Overcoming Transmission Constraints: Energy Storage and Wyoming Wind Power

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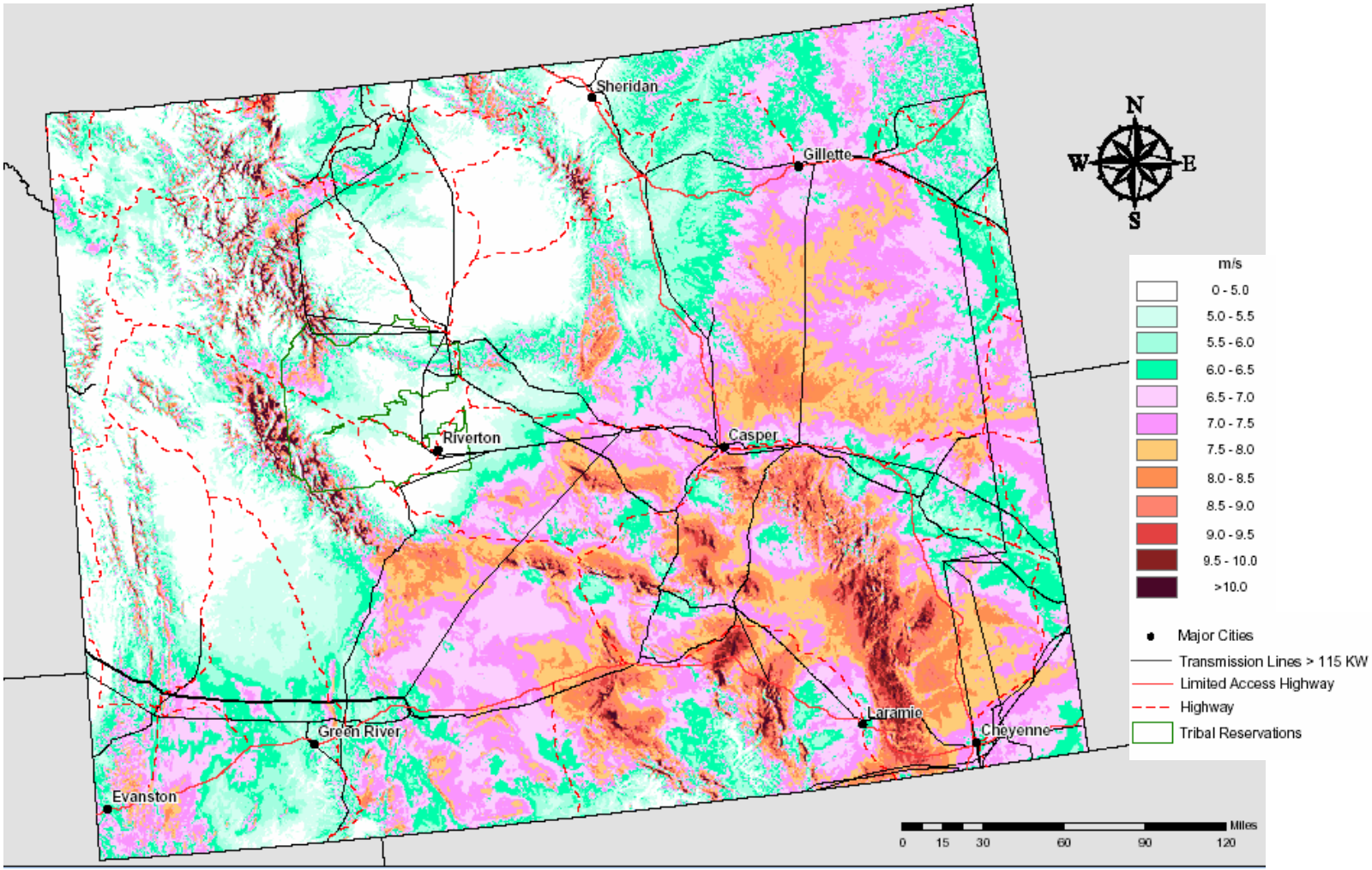
ACKNOWLEDGMENTS

- Funded by the Energy Storage Systems Program of the U.S. Department Of Energy (DOE/ESS) through Sandia National Laboratories (SNL).

Project Status

- Since ESA in May, we experienced further contractual issues that delayed our progress
- The analysis is almost complete; report drafting has begun
- Examining rebates and other incentives
- Scrubbed and enhanced the model with:
  - Alternate time-of-use schedules and tariffs
  - Multiple charge/discharge cycles/day
  - Salvage and rebate values
  - Scenario comparison

Wyoming Wind Speed at 50 Meters



Project Sponsors
NREL, the Bonneville Power Administration, Northwestern Energy, the Wyoming Business Council, enXco, the Northwest Power Planning Council, Zilkha Renewable Energy, Klickitat County, EnronWind, ABB, Renewable Energy Systems (USA) Inc., Chelan Public Utility District, Idaho Power, Windland, Inc., WSACAA Energy Project, Vestas, Jones & Stokes, CH2M Hill, Suzlon Energy, Northwest Wildlife Consultants, Inc., and Cielo Wind Power.
For more information see www.windpowermaps.org

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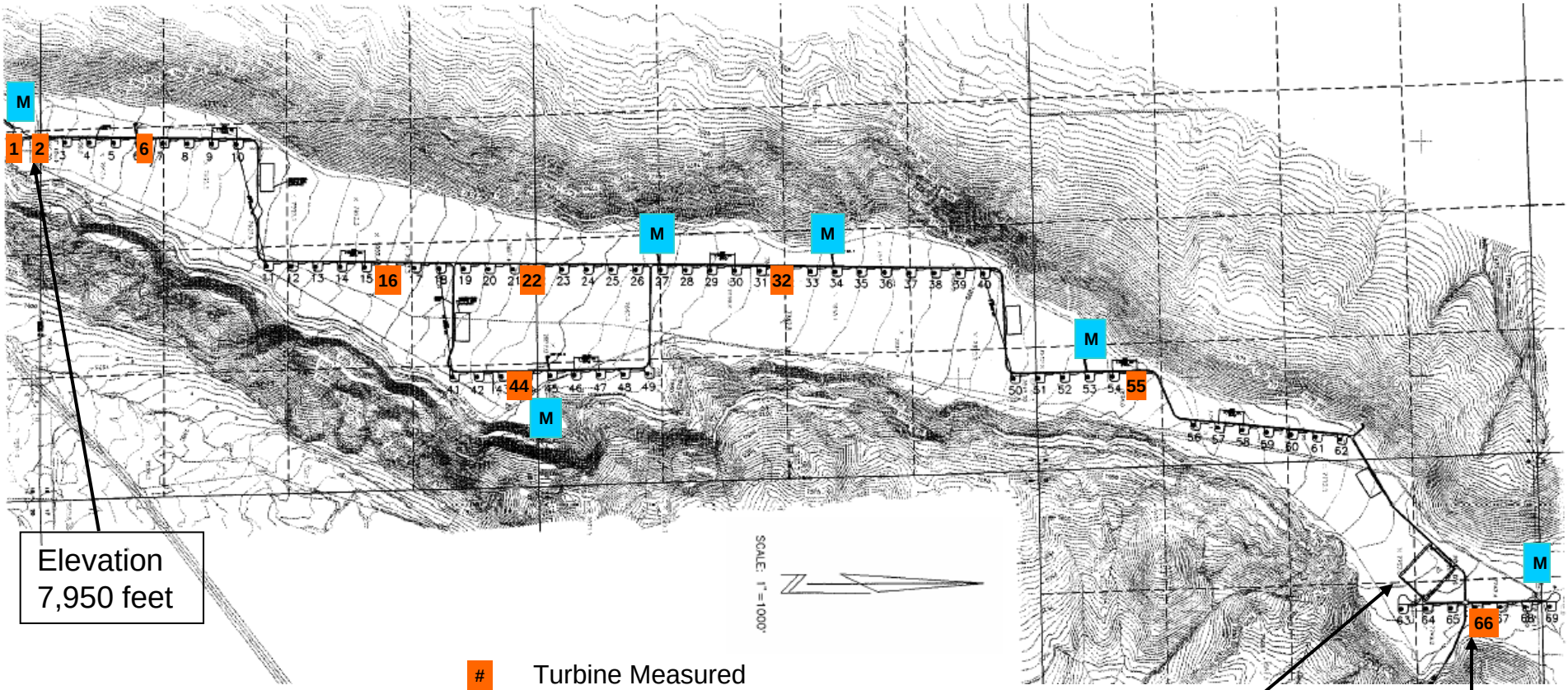
Foote Creek Rim I Layout



Elevation 7,950 feet

Turbine Measured

M Meteorological Station

Substation

Elevation 7,750 feet

Source: SeaWest, December 2004.

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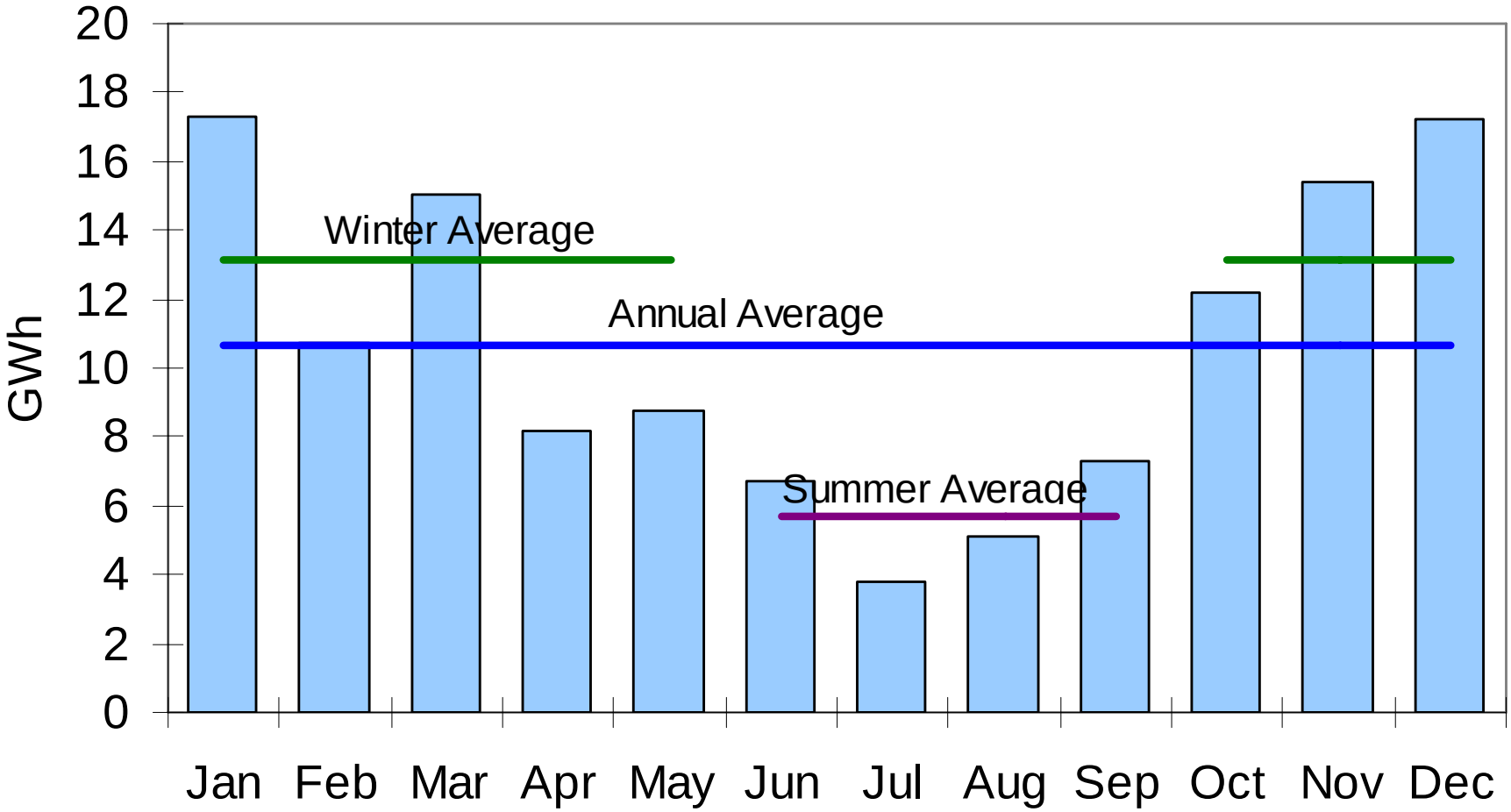
Wind Generation from Foote Creek Rim I



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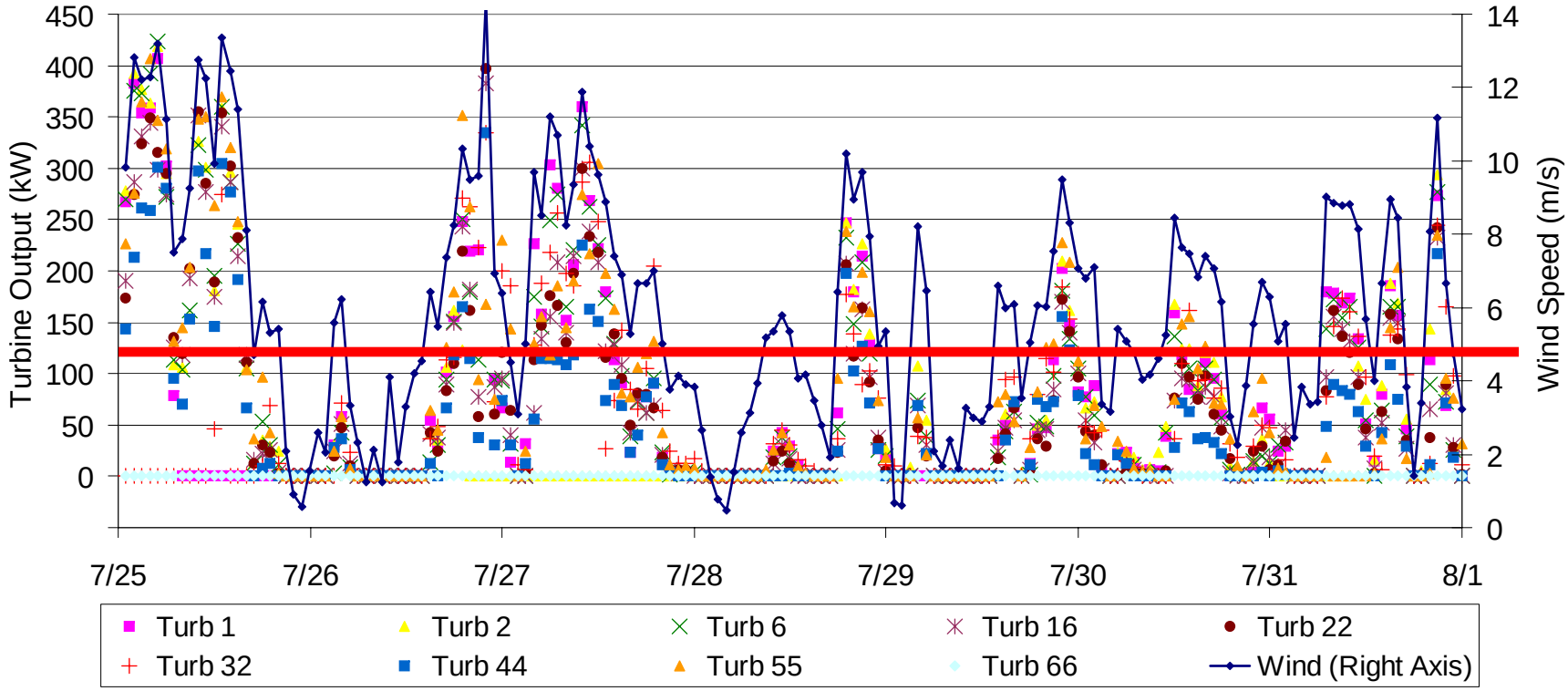
Wind Speed and Turbine Output in Summer

July 25 – 31, 2003



Source: Calculated from SeaWest Data on Wind Speeds at Turbines and Meteorological Stations, December 2004.

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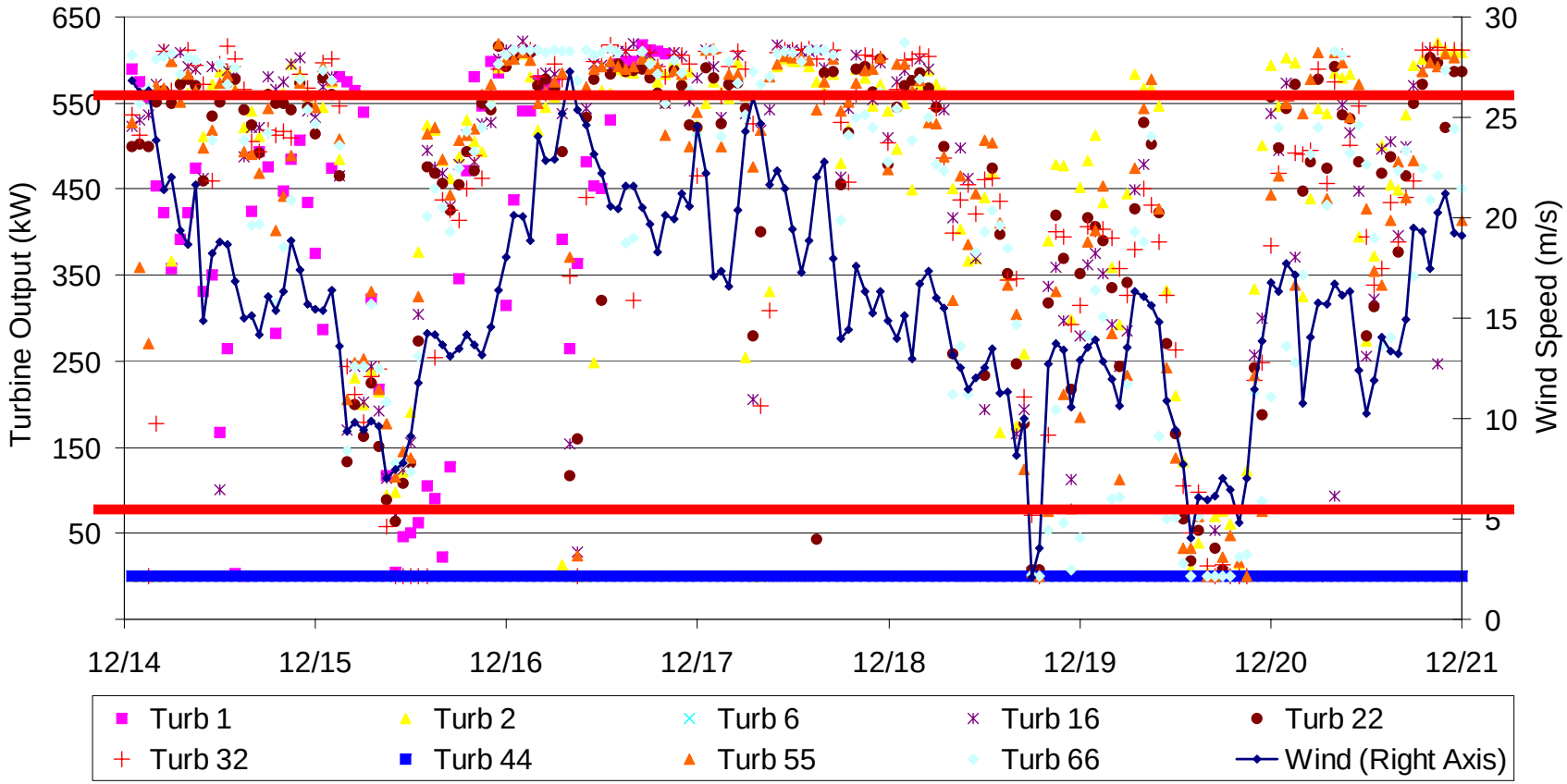
Wind Speed and Turbine Output in Winter

December 14 - 20, 2003



Source: Calculated from SeaWest Data on Wind Speeds at Turbines and Meteorological Stations, December 2004.

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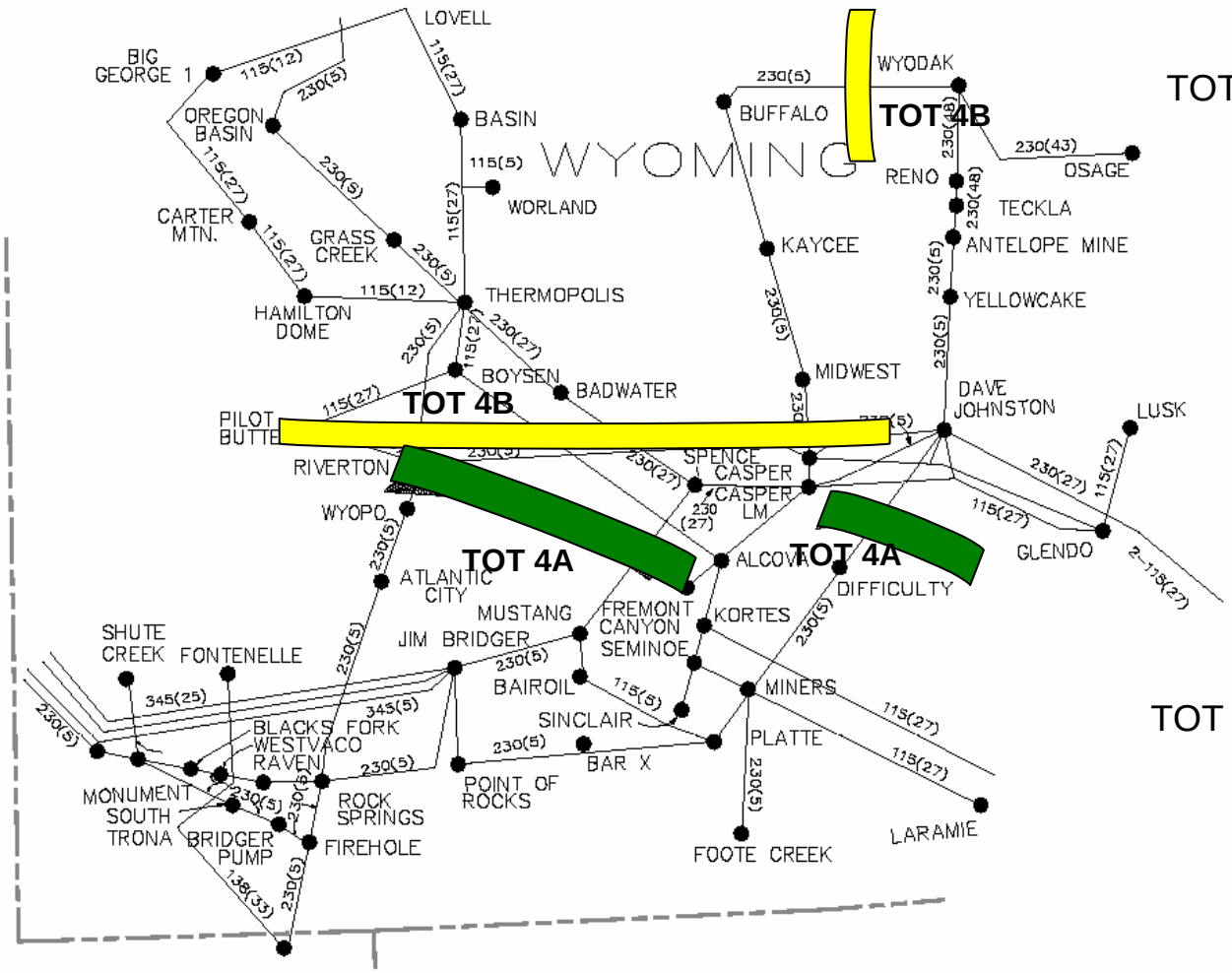
TOT 4A & 4B Transmission Flows in Wyoming



TOT 4B flows Northeast

TOT 4A flows Southwest

Source: PacifiCorp, 1990 Update of the TOT 4B vs 4A Nomograms, March 1991.

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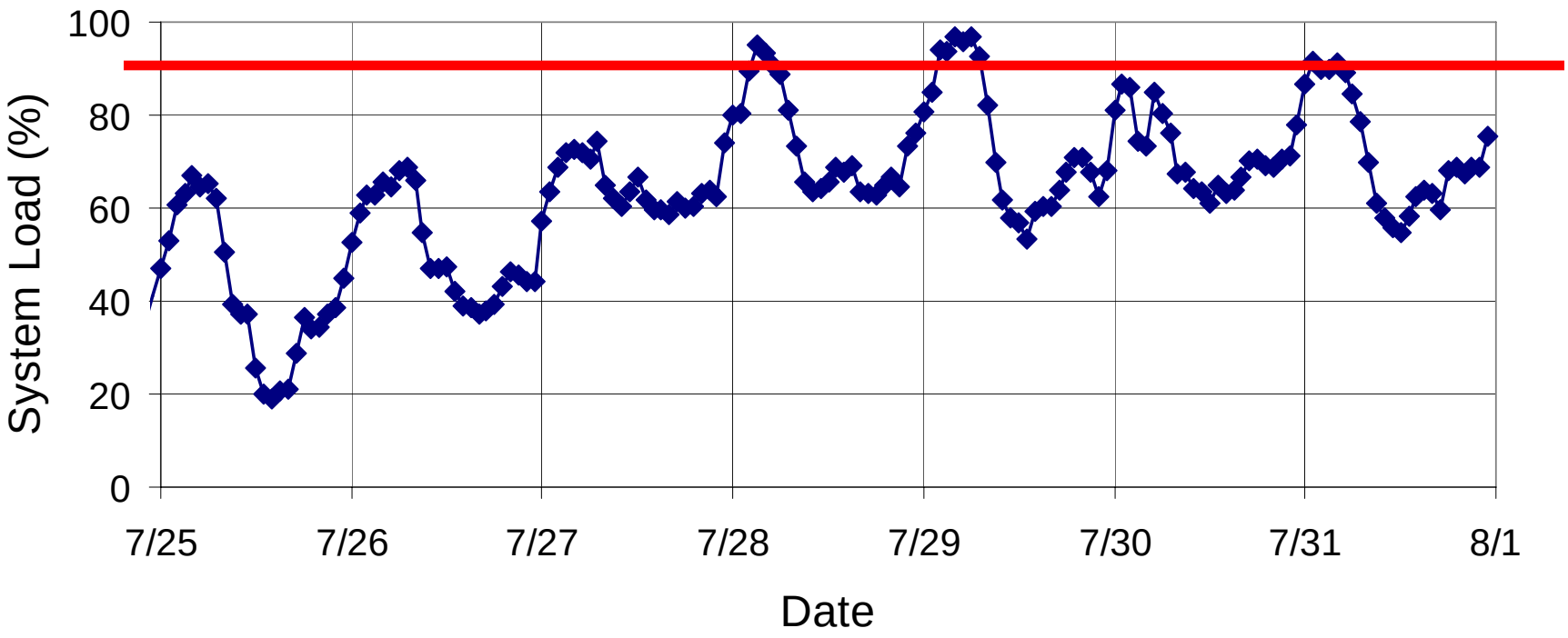
PacifiCorp TOT4 System Load in Summer

July 25, 2003 – July 31, 2003



Source: Calculated from PacifiCorp's End-of-Hour TOT 4A and 4B Load Data in Wyoming.

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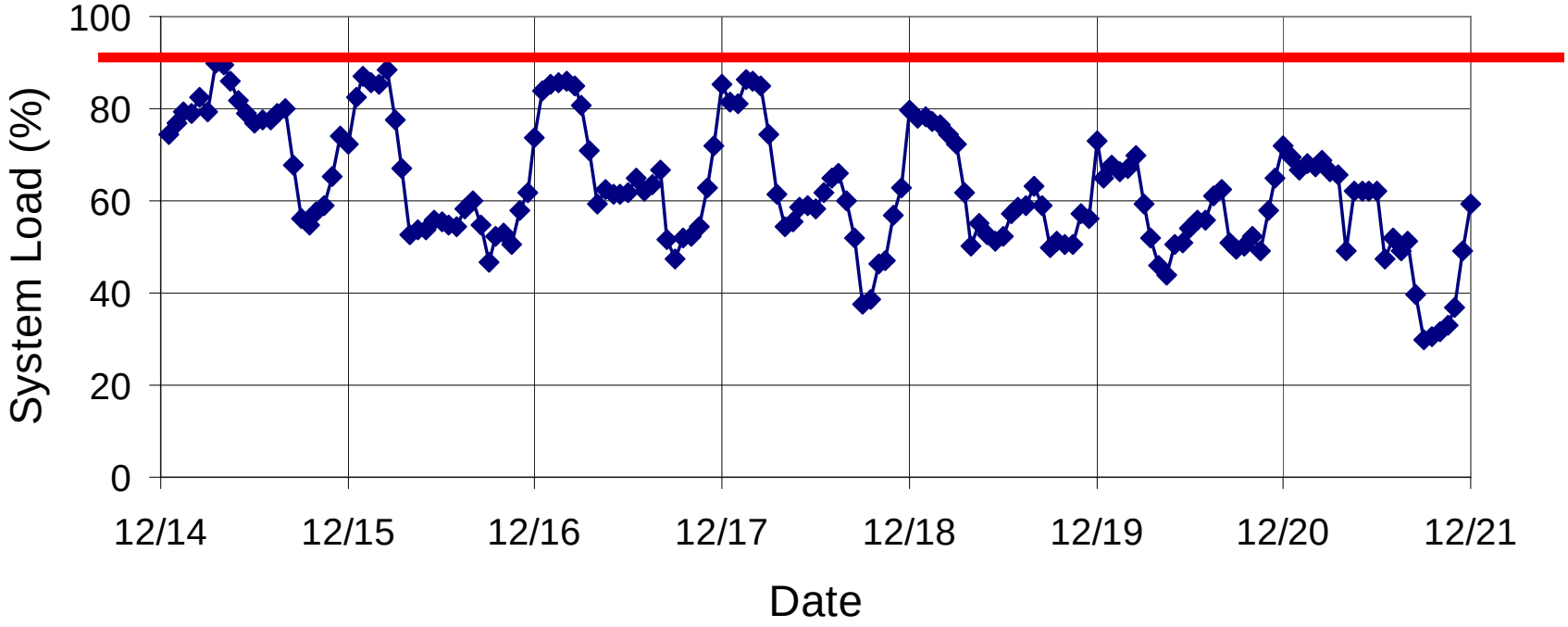
PacifiCorp TOT4 System Load in Winter
December 14, 2003 – December 20, 2003



Source: Calculated from PacifiCorp's End-of-Hour TOT 4A and 4B Load Data in Wyoming.

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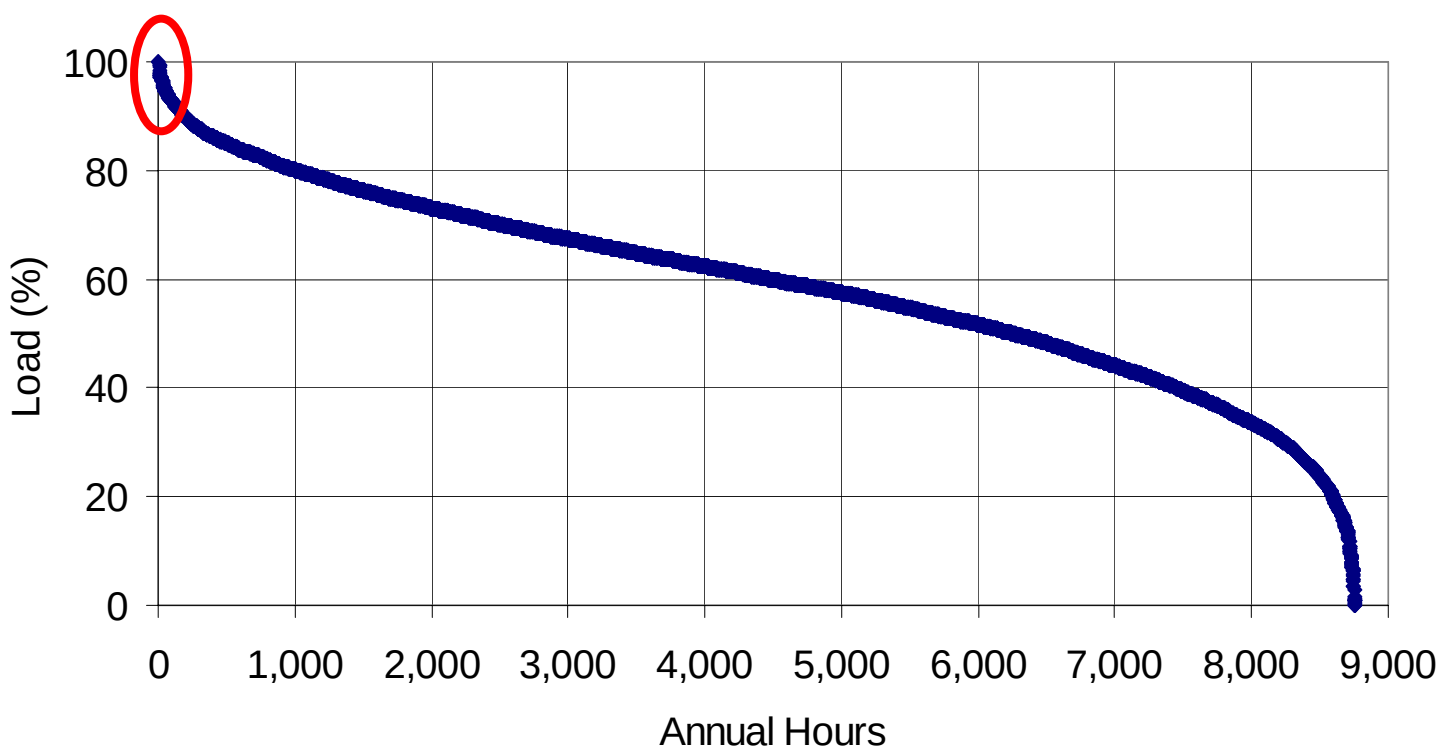
Wyoming TOT4 System Load Duration

In 2003, there were 187 hours spread over 47 days in which load duration exceeded 90%.



Source: Calculated from PacifiCorp's End-of-Hour TOT 4A and 4B Load Data in Wyoming.

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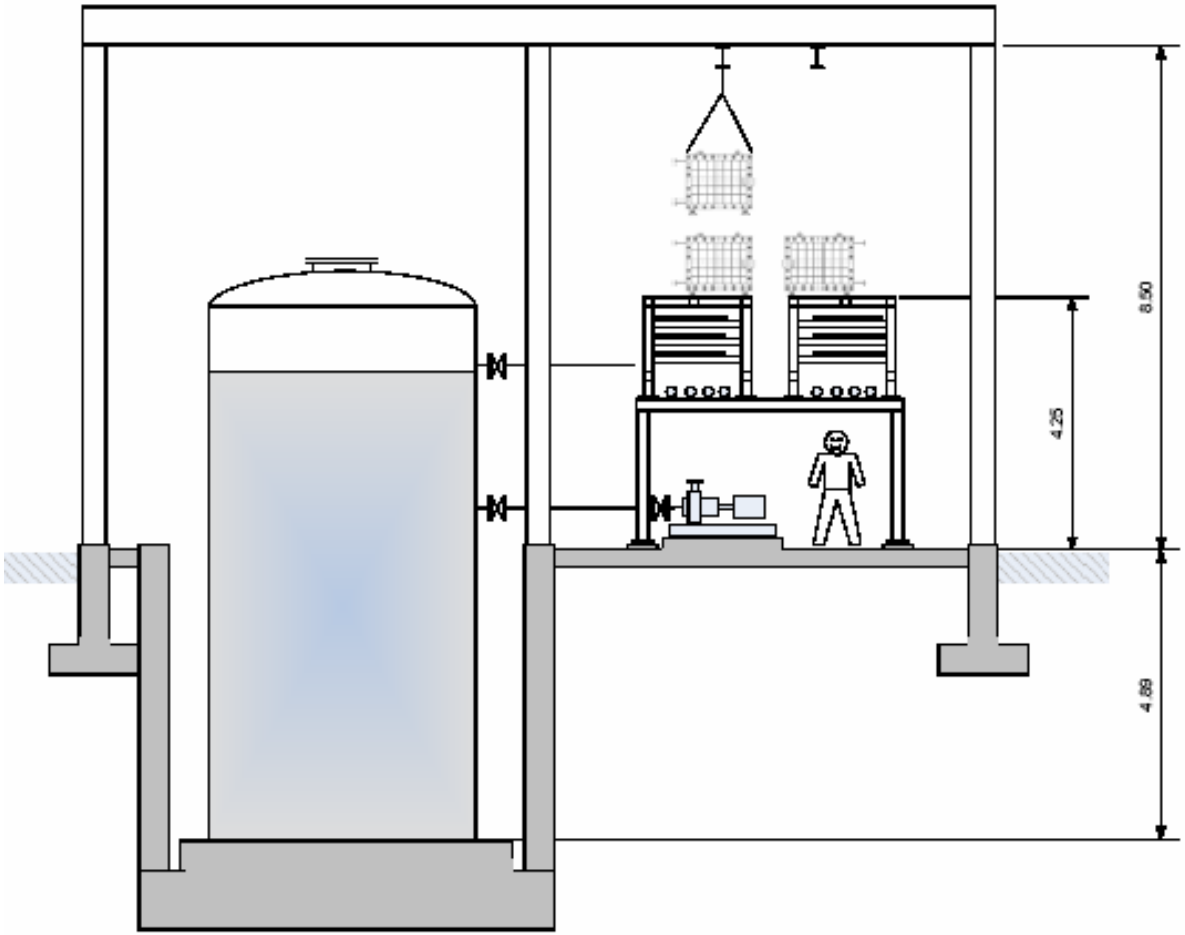
Conceptual Plan for Multi-MWh VRB Plant



Modeling Efforts

- Built and tested Excel model to calculate battery operation based on actual 2003 transmission congestion, wind turbine output, and potential output without congestion
- Performed sensitivity runs against a No Battery case, altering
  - Tariff time-of-use factors
  - Charge/discharge profile (start/finish times, once & twice a day)
  - Capacity (MW capacity, 8 hour discharge)
  - Round-trip efficiency
  - Installed and O&M costs (current and future)
  - Life expectancy
  - Interest rates
  - Salvage values
  - Rebates

Tariff Assumptions

Seasonal Time-of-Use Periods

Time-of-Use Period	Summer Months June - September		Winter Months October - May		Days/ week*
	start	finish	start	finish	
On Peak	12:00	18:00			5
Mid Peak	8:00	12:00	20:00	21:00	5
	18:00	23:00			5
Off Peak	23:00	8:00	6:00	20:00	5
			21:00	0:00	5
	0:00	24:00	6:00	0:00	2
Super Off			0:00	6:00	7

Seasonal Time-of-Use Energy Factors

Season	On Peak	Mid Peak	Off Peak	Super Off
Summer	1.4251	Sched	0.8526	
Winter		1.2185	Sched	0.7766

Seasonal Time-of-Use Capacity Factors ($/MWh)

Season	On Peak	Mid Peak	Off Peak	Super Off
Summer	255.10	0.26	0.26	
Winter		11.63	0.73	0.69

Model Sensitivity Runs – Time of Day Profiles

Aligning the battery charge/discharge profile with tariff time-of-use factors increased the MWh discharged and the revenue from capacity charges.

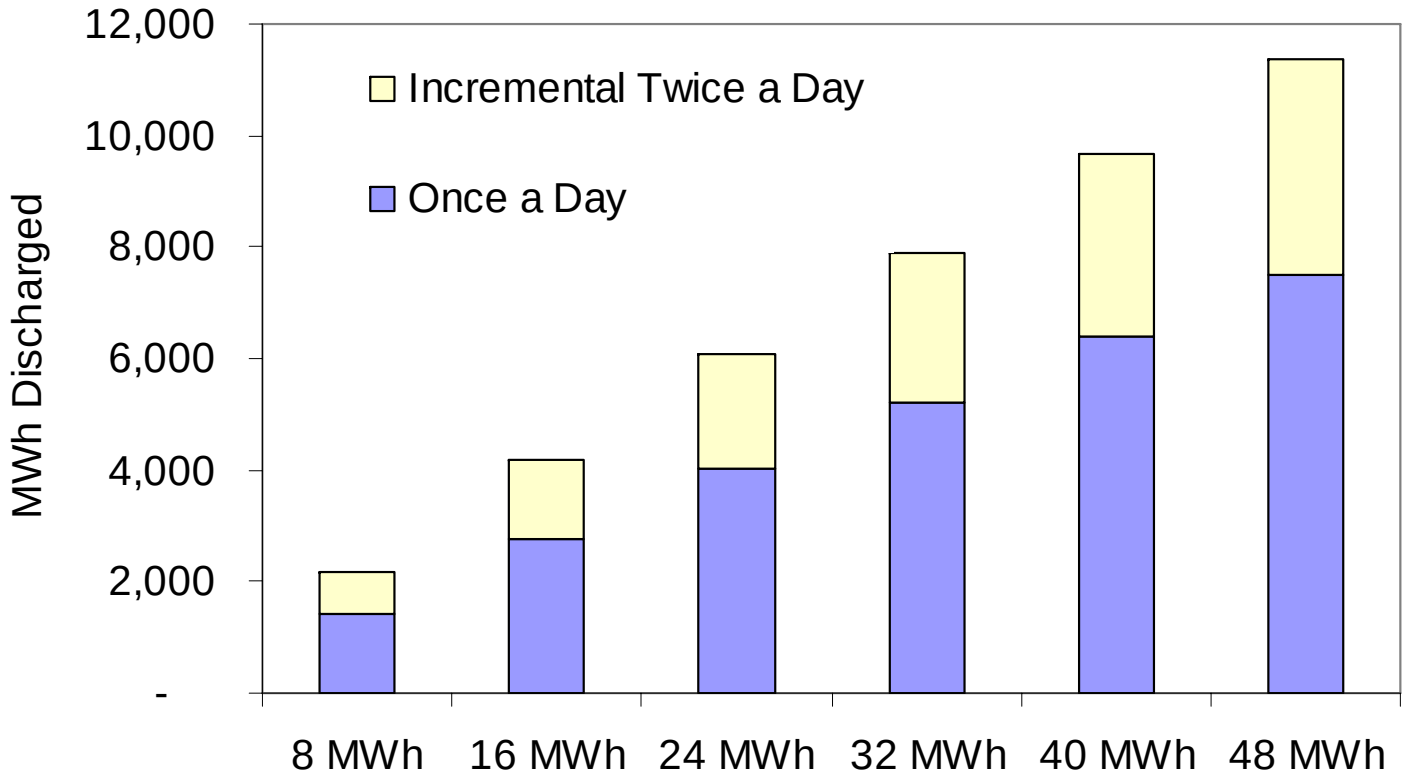
Restrictive tariff with low winter rates and efficiency losses worked against incremental revenue.

Variables	Once a Day	Twice a Day
Summer Charge	0:00 - 10:00	24:00 - 9:00; 19:00 – 21:00
Summer Discharge	12:00 - 20:00	11:00 – 19:00; 21:00 – 24:00
Winter Charge	0:00 - 10:00	0:00 - 10:00; 15:00 – 20:00
Winter Discharge	13:00 - 21:00	10:00 - 15:00; 20:00 – 24:00

Discharged MWh	4,020	6,083

Model Sensitivity Runs – Time of Day Results

Comparison of optimized once a day and twice a day operation yielded 50% more MWh discharged but 2% less incremental revenue



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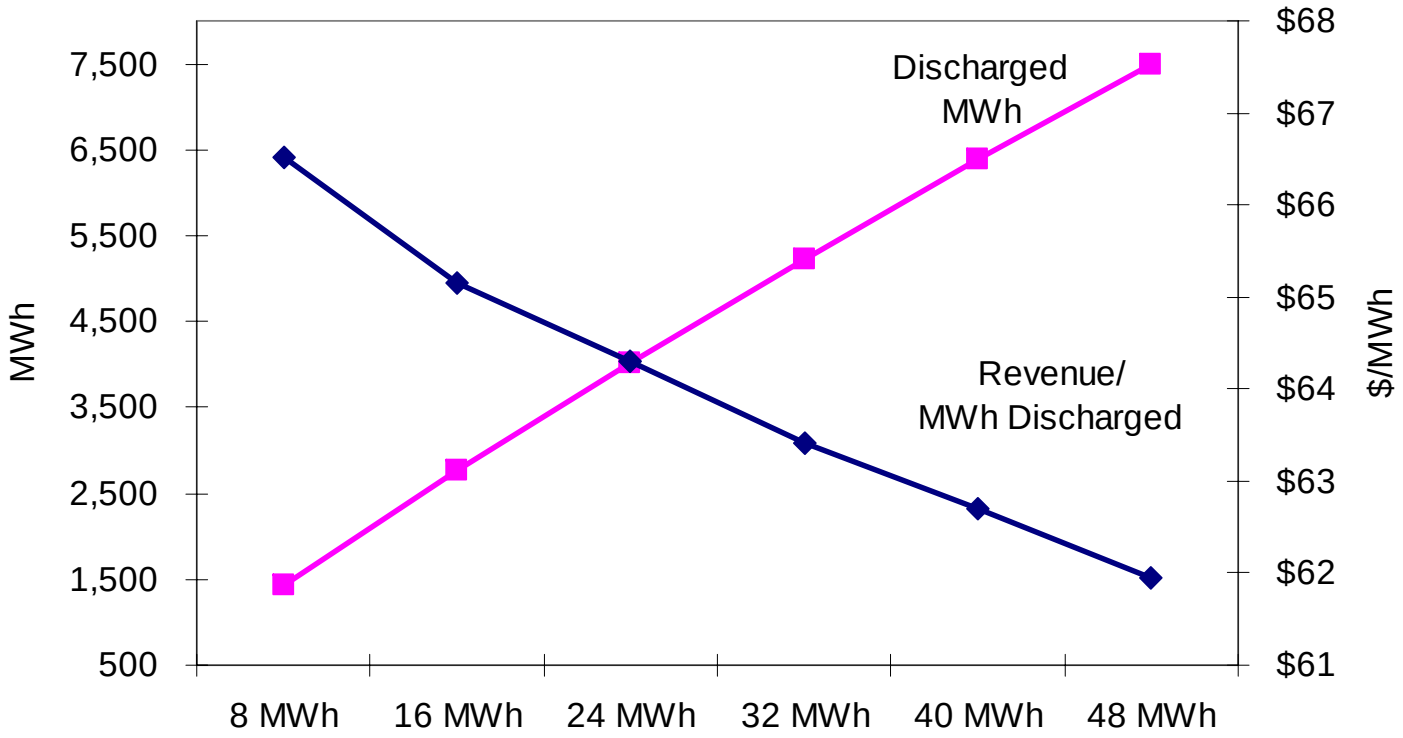
Model Sensitivity Runs - Capacity

Altering battery capacity from 8 MWh to 48 MWh while holding a once a day 10-hour charge and 8-hour discharge.

24 MWh is the optimal size. Energy discharged and revenue per MWh discharged are optimized: 4,020 MWh at $64/MWh.



Model Sensitivity Runs – Salvage Values

- VRB battery has two electrolyte storage tanks of active vanadium-sulfuric acid solutions
- Vanadium can be recovered from the electrolyte at the end of battery life
- VRB estimates this value at $76/kWh of energy storage capacity
  - Compared a range of salvage values to examine the contribution to cost reduction

Salvage Value	Reduction
$50/kWh	13%
$76/kWh	19%
$100/kWh	25%

CEC Pilot Performance-Based Incentive Program

- 50¢/kWh incentive for eligible renewable energy systems
  - Photovoltaic systems only at present
  - Equipment to store the electricity is not eligible (batteries, charge controllers, etc.)
- Incentives are paid for the first three years only
- Maximum available funding;
  - $ 400,000 per project
  - $1,000,000 for corporate or government parent
- Apply to CEC with preliminary reservation; participate in CEC monitoring; submit quarterly invoices to CEC; receive payments within two months

What if energy storage qualified for 1/10 of this rebate?

Model Sensitivity Runs – Rebate Values

- Assume that CEC extends its pilot performance-based incentive program to energy storage
- Energy storage equipment could obtain a “reasonable” portion of the 50¢/kWh renewable energy rebate, e.g.,
  - 1% or 0.5¢/kWh
  - 5% or 1¢/kWh
  - 10% or 5¢/kWh
- The resulting cost reduction during the initial years would be significant:

Rebate Value	Reduction
0.5¢/kWh	1.2%
1¢/kWh	2.4%
5¢/kWh	11.9%

Wrapping Up

- Complete analysis in a Final Report by year end 2005
- Perform a team review in January 2006
- Document the model, its ability to handle alternate time-of-use schedules and tariffs.
  - The model is robust; it can provide reliable analysis of wind speeds and turbine outputs in other transmission-constrained markets.
- Thank you to DOE Energy Storage Program, Sandia National Laboratories, Wyoming Business Council, PacifiCorp, and VRB