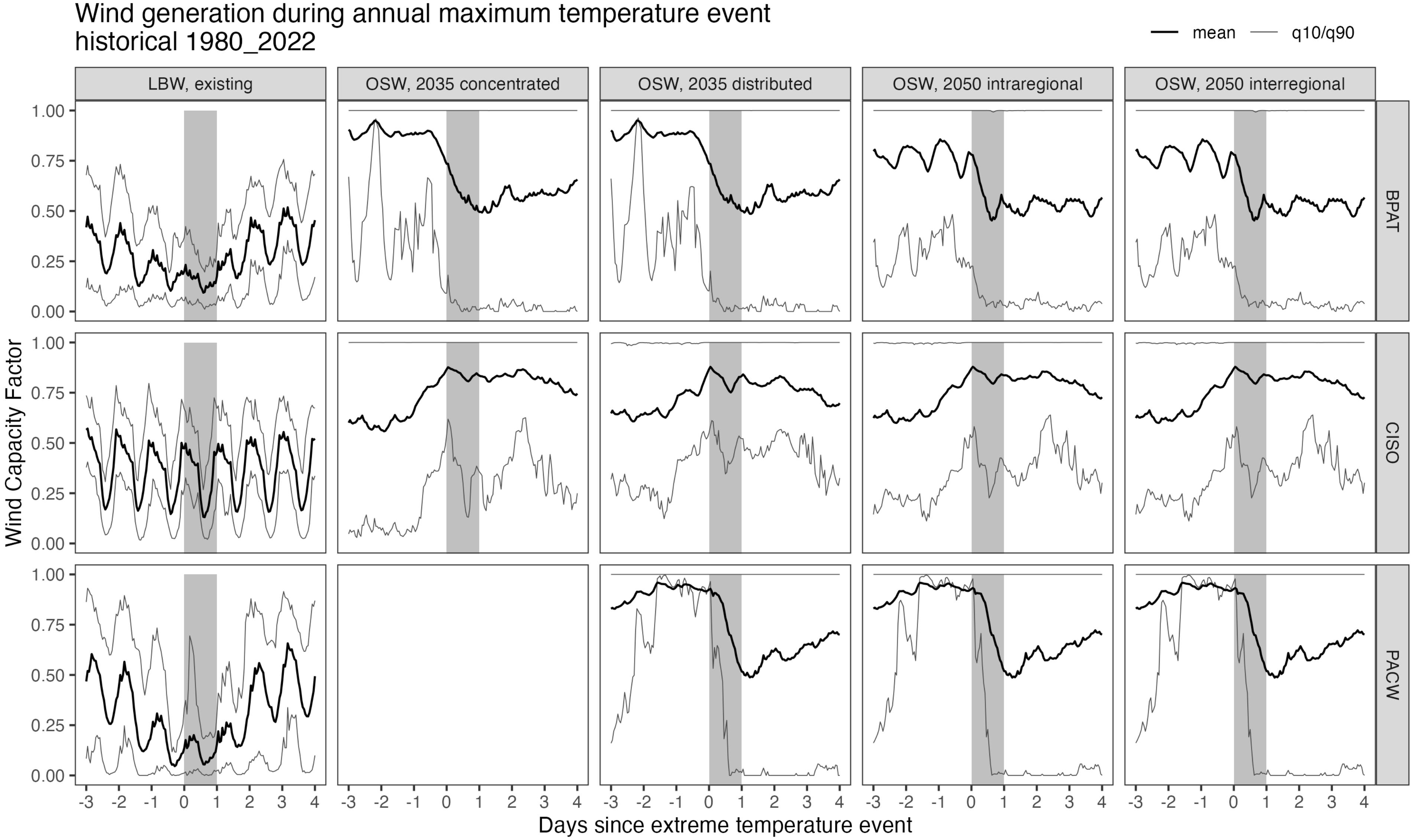


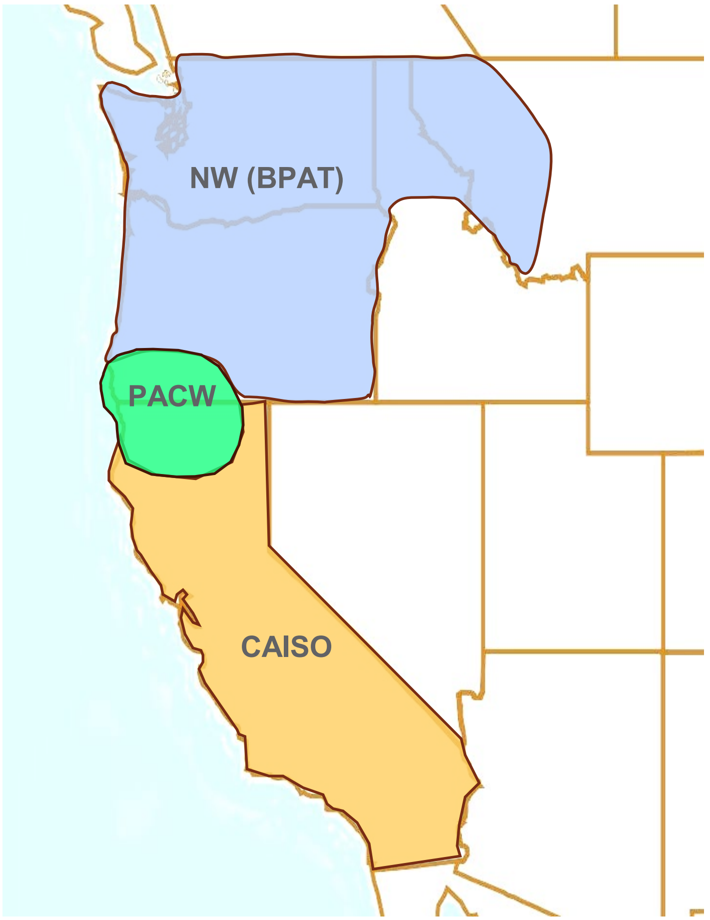


OSW profiles, gross capacity factor, historical weather, heat waves

Existing Wind

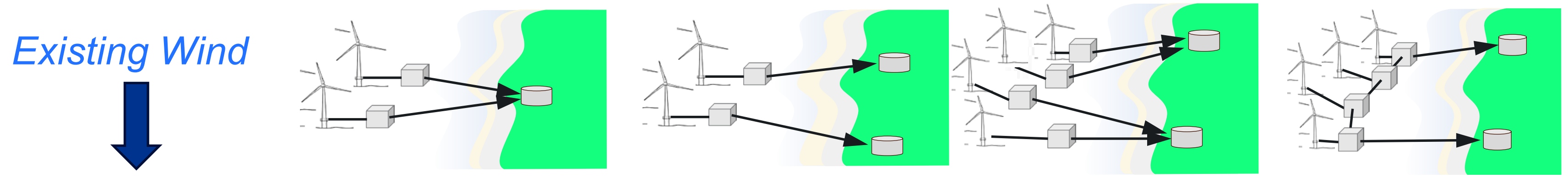


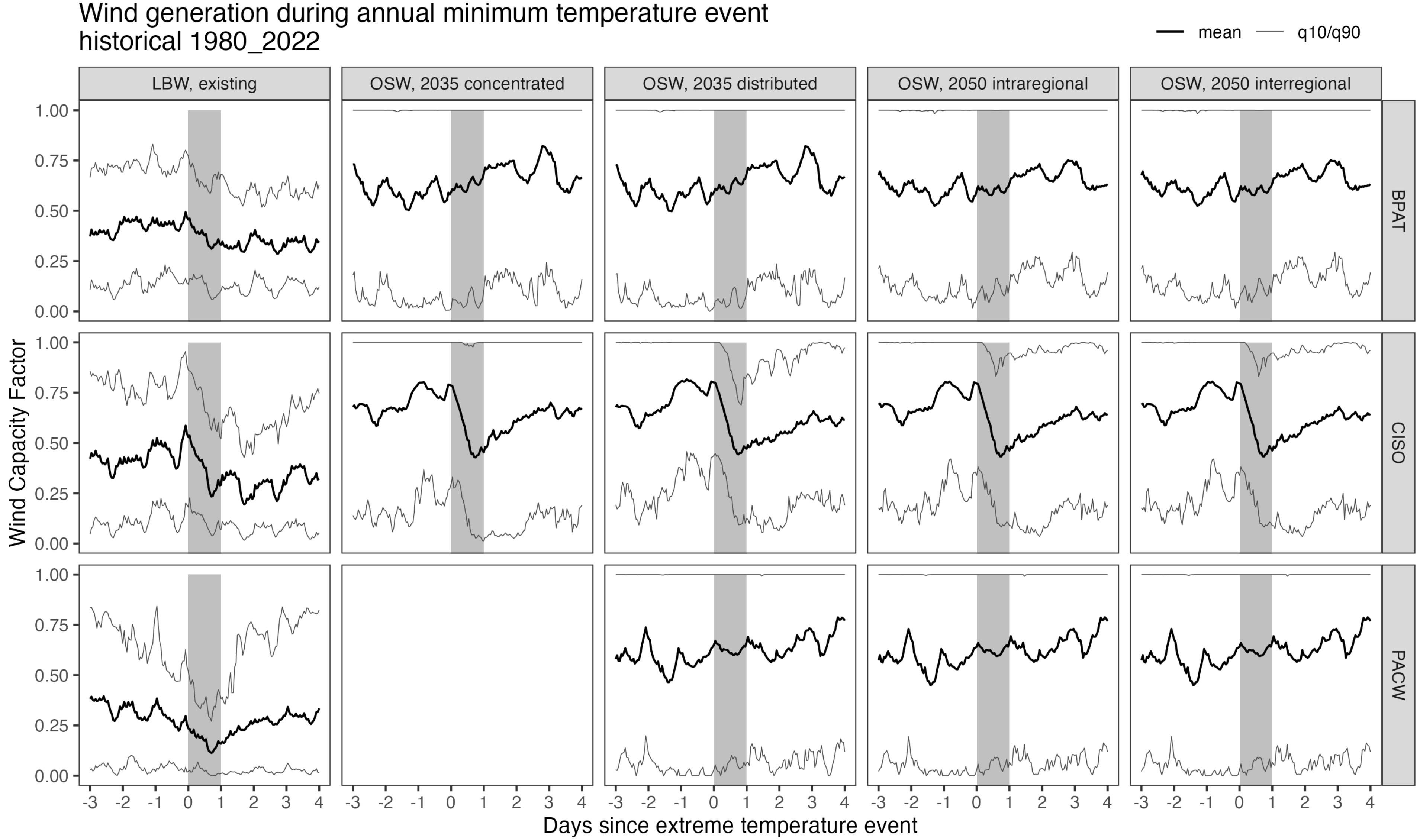


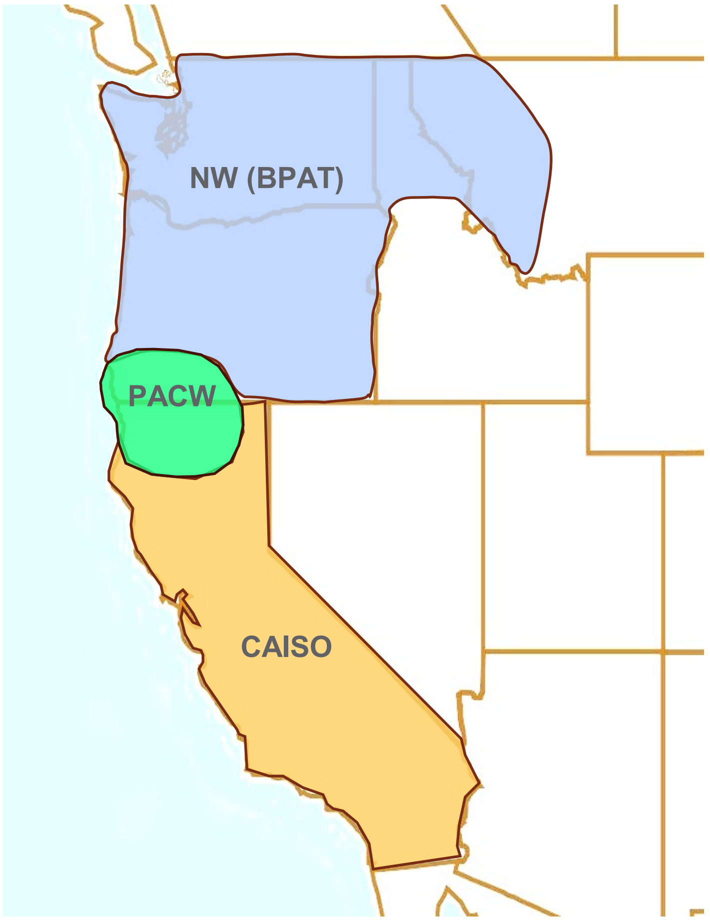


**LBW—Land-based Wind*

OSW profiles, gross capacity factor, historical weather, cold snaps



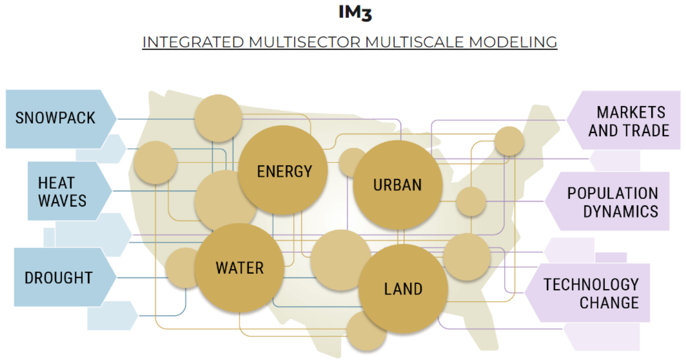




**LBW—Land-based Wind*

Time series: Hourly Load (1980 – 2059)

- Meteorology: IM3 Thermodynamic Global Warming (TGW) Numerical Weather Prediction model datasets, spanning 1980 – 2022
  - Future climate scenarios with Representative Climate Pathway 4.5, 8.5 (RCP4.5, RCP8.5) , spanning 2022-2059
- Wind + Solar Generation: TGW + EIA 860 plant configurations
- **Load**
  - Feed-forward neural net trained for each BA based on population-weighted weather by county[1]
  - Projected Evolved Energy Research's (EER)[2] electrified load growth scenarios based on bottom-up energy demand forecasts for 2035 & 2050, to historical and future weather years.



[1] im3.pnnl.gov

[2] Full EER Report for 2022:
https://www.evolved.energy/post/adp2022

Time series: Weekly Hydropower (2001 – 2022)

- Meteorology: IM3 Thermodynamic Global Warming (TGW) Numerical Weather Prediction model datasets, spanning 1980 – 2022
  - Future climate scenarios with Representative Climate Pathway 4.5, 8.5 (RCP4.5, RCP8.5) , spanning 2022-2059
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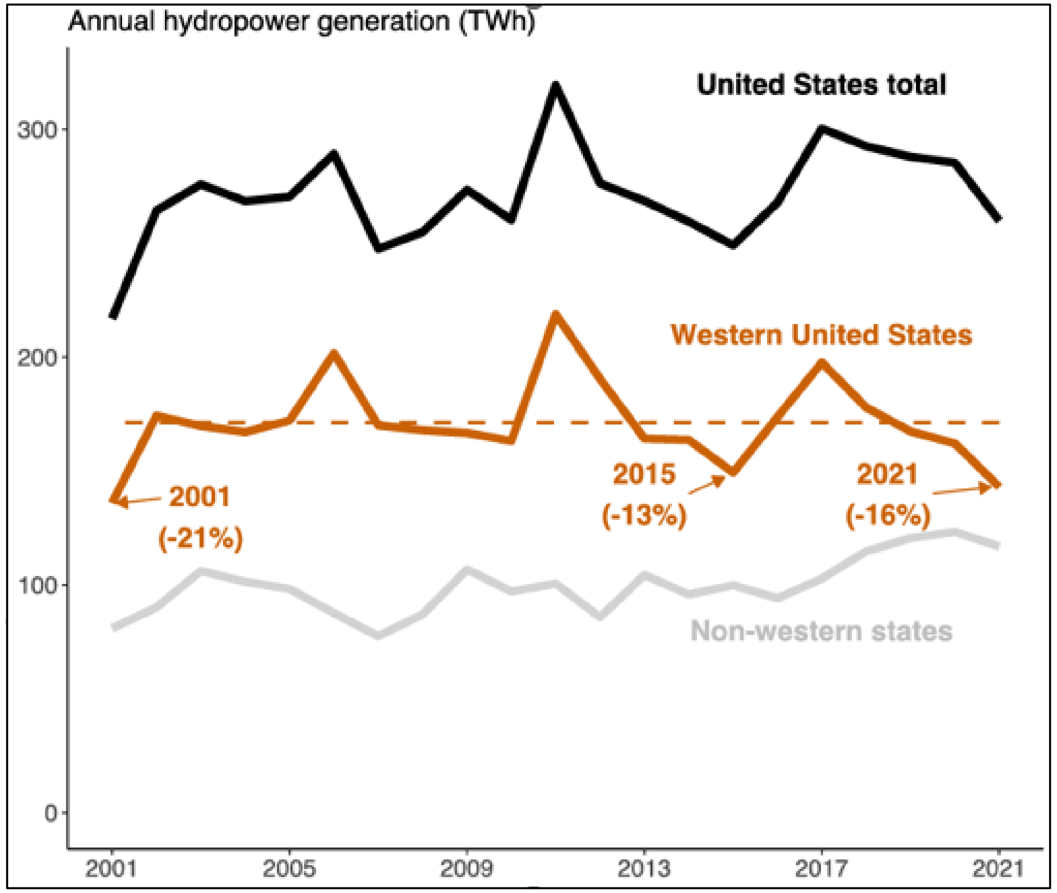
- Load:
  - Feed-forward neural net trained for each BA based on population weighted weather by county
  - Projected Evolved Energy Research's (EER) electrified load growth scenarios based on bottom-up energy demand forecasts for 2035 & 2050, to historical and future weather years.
- **Hydro**: Observed monthly/weekly volumes from EIA923 for 2001-2022



Turner, S.W.D., Voisin, N. & Nelson, K. Revised monthly energy generation estimates for 1,500 hydroelectric power plants in the United States. *Sci Data* **9**, 675 (2022). https://doi.org/10.1038/s41597-022-01748-x

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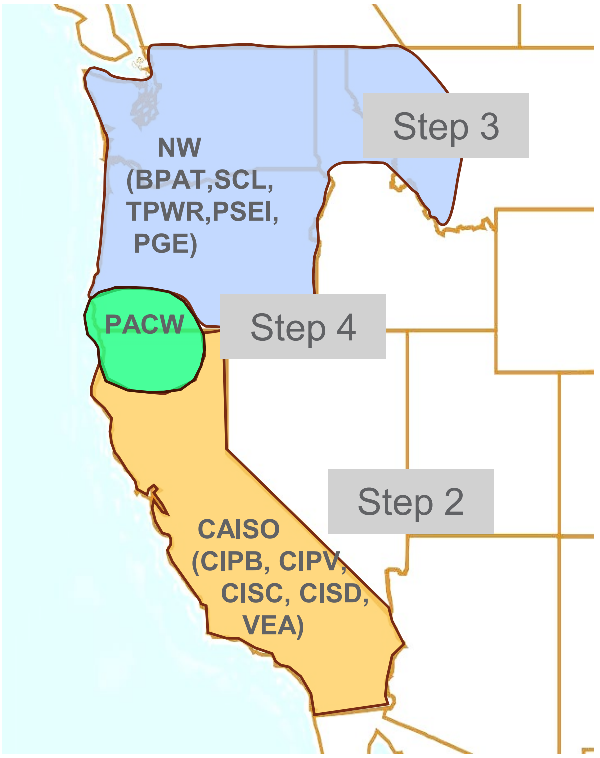
NREL Transforming ENERGY

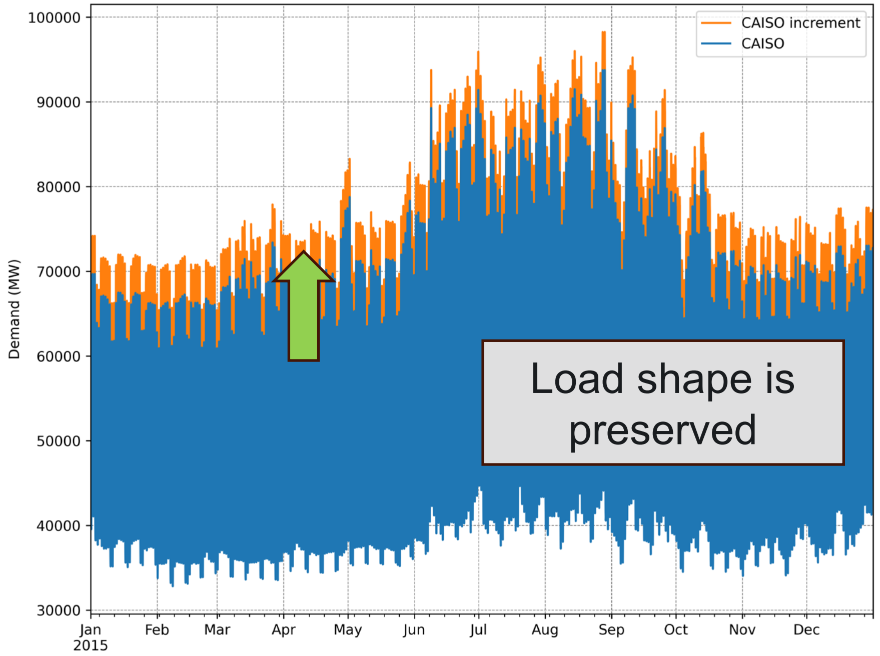
Effective Load Carrying Contribution: Balancing Method

With OSW included, all historical weather years, and seven representative hydro years (2001, 2002, 2004, 2005, 2007, 2009, 2011):

1. Seed problem by running ~150% load scaling for CAISO + PACW + NW, and isolate weeks of unserved energy (USE). Complete remaining steps on these problems.
2. Disallow USE everywhere but CAISO. Increment CAISO load until LOLE = 0.1. Lock loads and USE in CAISO.
3. Retain loads and USE from prior step. Allow USE in NW and increment NW load until LOLE = 0.1 in NW.
4. Retain loads and USE from prior step. Allow USE in PACW and increment PACW load until LOLE=0.1 in PACW.

Repeat steps 1-4 without OSW and compare the loads between the balanced final runs to define the ELCC.

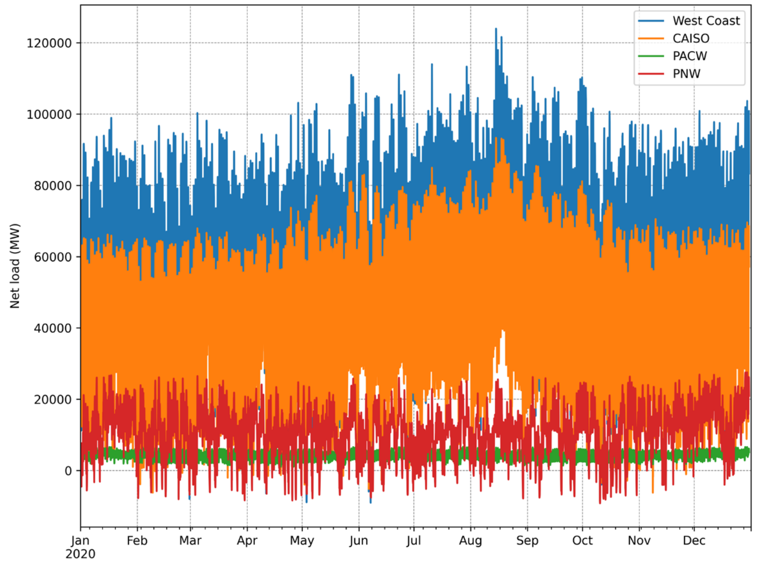




ELCC findings (preliminary)

- Increment load shape to reach LOLE=0.1 in all three regions, take difference of increments with and without OSW to quantify ELCC of OSW

Topology Set	CAISO ELCC (MW)	PACW ELCC (MW)	PNW ELCC (MW)	Total ELCC (%)
2035 Concentrated	7178	0	0	48%
2035 Distributed	7438	0	0	50%
2050 Radial	13472	0	0	41%
2050 Intraregional	13472	0	0	41%
2050 Interregional	13474	0	0	41%



- OSW provides robust ELCC through 2050
- Critical system needs are driven by CA net loads in mid-late summer evenings
- Improvement in 2035 by injecting more OSW into CIPB
- No RA value of the interregional or intraregional transmission given the onshore system designs

Thank you

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