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Docket Number:	15-RETI-02
Project Title:	Renewable Energy Transmission Initiative 2.0
TN #:	213505
Document Title:	Panel 1 Presentation - RETI 2.0 Western Outreach Workshop
Description:	By David Hurlbut - RETI 2.0 Western Outreach Project: Las Vegas Workshop 9-1-16
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Organization:	National Renewable Energy Laboratory (NREL)
Submitter Role:	Public
Submission Date:	9/6/2016 11:31:17 AM
Docketed Date:	9/6/2016

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

RETI 2.0 Western Outreach Workshop

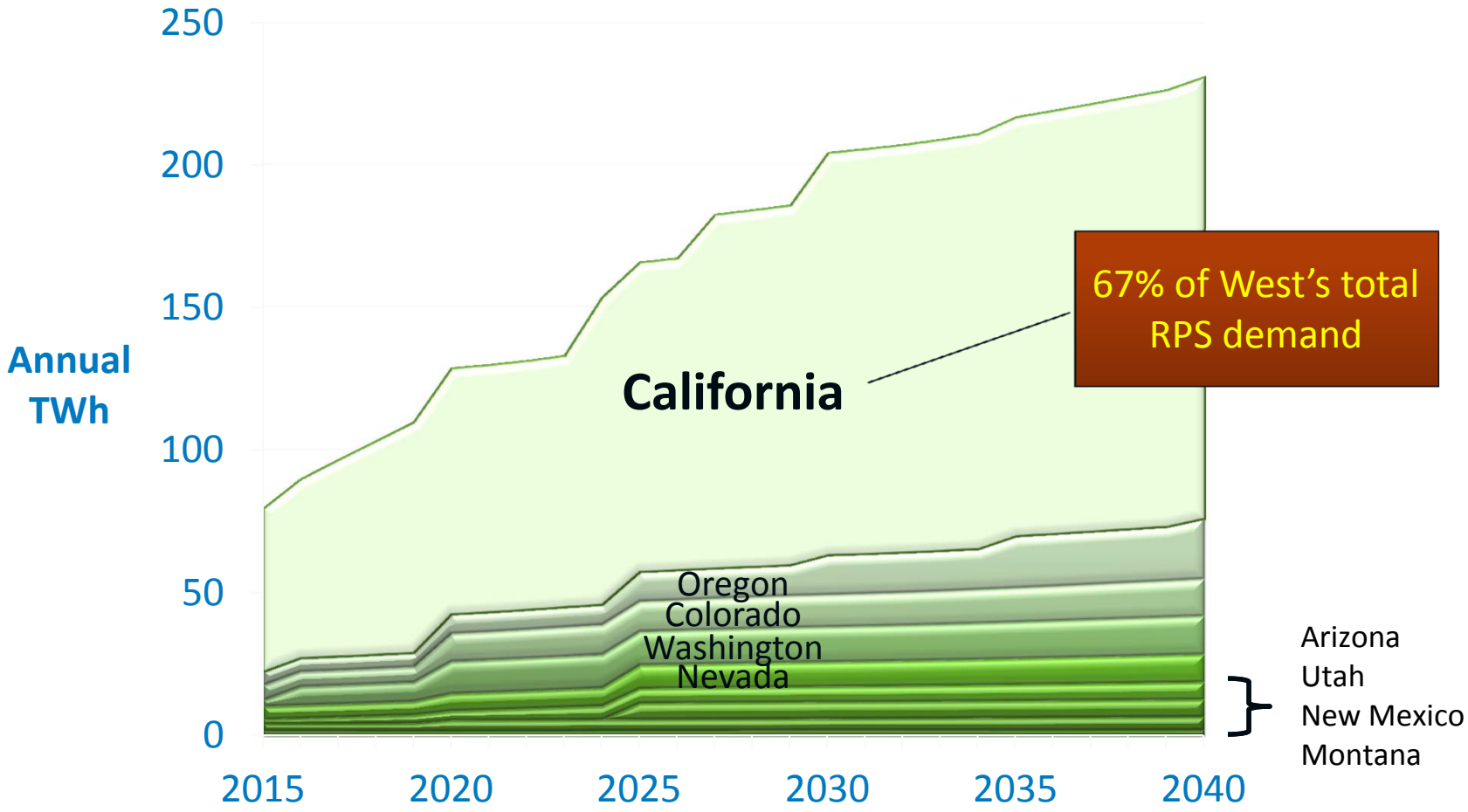
David Hurlbut

September 1, 2016
Las Vegas, Nevada

Topics

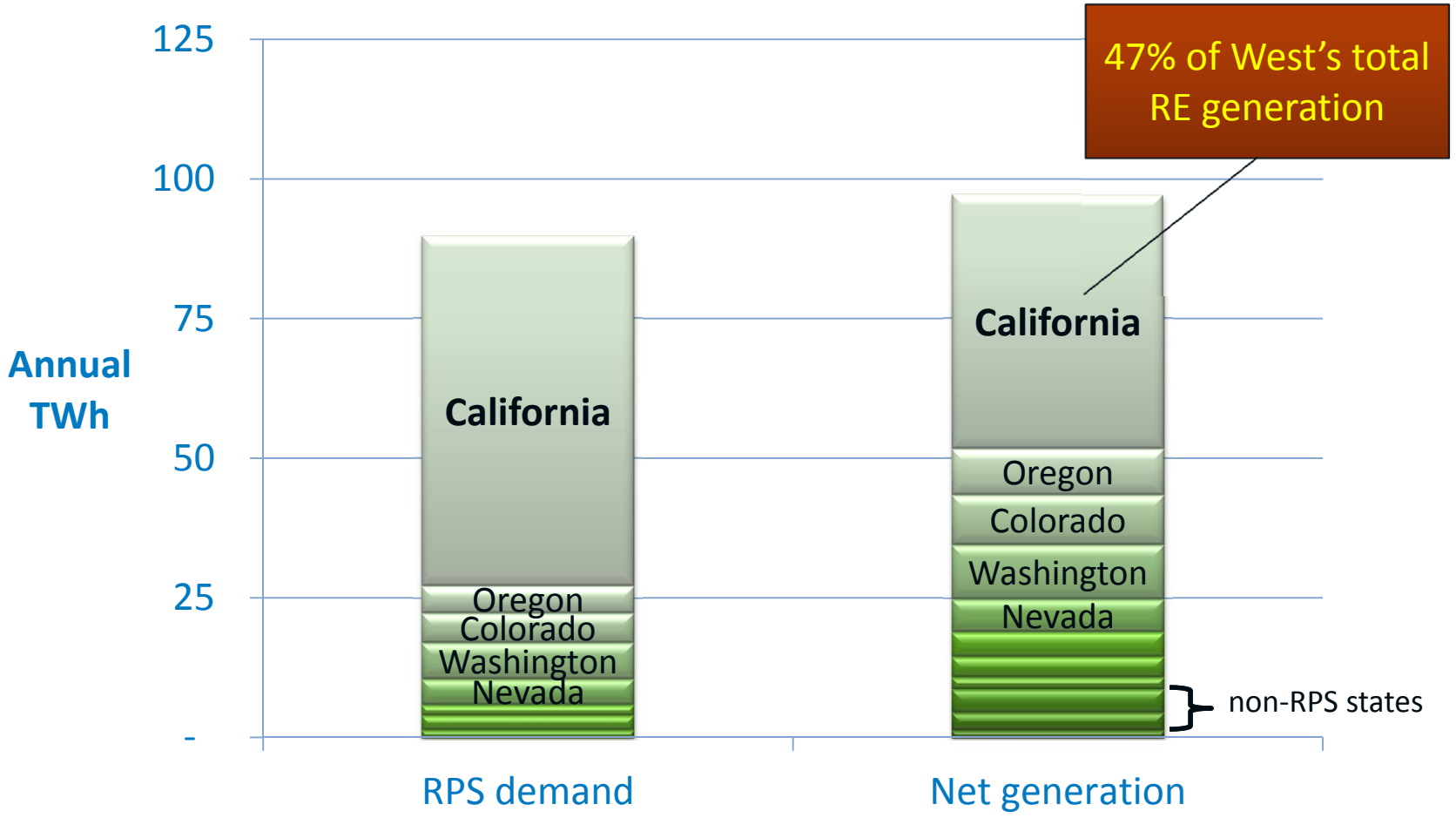
- West-wide RPS demand by state
- Current renewable energy generation by state
- Mapping current renewable energy development to WREZ resource analysis
- Potential for re-purposing existing transmission
- Technology cost trends

Total demand for renewables under existing state laws



Lawrence Berkeley National Laboratory, RPS Demand Projections, July 2016 (ex. Utah)
NREL projections, Sept. 2016 (Utah)
Projections exclude carve-outs for distributed generation

2016 RPS demand and net generation from renewables



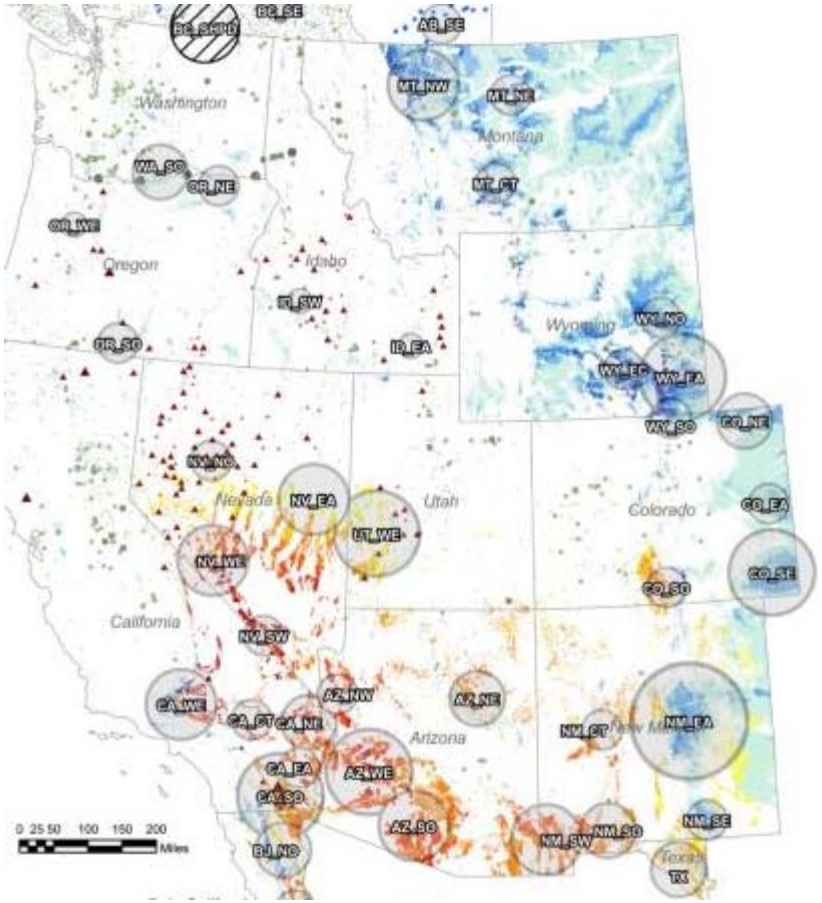
12 months ending July 2016
EIA Form 923 database (wind, solar, geothermal, biomass)

Observations

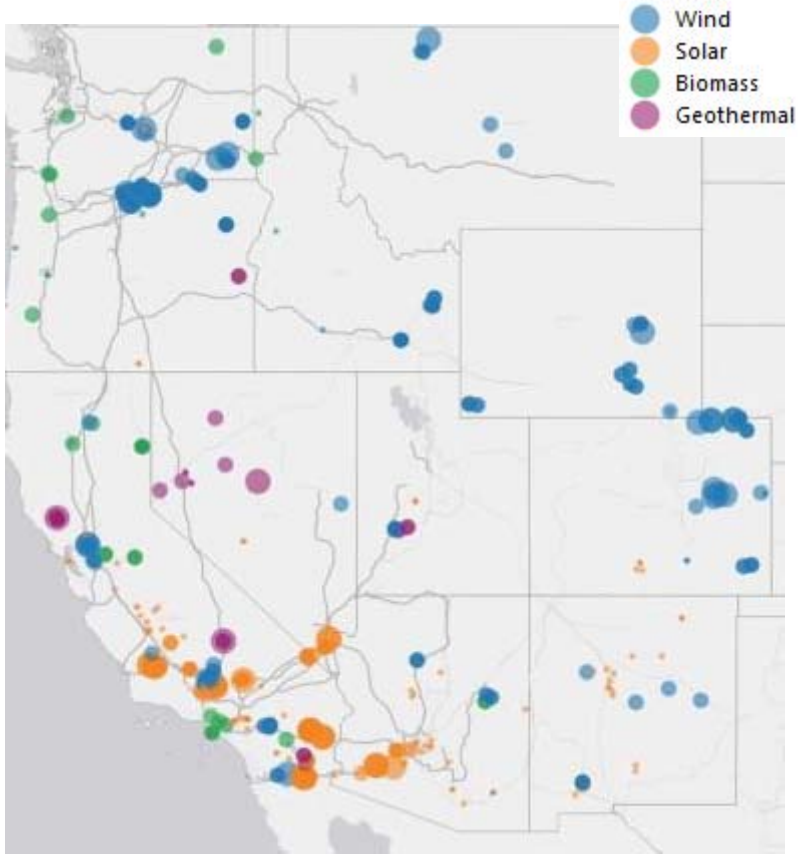
- California has twice as much RPS demand as all other western states combined
  - Magnitude of demand will tend to create new supply, provided that California is a buyer in the Western market
  - Existing development is not a reliable indicator of what supply would look like if California were in the market
- Every western state is generating more RE than required under its RPS for 2016, except California
  - While a given state's RPS requirement and its generation from renewables do not necessarily map to one another, the supply/demand balances suggest that western states except California tend to be natural suppliers more than they tend to be natural demand centers
  - EIM framework could provide a platform for new regional net load forecasting/scheduling protocols that could simultaneously address excess solar generation in California and provide non-California resources with market access

Development is largely following expected patterns

WREZ Resource Map



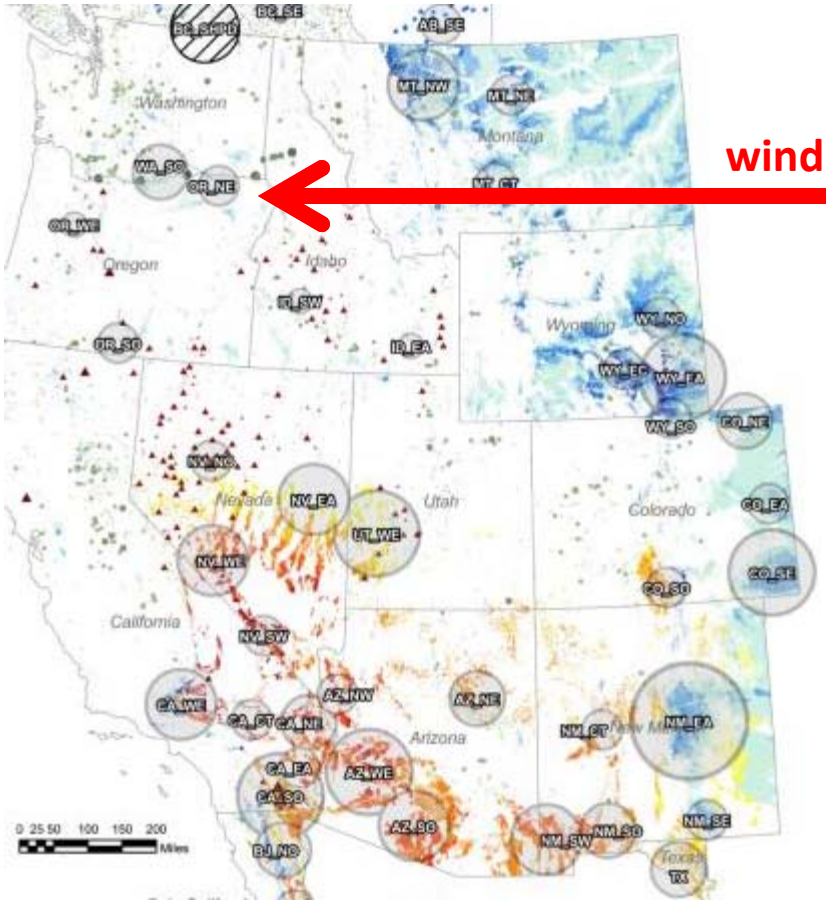
Generation from renewables (2015)



Map shows transmission lines 345 kV and larger

Development is largely following expected patterns

WREZ Resource Map



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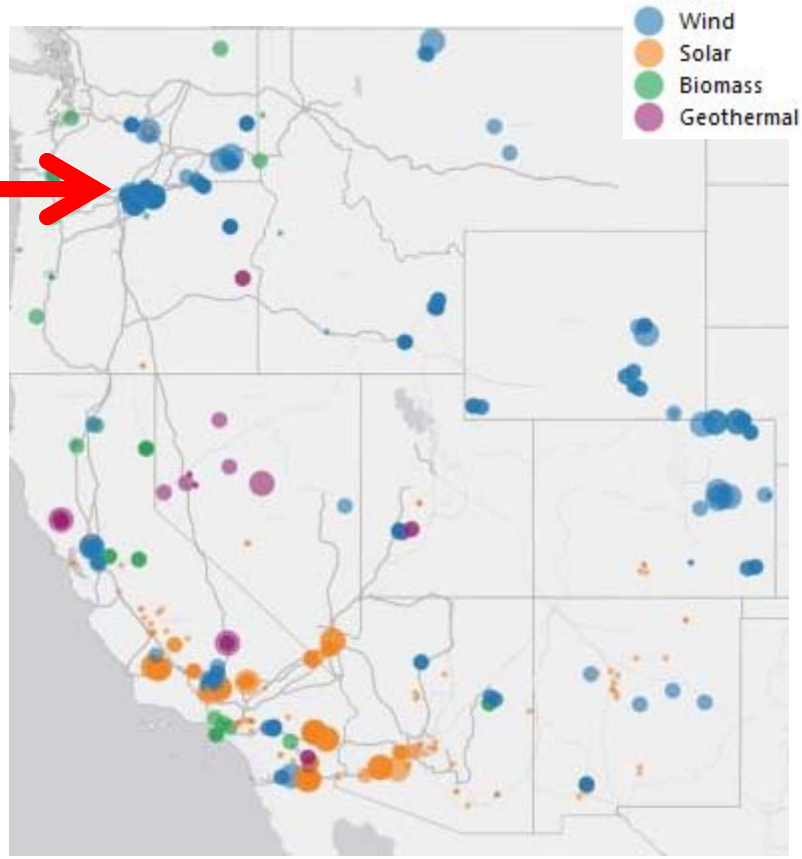

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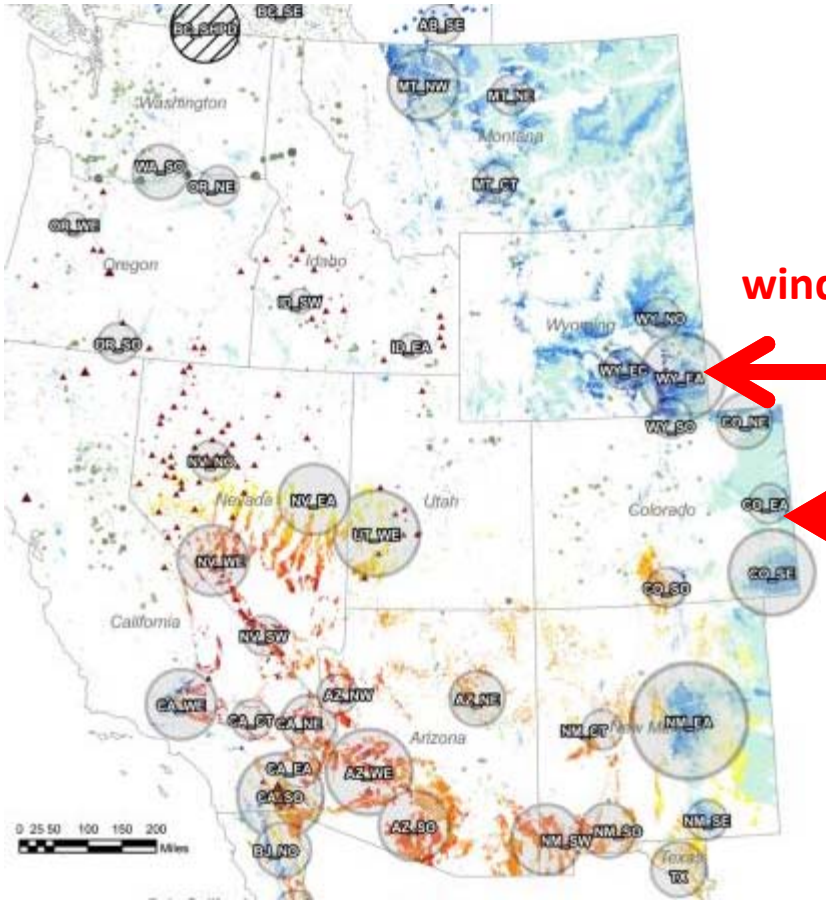
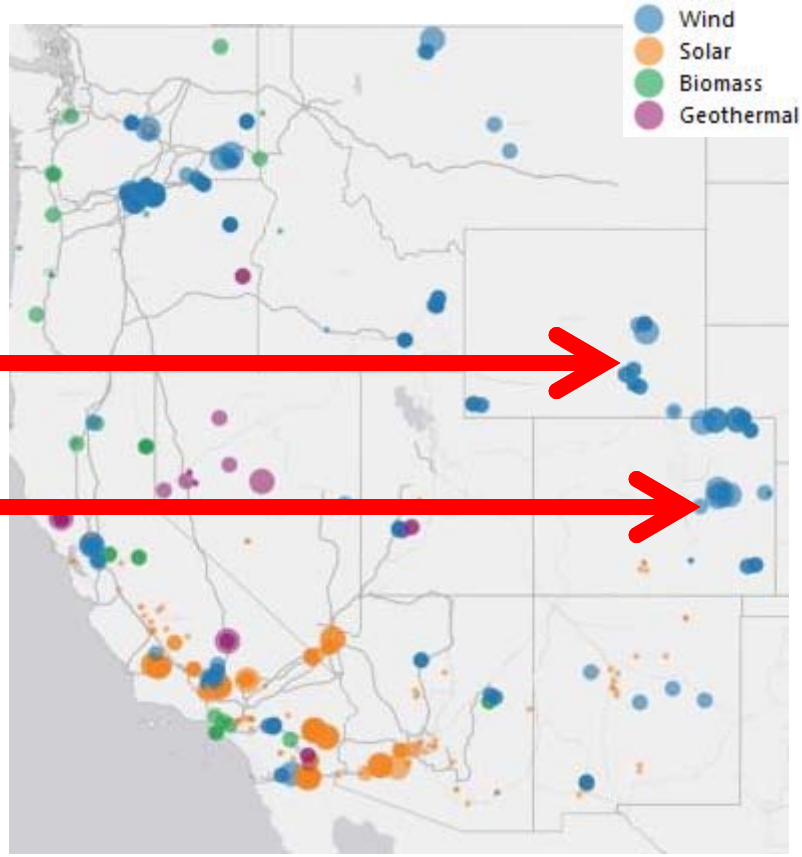


wind

Generation from renewables (2015)



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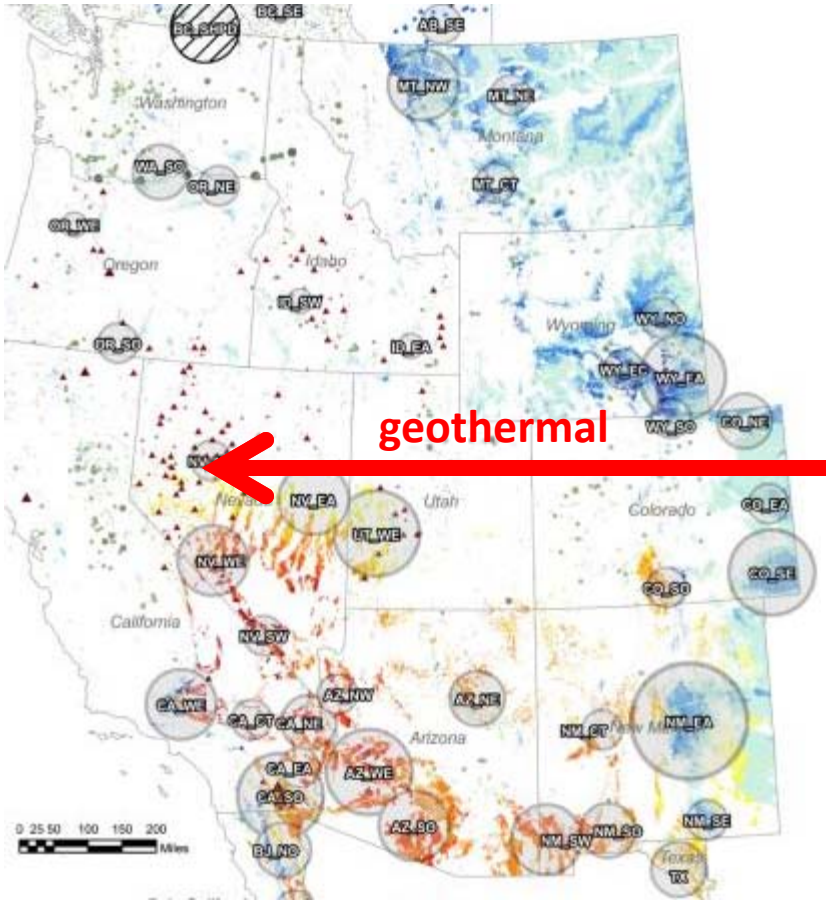
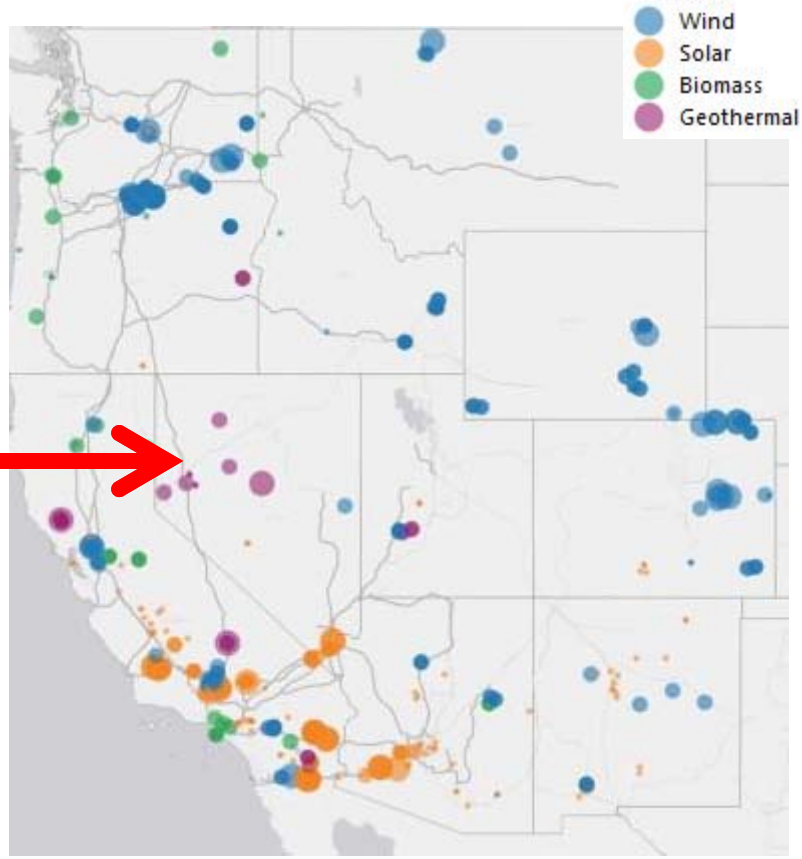


geothermal

Generation from renewables (2015)



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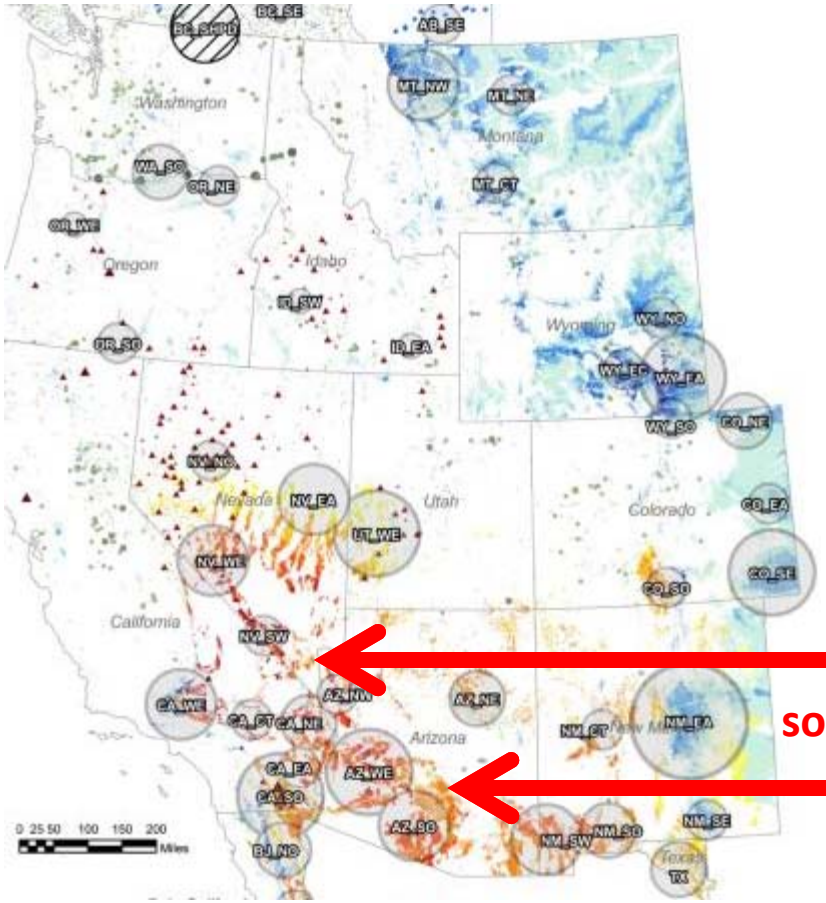

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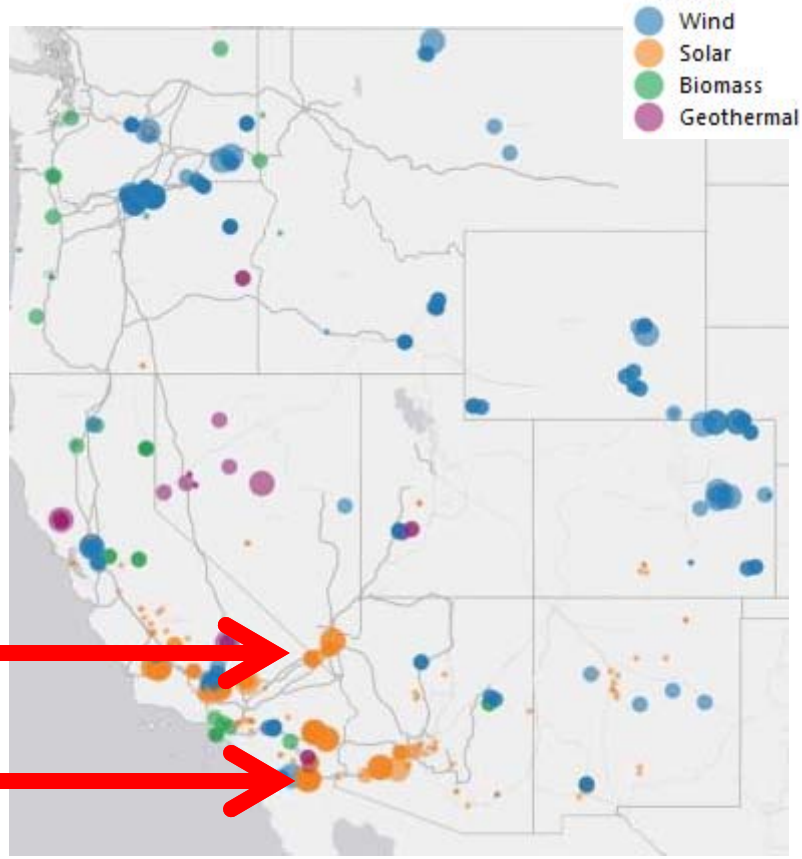


solar

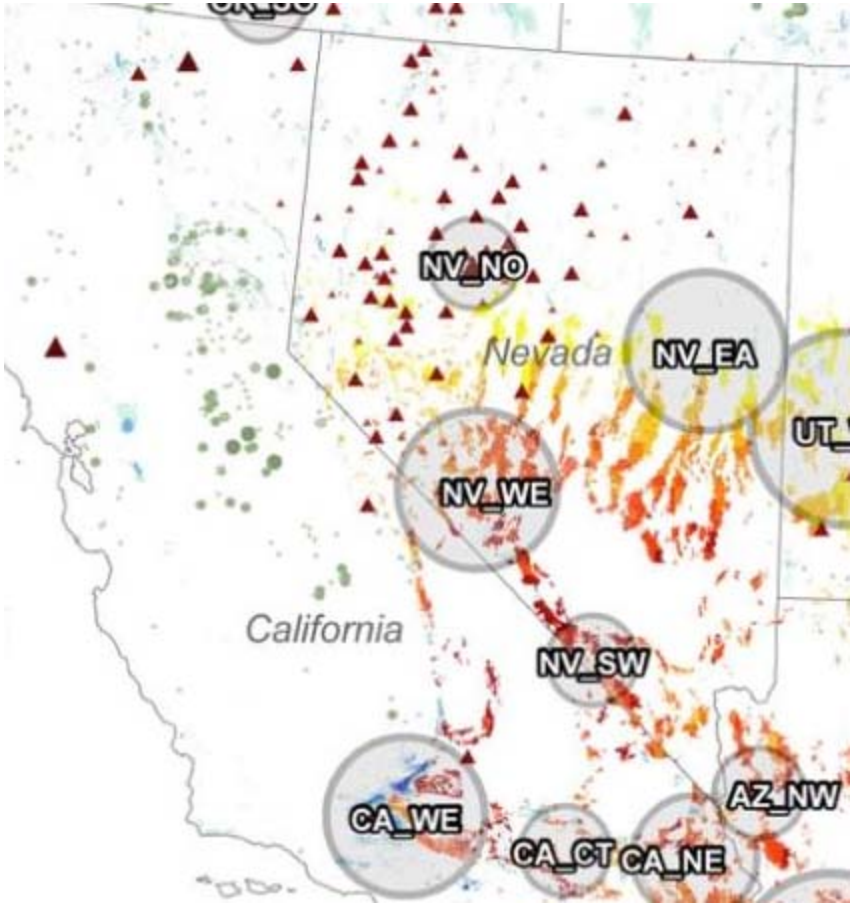
Map shows transmission lines 345 kV and larger

Observations

- Most development has been consistent with WREZ resource assessment, favoring access to nearby load via existing transmission
  - Columbia Gorge is a mature wind zone with legacy exports to California
    - Nearly all existing wind was installed 2012 or earlier
    - 2015 capacity factors ranged from 19% to 31% (avg. 24%)
  - Colorado appears to be the load sink for wind development in Colorado and some in eastern Wyoming
- REZ wind resources in New Mexico, Montana, and Wyoming are relatively underdeveloped based on their quantity and likely productivity
  - In-state native load is relatively small
  - Little existing transmission capability to reach large loads farther West

Transmission limitation

WREZ Resource Map



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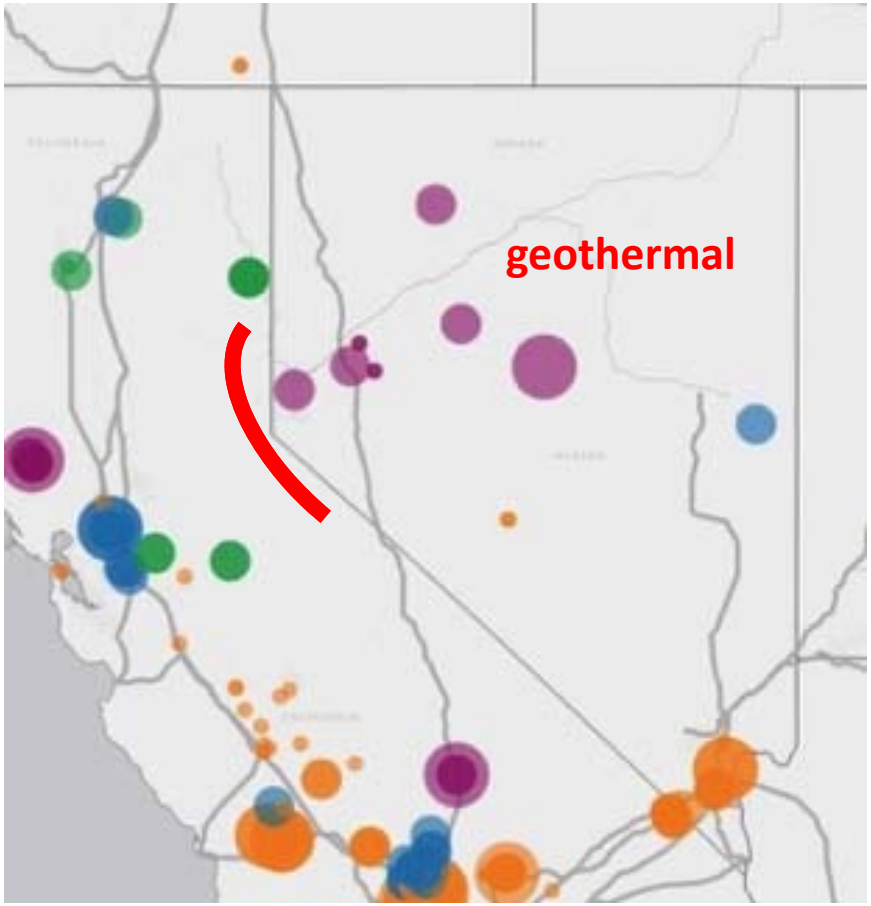
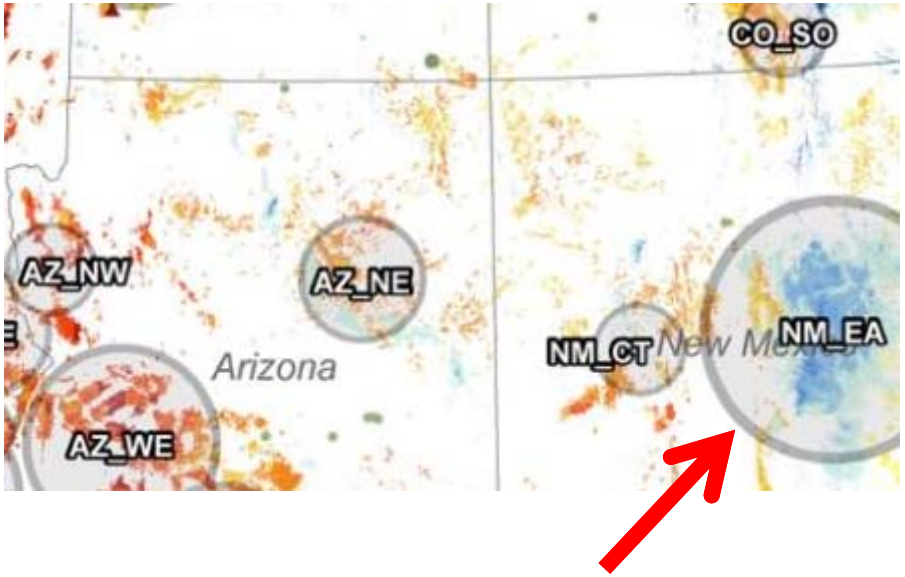


Observations

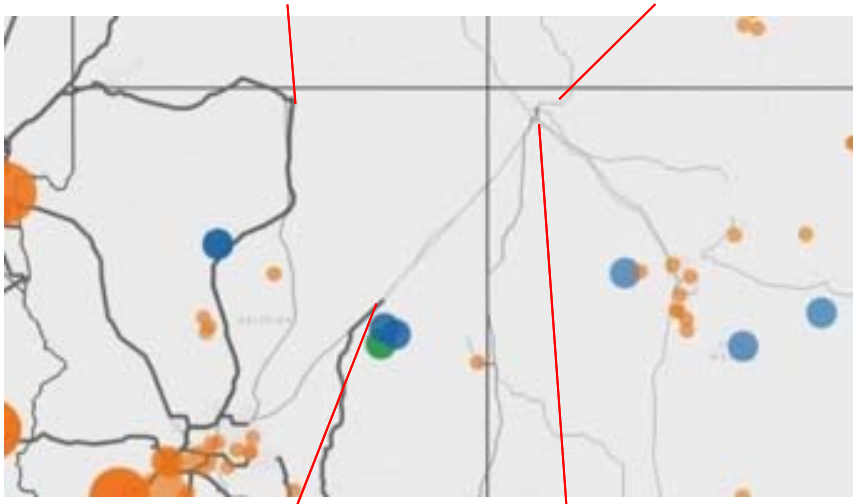
- Geothermal development in western Nevada is consistent with WREZ resource assessments
- Development has coincided with reduced use and retirement of Reid Gardner coal plant
  - Net generation from Nevada's baseload geothermal in 2016 is close to Reid Gardner's average annual generation from 2000 to 2014
- Very limited transfer capability across the Sierras to California
  - Section 368 corridor designated

Potential for re-purposing existing transmission

WREZ Resource Map

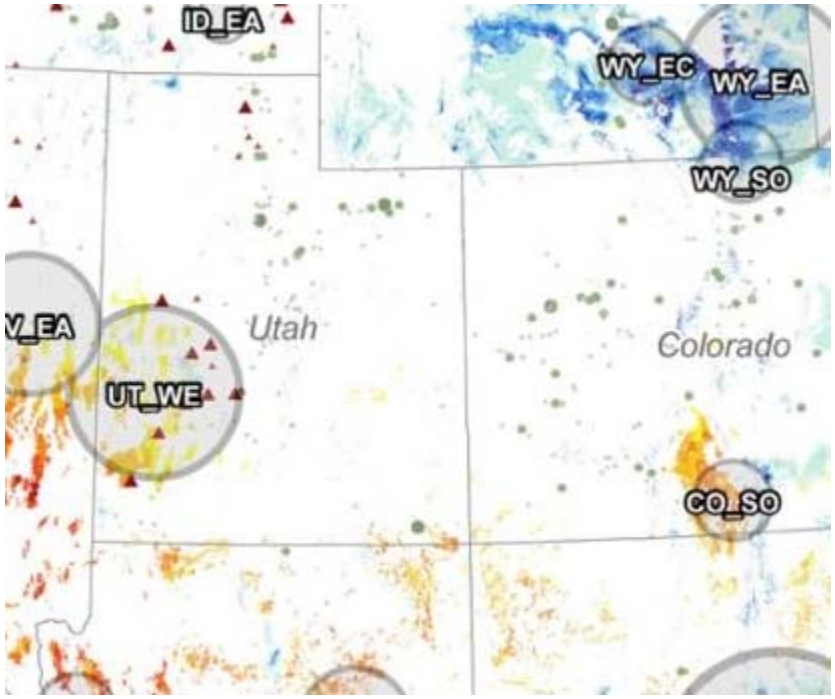


Known coal reductions

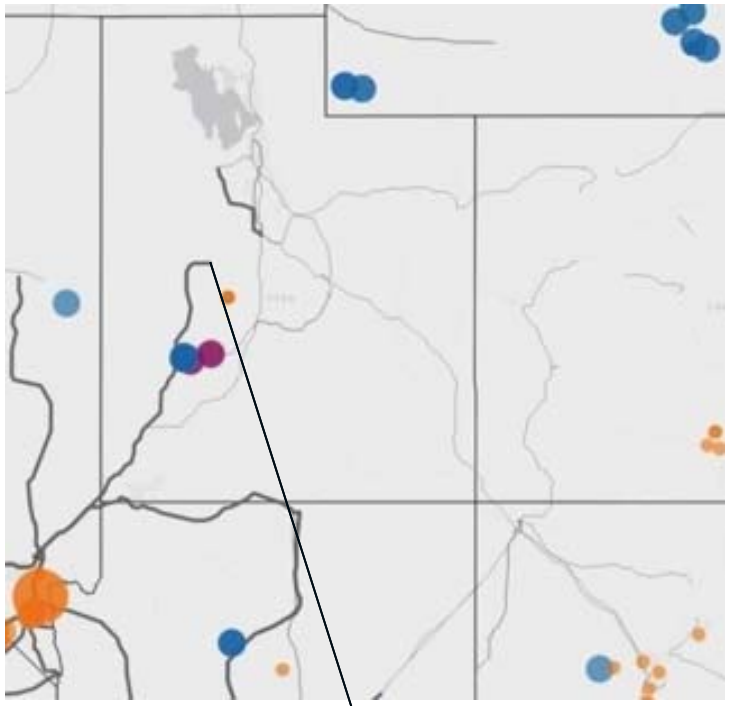


Potential for re-purposing existing transmission

WREZ Resource Map



potential coal reduction

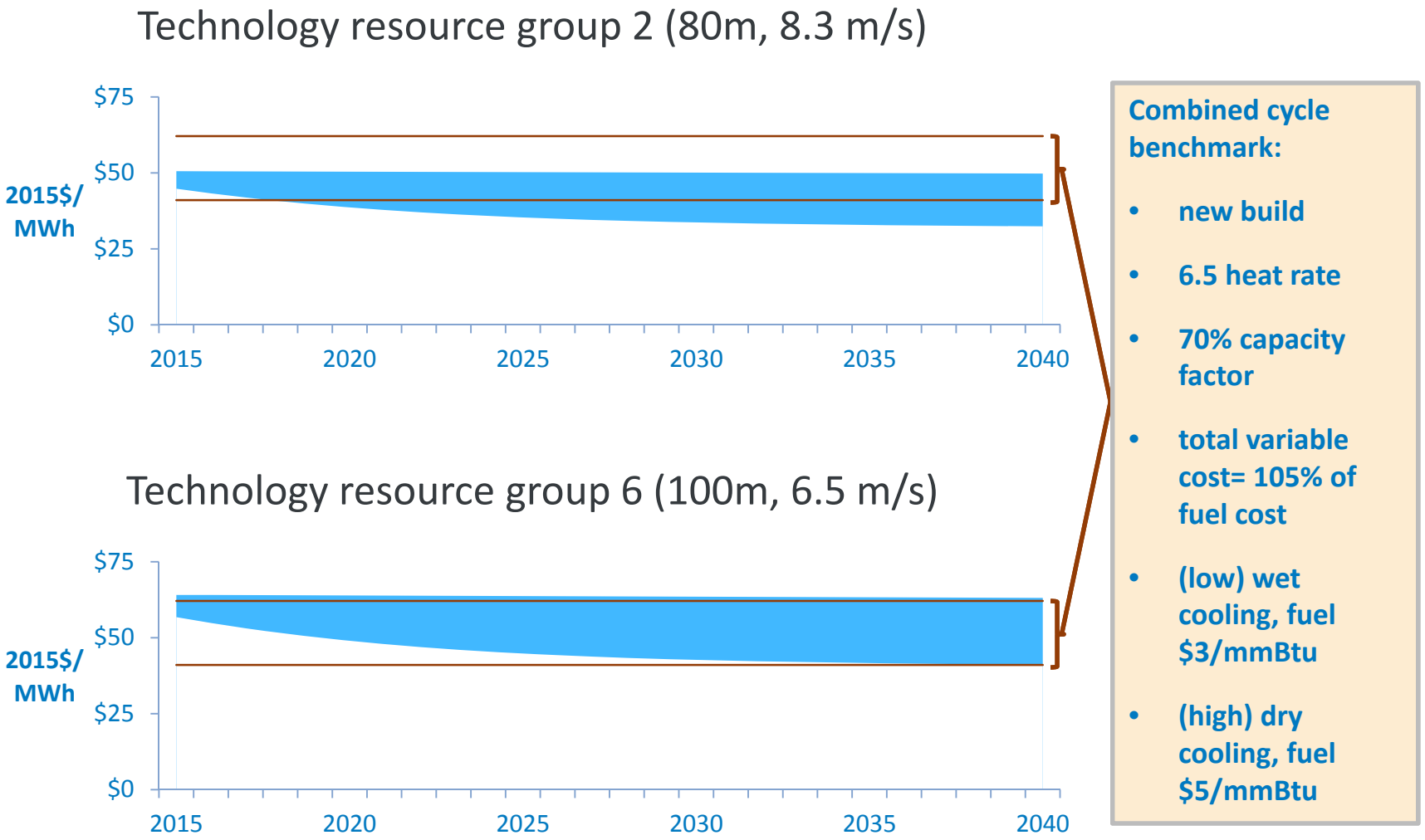


Intermountain
as much as -1.8 GW in 2025

Observations

- Potential for repurposing existing transmission to link California with other western markets
  - Navajo-Four Corners
    - Proximate to New Mexico wind, but would need interconnecting lines (coincident with Sec. 368 corridor)
  - Central Utah
    - Proximate to Wyoming wind, but would need interconnecting lines (coincident with Sec. 386 corridors)
    - Very close to wind, solar, geothermal that could form a diverse, multi-resource renewable energy portfolio

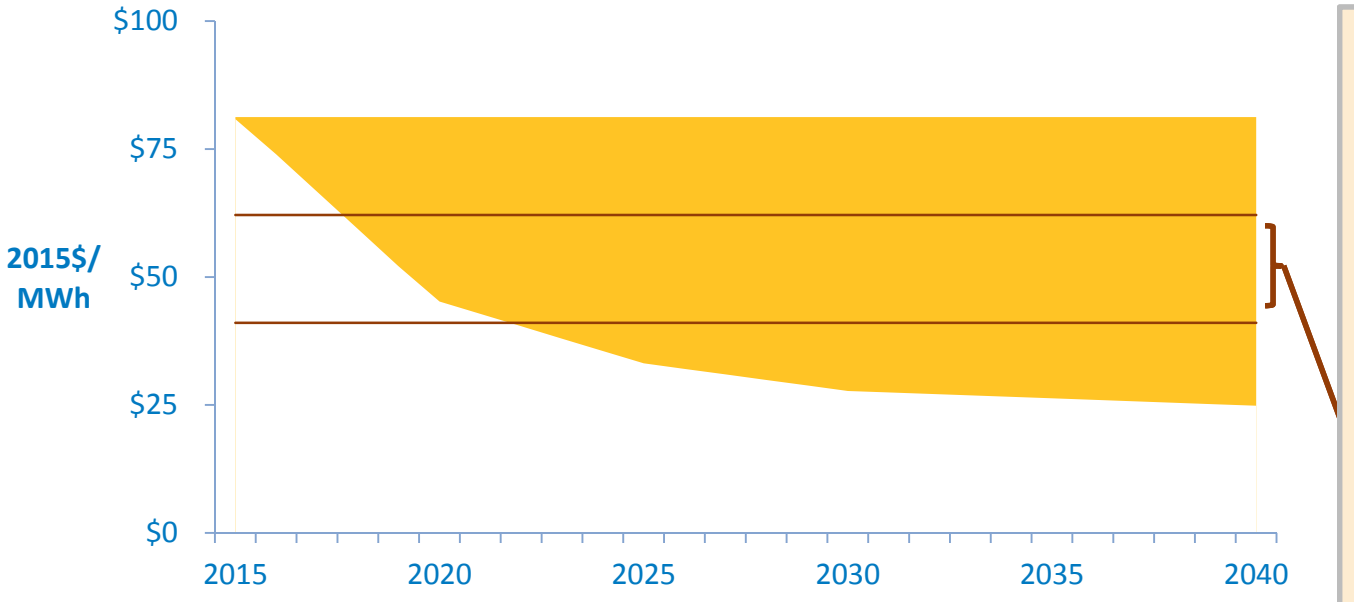
Busbar cost trends for wind (excluding PTC)



NREL, 2016 Annual Technology Database and Standard Scenarios (discussion draft)

Busbar cost trends for utility-scale solar

(single-axis tracking, 28% capacity factor; excludes ITC)



Combined cycle benchmark:

- **new build**
- **6.5 heat rate**
- **70% capacity factor**
- **total variable cost= 105% of fuel cost**
- **(low) wet cooling, fuel $3/mmBtu**
- **(high) dry cooling, fuel $5/mmBtu**

NREL, 2016 Annual Technology Database and Standard Scenarios (discussion draft)

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Potential for re-purposing existing transmission

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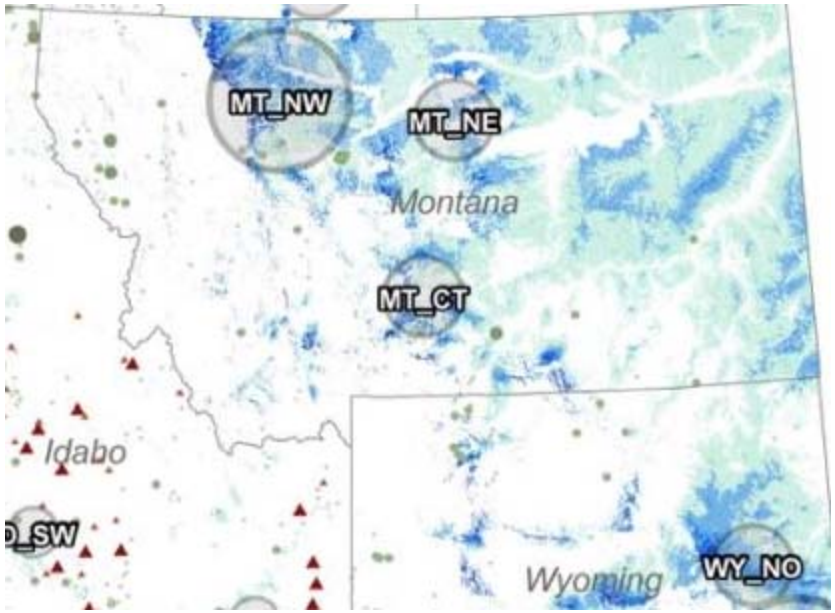
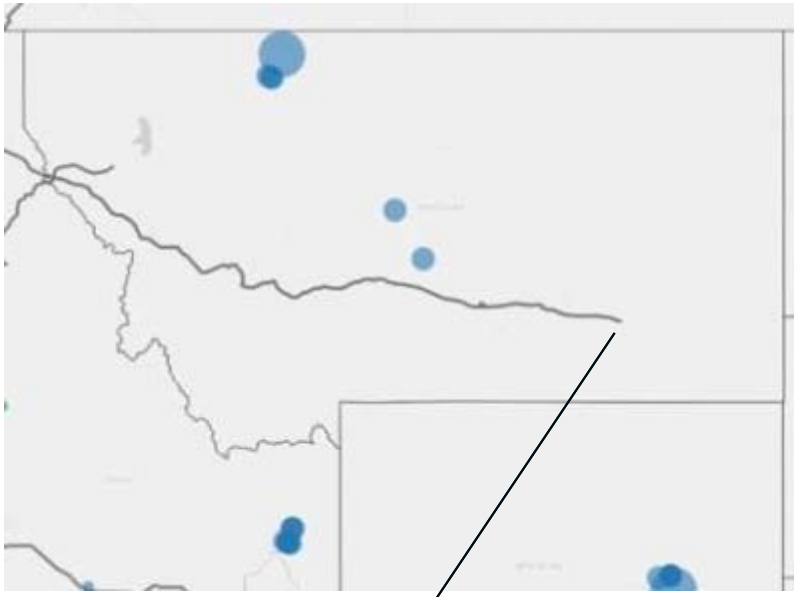


potential coal reduction



Colstrip
614 MW in 2025