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BLACK & VEATCH



RETI Phase 2 Update Workgroup

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November 12, 2009

RETI Phase 2 Update Workgroup Issues

- Economic Model Update
 - Model review
 - Incentives Assumptions
- Extended Analysis of Out-of-State Resources
 - Screening
 - Transmission Approach
- CREZ and Technology Updates
- Net Short Update
- RPS Implementation Timelines



Technology Costs

- RETI Phase 1 (vetted by RETI stakeholders)
 - WREZ (vetted by WREZ stakeholders)
 - RETI Phase 2?

Cost Basis

- 2010 Dollars – “for contracts signed today”
- “All-in costs”
 - Capital costs include: EPC costs plus all owners costs: project advisors, development costs, interest during construction, insurance, financing fees, development fee, insurance, owner's engineer, independent engineer, construction management, land (if applicable), spare parts, sales taxes, start-up, etc.
 - Operations and maintenance costs include: all normal O&M costs, on-going capital expenditures, property tax, and insurance
- Commercial technologies
- No assumed performance or cost improvement
- No escalation of costs

Biomass Assumptions

- Combustion-based technology (stoker / fluidized bed)
- Projects > 15 MW

Performance	RETI Ph. 1	WREZ	RETI Ph. 2
Net Plant Heat Rate (HHV, Btu/kWh)	14,000 to 15,800	14,000 to 16,000	14,000 to 16,000
Capacity Factor (percent)	80	85	85
Economics (2010\$)			
Total Project Cost (\$/kW)	4,350 to 5,500	3,500 to 4,500	4,000 to 5,000
Consolidated O&M (\$/MWh)	23 to 31	25 to 35	25 to 35

WREZ stakeholders felt capital costs were too high and reflected California-centric costs.

RETI Phase 2 adopts WREZ, except capital cost (between WREZ and RETI Phase 1)

Geothermal Assumptions

- Conventional binary or flash technology, depending on resource

Performance	RETI Ph. 1	WREZ	RETI Ph. 2
Capacity Factor (percent)	80-90	80-90	80-90
Economics (2010\$)			
Total Project Cost (\$/kW)	4,000-6,750 (avg. 5,800)	4,000-8,000 (avg. 6,300)	4,000-8,000 (avg. 6,300)
Consolidated O&M (\$/MWh)	31 to 41	27 to 42	27 to 42

WREZ considered additional sites that RETI did not. Capital costs were also increased to account for observed escalation in costs.

RETI Phase 2 adopts WREZ

Geothermal Output Profile Modifications

- Original Proposal:
 - In RETI Phase 1, all geothermal projects assumed to have flat output profile, with a capacity factor of 80-90 percent
 - *Essentially assumed all plants were water cooled*
 - Binary cycle plants are typically dry cooled
 - Flash cycle plants normally are water cooled, using the condensate from the geothermal fluid
 - New geothermal developments subject to same water constraints as solar thermal
 - Assume dry-cooled for all binary plant locations, unless wet cooling has been specifically approved (permitted) for a pre-identified site
- Geothermal industry suggests wet cooling should be assumed – plants can be designed for higher output in summer if so desired, change in Nevada law. No change in output profile. – **UNDER REVIEW**

Wind Assumptions

- Conventional, horizontal-axis, 3-blade machine, 80m hub-height

Performance	RETI Ph. 1	WREZ	RETI Ph. 2
Capacity Factor (percent)	25 to 40	32 to 42	CA: 25 to 40 OOS: 32 to 42
Economics (2010\$)			
Total Project Cost (\$/kW)	2,250 to 2,700	2,350 to 2,700	2,350 to 2,700
Consolidated O&M (\$/MWh)	18 to 25	23	23

In-state capacity factors would be unchanged and based on original (detailed) RETI Phase 1 analysis. Out-of-state resources would be replaced by WREZ capacity factor by class estimates (shown on next slide)

RETI Phase 2 adopts WREZ, CA performance from RETI Phase 1

Assumed Capacity Factor vs. NREL Wind Class at 50 m Out-of-state Resources

- Recommendation of LBNL based on review of data from newly operational projects built from 2005-2007
 - Class 2: 25%
 - Class 3: 32%
 - Class 4: 36%
 - Class 5: 39%
 - Class 6: 42%
 - Class 7: 46%

Solar Technologies

- Decided Previously:
 - RETI Phase 2: Assume dry-cooling for solar thermal plants, wet-cooling will be used if plant is already permitted to use water.
 - RETI Phase 2: Assume no storage for solar thermal trough plants, unless pre-identified for a specific site
 - RETI Phase 2: Commercial technologies include: parabolic trough, tracking crystalline PV, and thin film PV

Solar Thermal Assumptions

- Dry-cooled Parabolic Trough, with no storage**

Performance	RETI Ph. 1	WREZ	RETI Ph. 2
Capacity Factor (percent)	22 to 32*	20 to 28	20 to 28
Economics (2010\$)			
Total Project Cost (\$/kW)	4,700 to 5,300*	5,350 to 5,550	5,350 to 5,550
Consolidated O&M (\$/MWh)	30	30	30

*Ranges include wet cooled projects, which typical have higher CF and lower capital cost

- Dry-cooled Parabolic Trough, with 6 hrs storage***

Performance	RETI Ph. 1	WREZ	RETI Ph. 2
Capacity Factor (percent)	NA	29 to 39	29 to 39
Economics (2010\$)			
Total Project Cost (\$/kW)	NA	7,650 to 7,850	7,650 to 7,850
Consolidated O&M (\$/MWh)	NA	22	22

*Storage based on oversized field with 200 MW steam turbine output

RETI Phase 2 adopts WREZ

Solar Photovoltaic Assumptions (Large Systems: 20 MW +)

- **Single-Axis Tracking Crystalline**

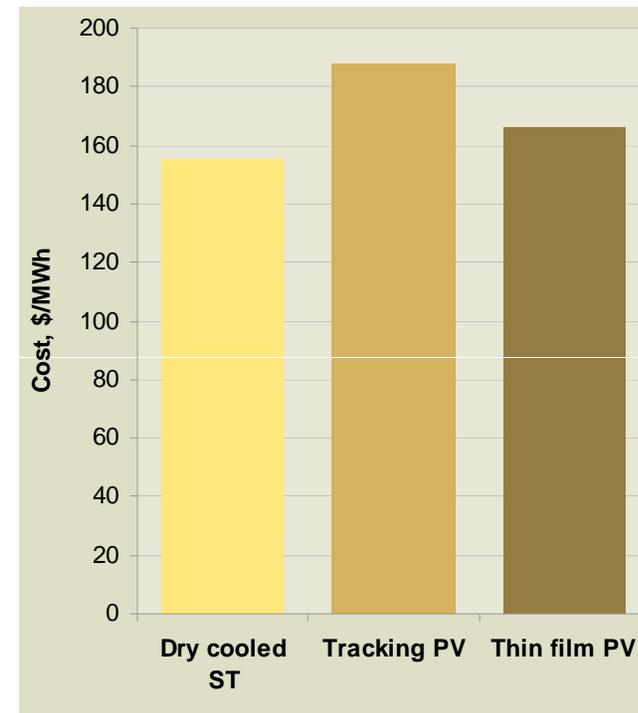
Performance	RETI Ph. 1	WREZ	RETI Ph. 2
Capacity Factor (percent)	23 to 28	26 to 31	23 to 31
Degradation			0.75%/year
Economics (2010\$)			
Total Project Cost (\$/kWe)	7,040 to 7,150	5,750 to 5,950	4,000 to 5,000
Consolidated O&M (\$/MWh)	19 to 23	26	19 to 26

- **Fixed-tilt Thin Film**

Performance	RETI Ph. 1 <i>(sensitivity only)</i>	WREZ	RETI Ph. 2
Capacity Factor (percent)	18 to 27	22 to 27	18 to 27
Degradation			1%/year
Economics (2010\$)			
Total Project Cost (\$/kWe)	3,700 to 4,000	4,550 to 4,750	3,700 to 4,250
Consolidated O&M (\$/MWh)	13	24	13 to 24

Multiple Solar Technologies Possible per Site

- Black & Veatch will compare the performance and cost of solar thermal and the two solar PV technologies for all large scale solar sites
- CREZ economics will be based on the lowest cost technology per site
- In this manner, solar CREZs are evaluated in their best possible “light”



**HYPOTHETICAL – FOR
EXAMPLE ONLY**

Advanced Solar Technologies

- Advanced solar technologies are emerging, for example:
 - Solar Power Tower
 - Solar Stirling Dish
- Recommend treating as a sensitivity study with independently vetted cost and performance, similar to thin film in RETI Phase 1



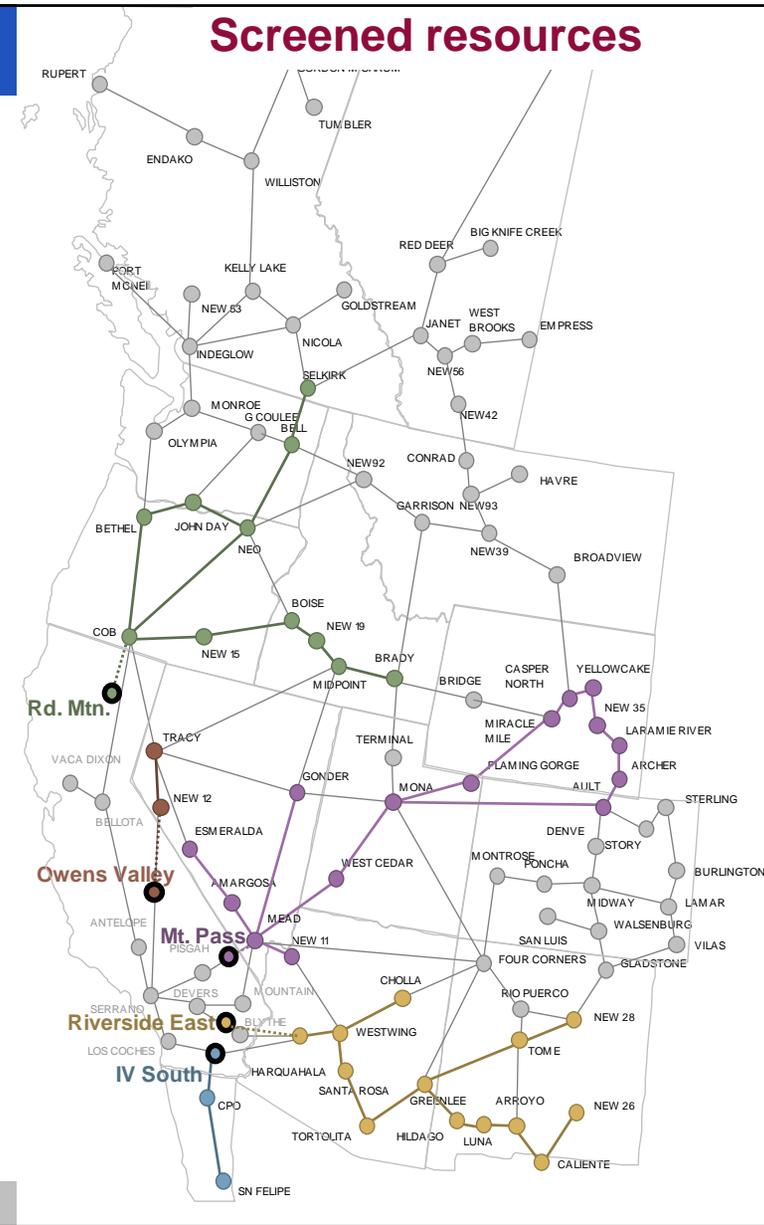
Transmission

Transmission Cost Approach

- Out-of-state resources
 - 500 kV single-circuit ac transmission, 1500 MW capacity, \$1.8 million/mile, federally financed, delivered to “gateway CREZs” (e.g., Mountain Pass)
 - From WREZ Transmission Characteristics Working Group
 - **Open issue: Line utilization**
- In-state transmission costs:
 - Include all costs for 2A Collector Lines; allocation based on 2A shift factors
 - Include 50% of the 2A Foundation and Delivery Line costs; allocation based on 2A shift factors
 - **Open issue: Cost basis**

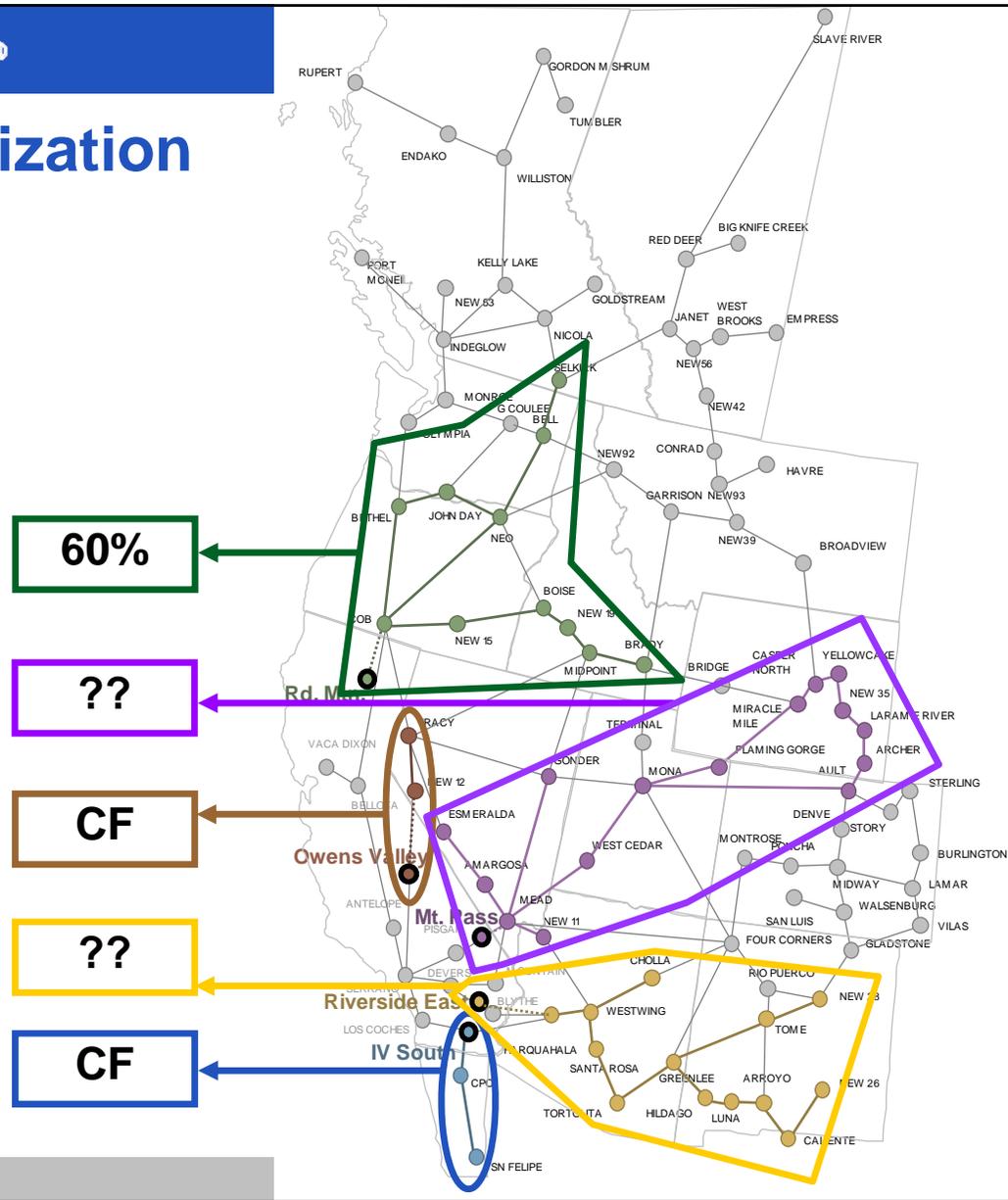
OOS Resources Delivered to California Gateway Substations / CREZs Shift Factors from Phase 2A

- COB > Round Mountain
- NEW 12 (CA/NV) > Owens Valley
- MEAD > Mt. Pass
- ALAMORIO > Imperial Valley South
- HARQUAHALA > Riverside East



Transmission Utilization

- **Pacific Northwest** has lots of existing transfer, blend of resources (including hydro, biomass, geothermal, wind) → use 60%
- **N. Nevada** is largely geothermal → use resource CF (80-90%)
- **Baja** is all wind → use resource CF
- Performing additional analysis on blended wind and solar dominated resource areas
 - **WY/UT/etc** – predominately wind
 - **AZ/NM** – Mixed wind and solar





Renewables Transmission Utilization

Wyoming Wind Case Study

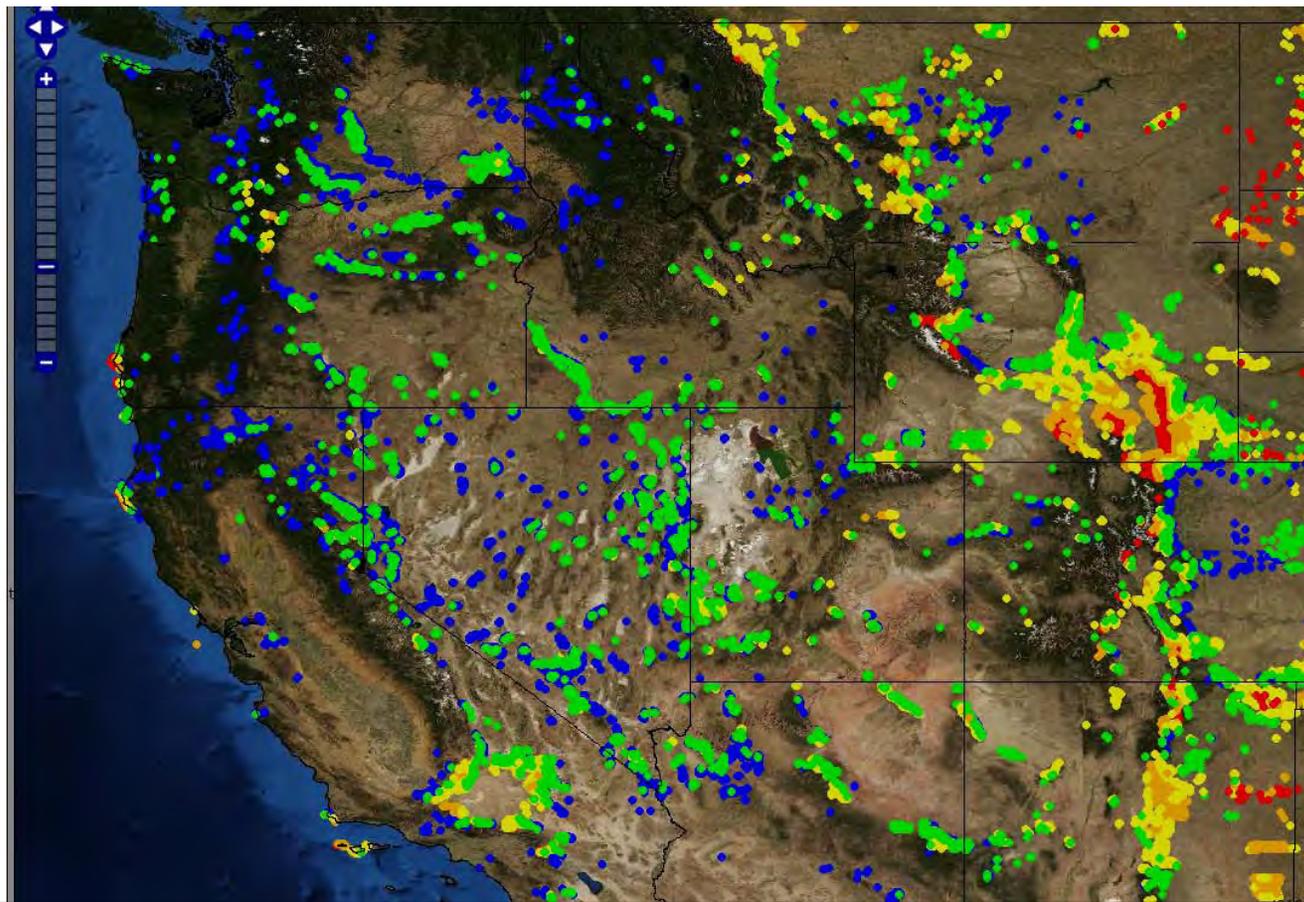
Work in progress

Data Source – NREL's Western Wind and Solar Integration Study

- 10 minute data for thousands of sites from <http://mercator.nrel.gov/wysi/>

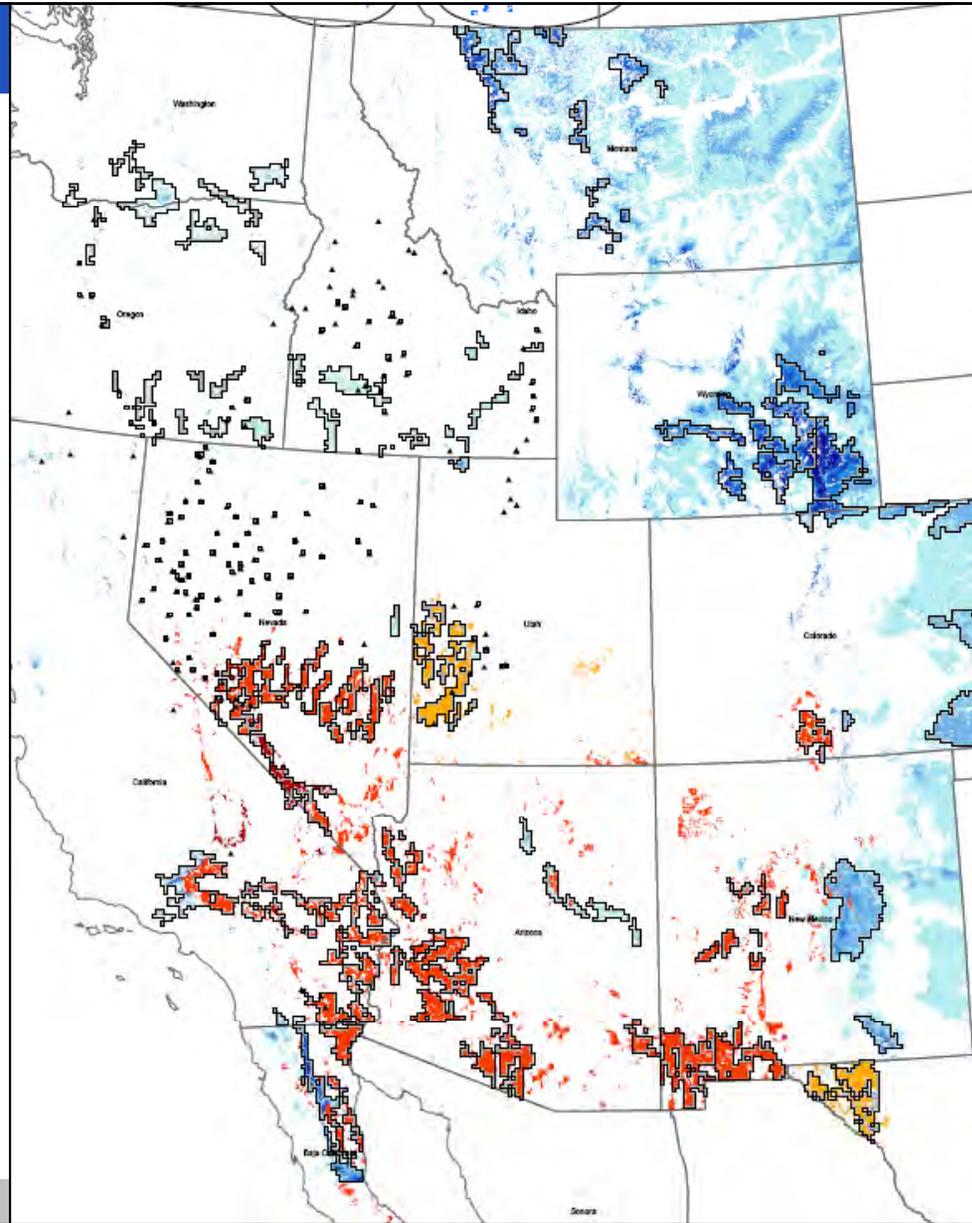
Capacity Classes

- < 25 %
- 25% - 30%
- 30% - 35%
- 35% - 40%
- > 40%



Data Regions

- Aggregated by WREZ QRA region, as outlined in this map
- This is the data currently available for analysis

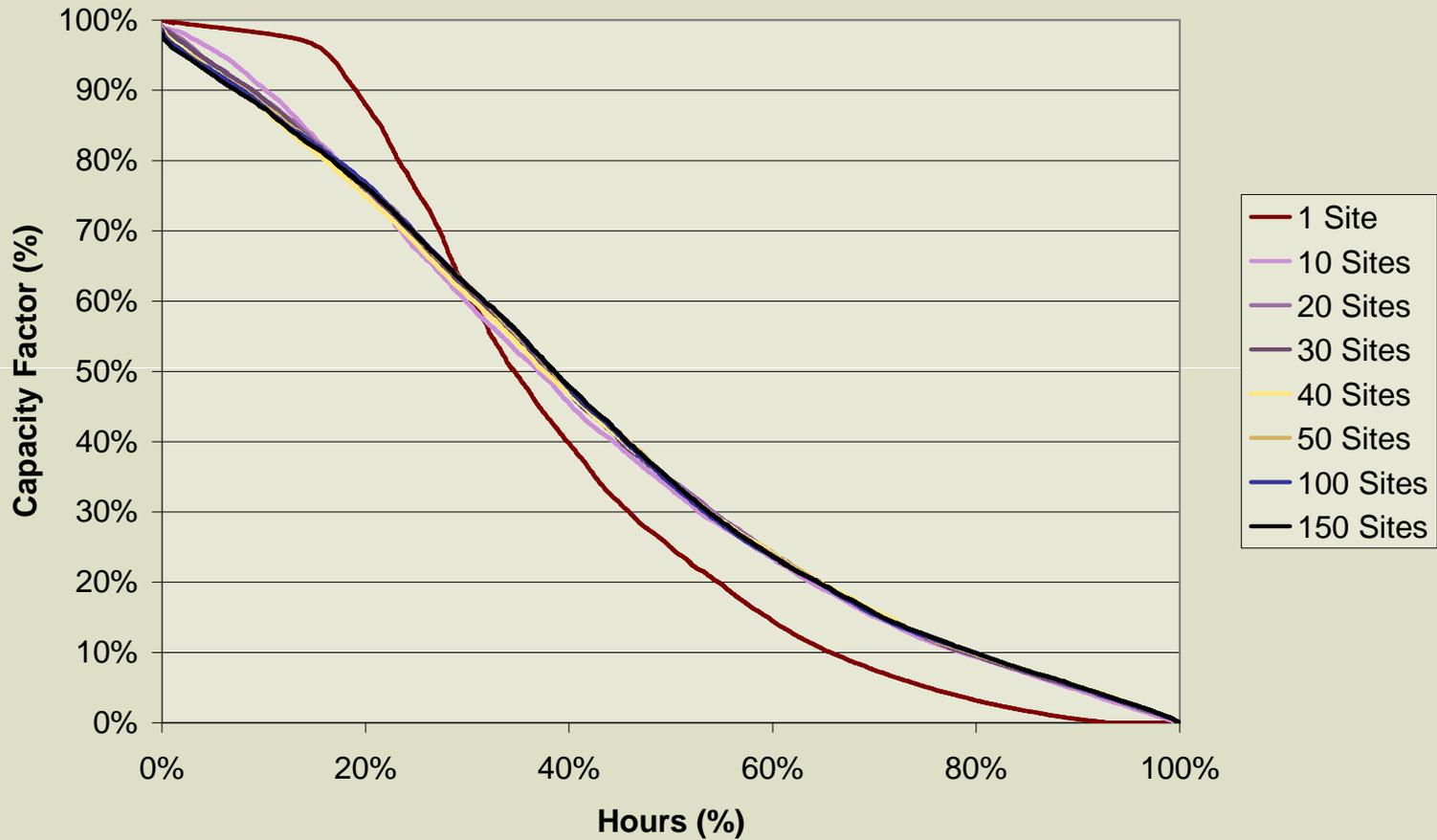


Aggregation and Analysis Process

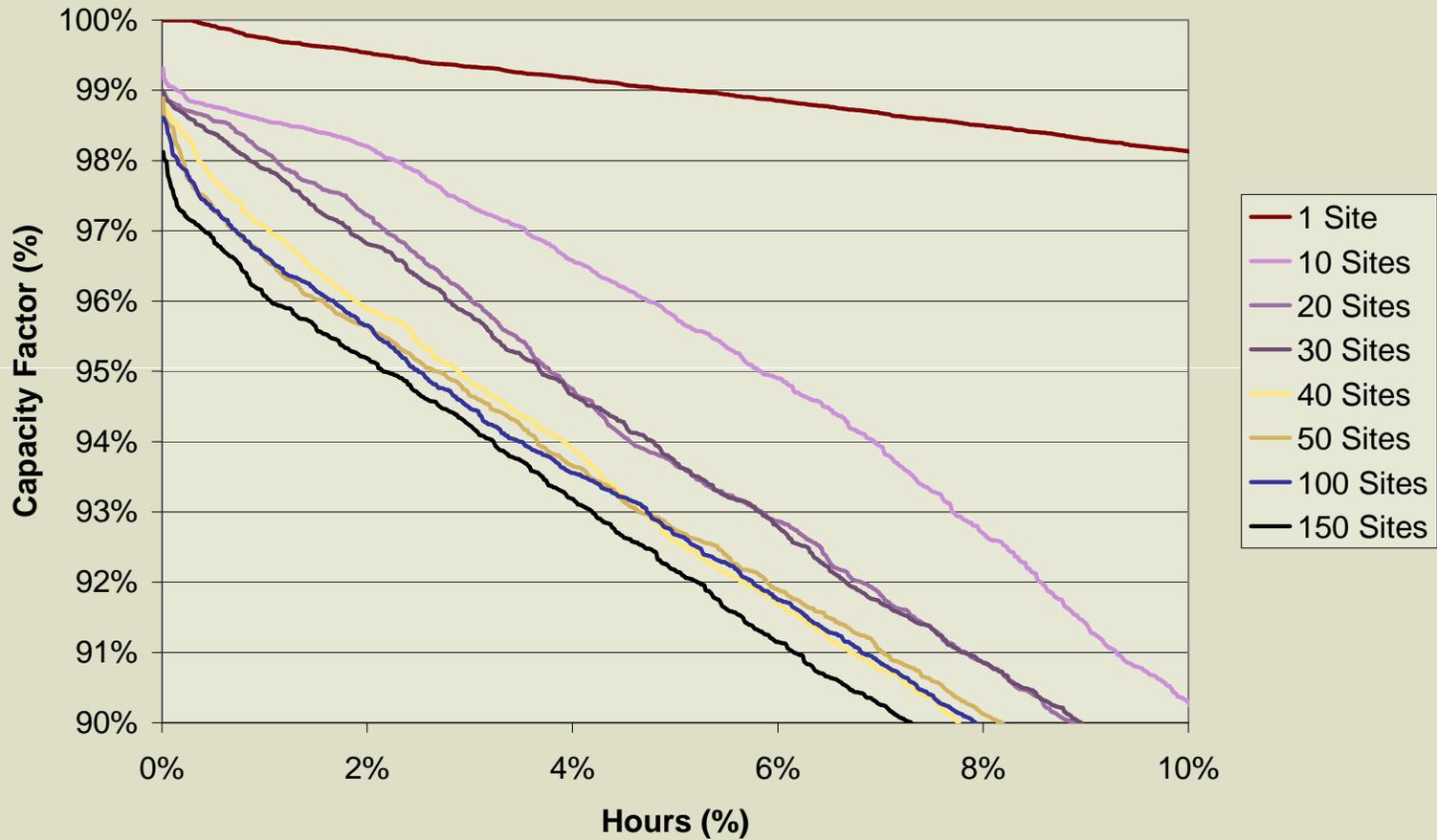
10 minute site data, MW

- Random sites selected, aggregated by QRA or State, over min. specified CF
- Aggregated into hourly site data, MW, 8760
 - Sorted in Descending order
 - Normalized to CF, based on 30 MW max
 - 8760 hours normalized to % of hours

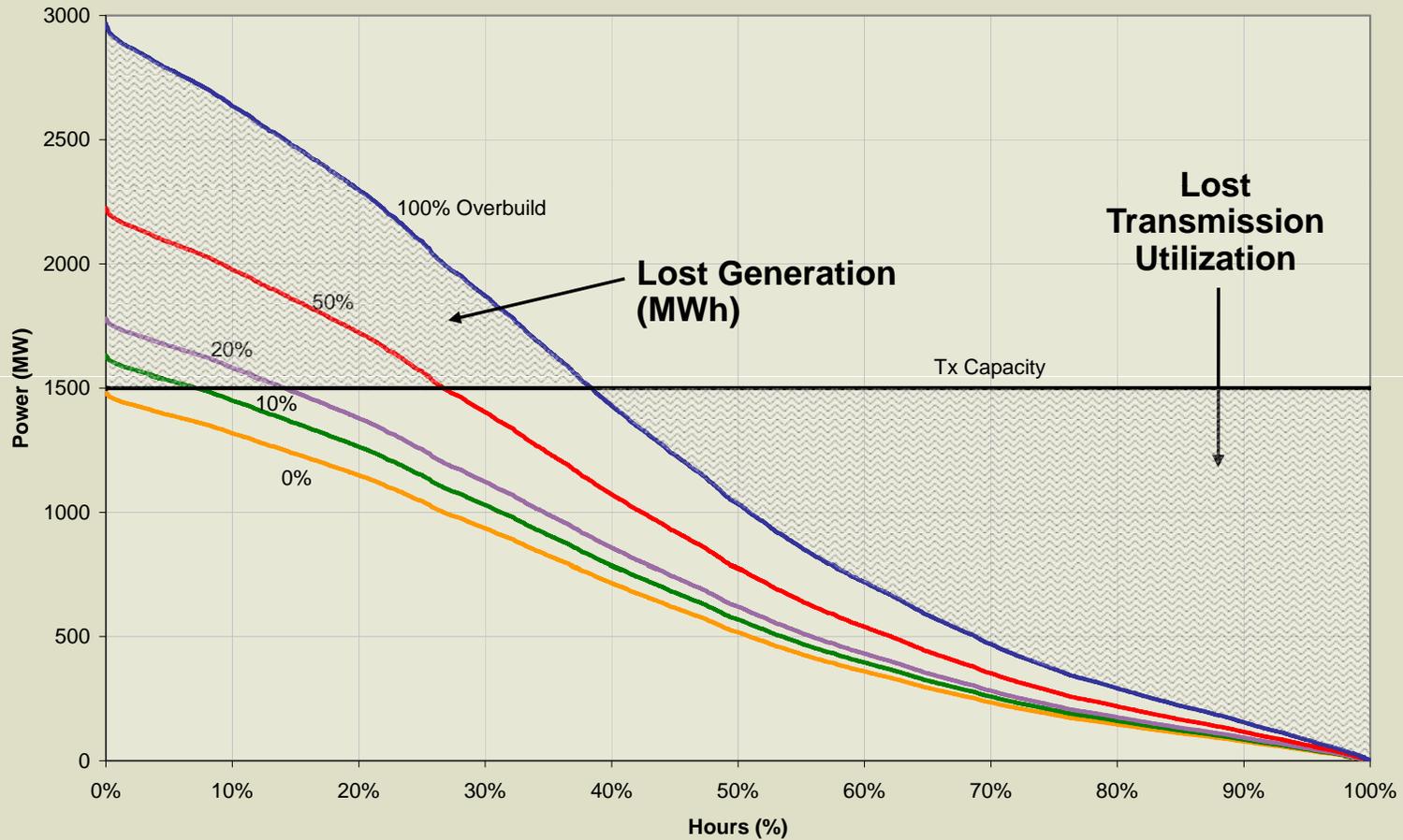
Random 30 MW sites in Wyoming



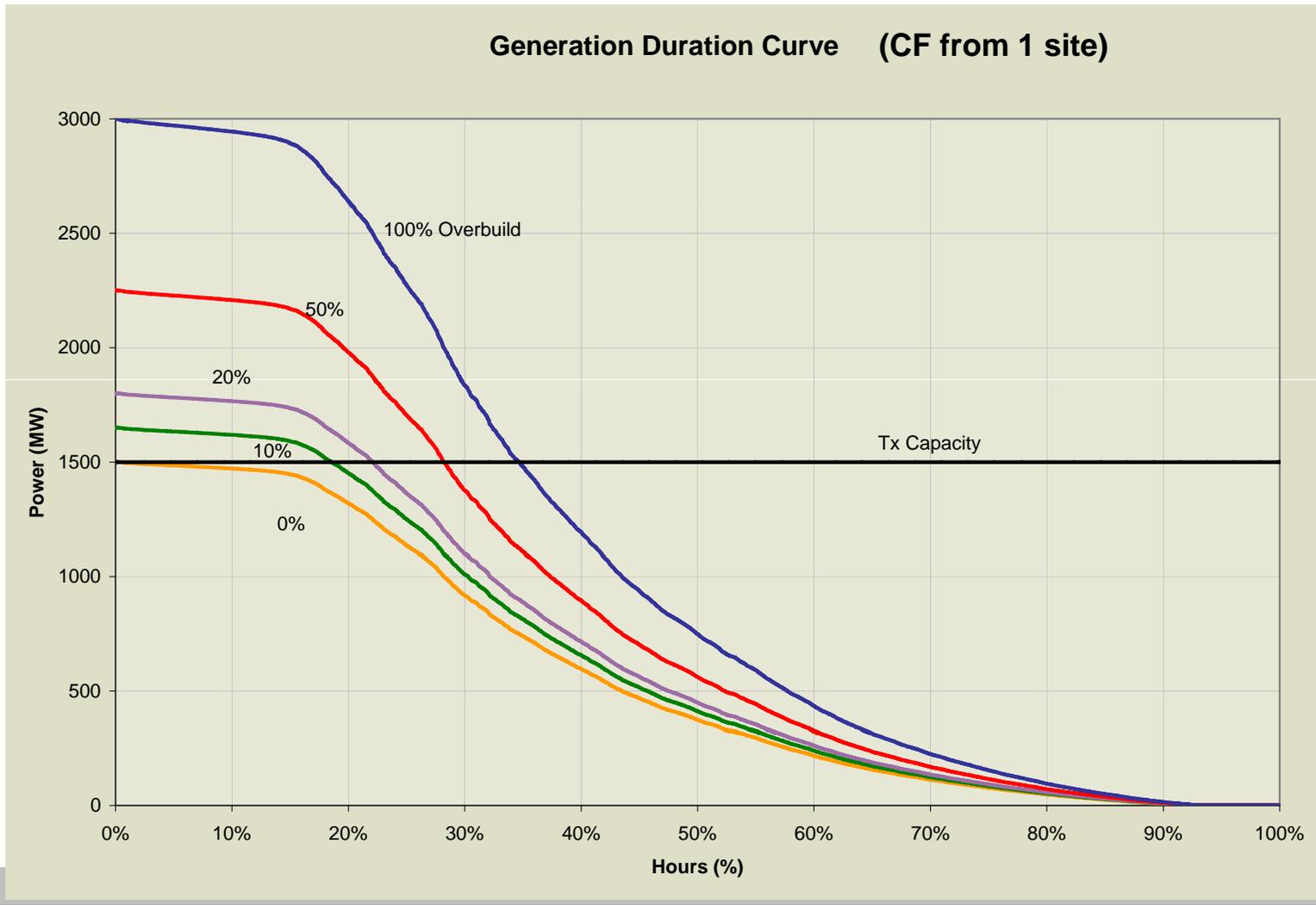
Random 30 MW sites in Wyoming



Overbuild Tradeoff (using curve from 50 sites)



Shape for a single site (no mitigation of variability) is very different



Transmission Utilization at Optimal Overbuild (Cost-based)

