And Now For Something Completely (or not so) Different

Joel Molander
Manager – Hydro Assets

March 18, 2010

PUGET SOUND ENERGY
The Energy To Do Great Things

Presentation Outline

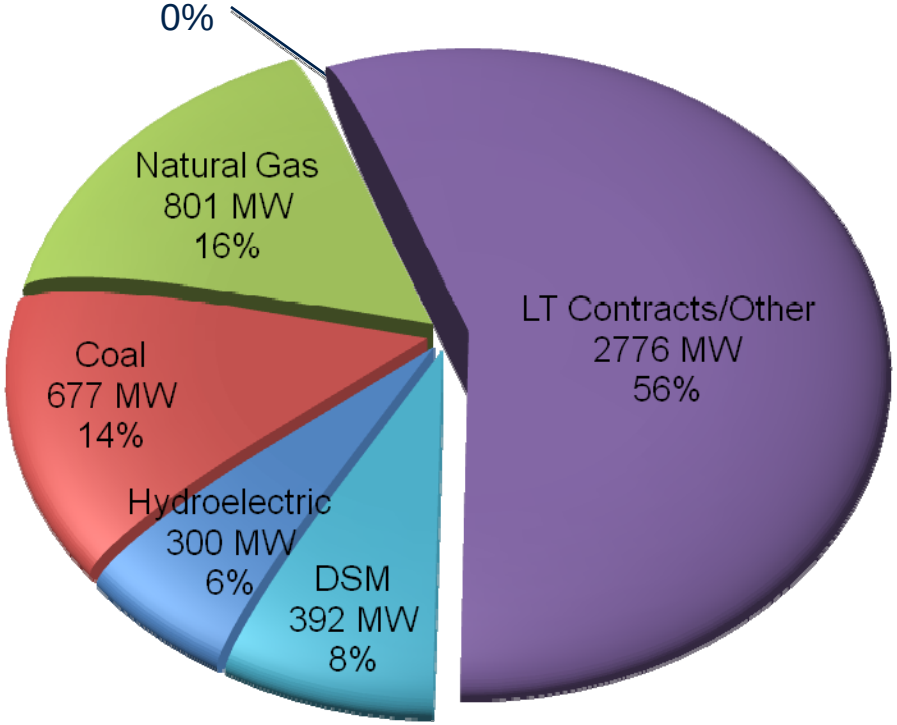
- Introduction to PSE
- Portfolio Overview
- Prospective Resource Need and Load Outlook
- RPS Requirements and PSE's Renewable Assets
- Operational Implications
- Integration Costs and Effects on Legacy Assets
- Future Challenges and Opportunities

Puget Sound Energy

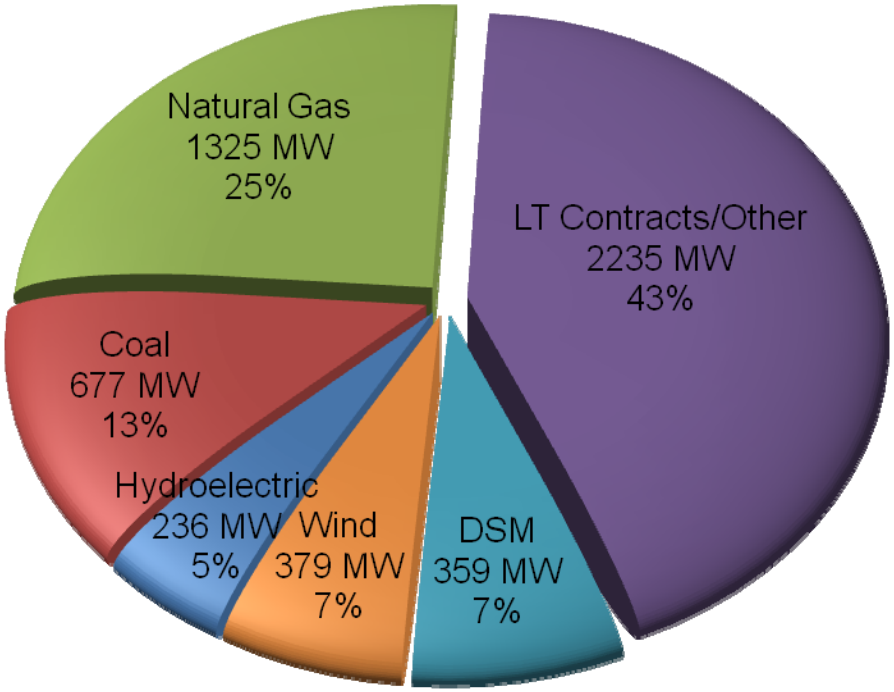
- Washington State's oldest and largest utility
- 1 million electric customers
- More than 700,000 natural gas customers
- Service territory stretches across 11 counties
- Privately held

Energy Resources – Our Changing Resource Mix

2002



2008

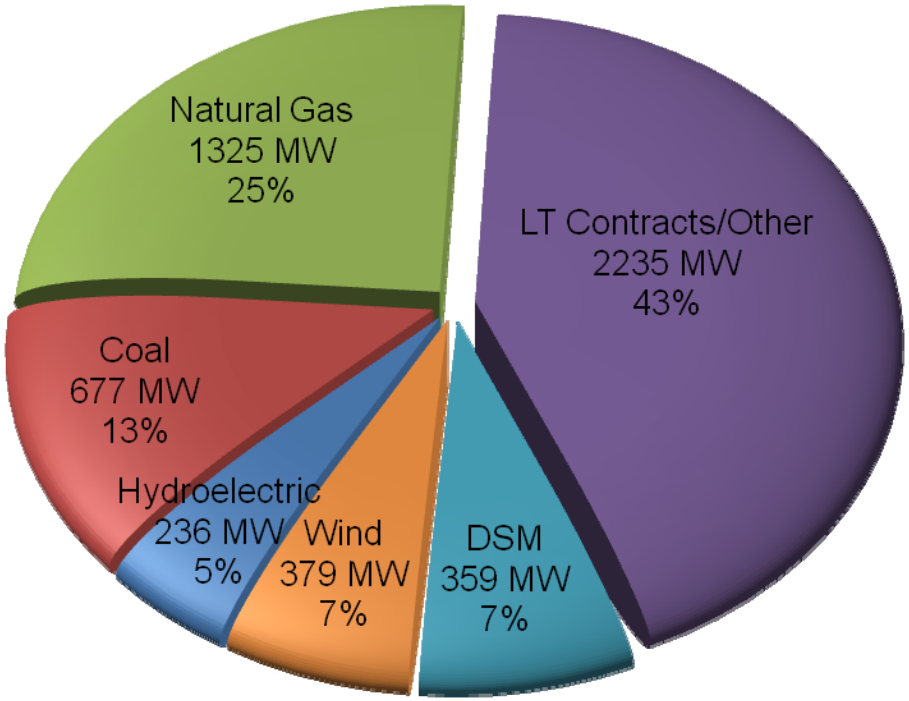


4,946 MW
44% Owned

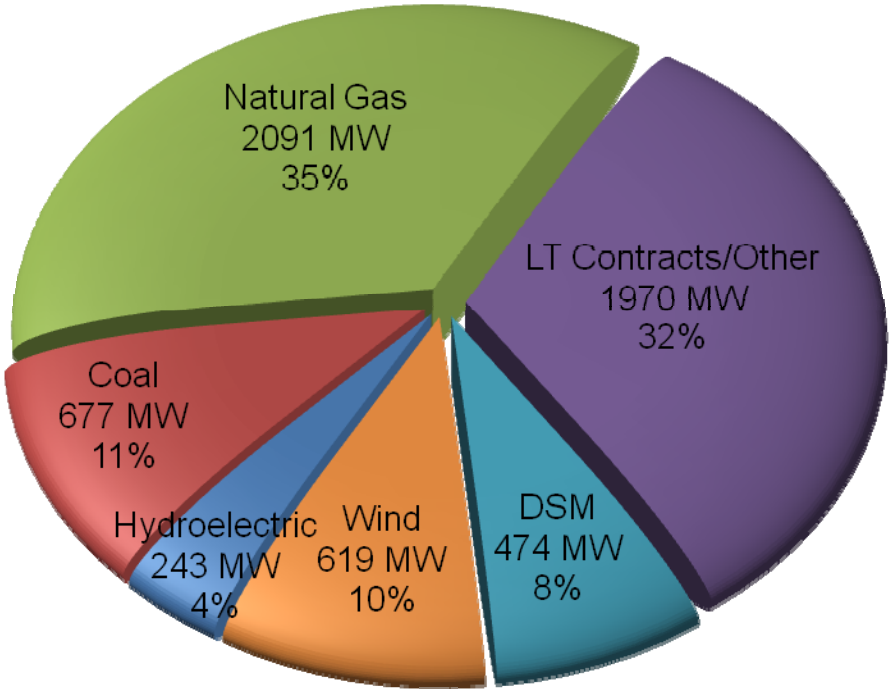
5,211 MW
57% Owned

Energy Resources – Our Future Resource Mix

2008



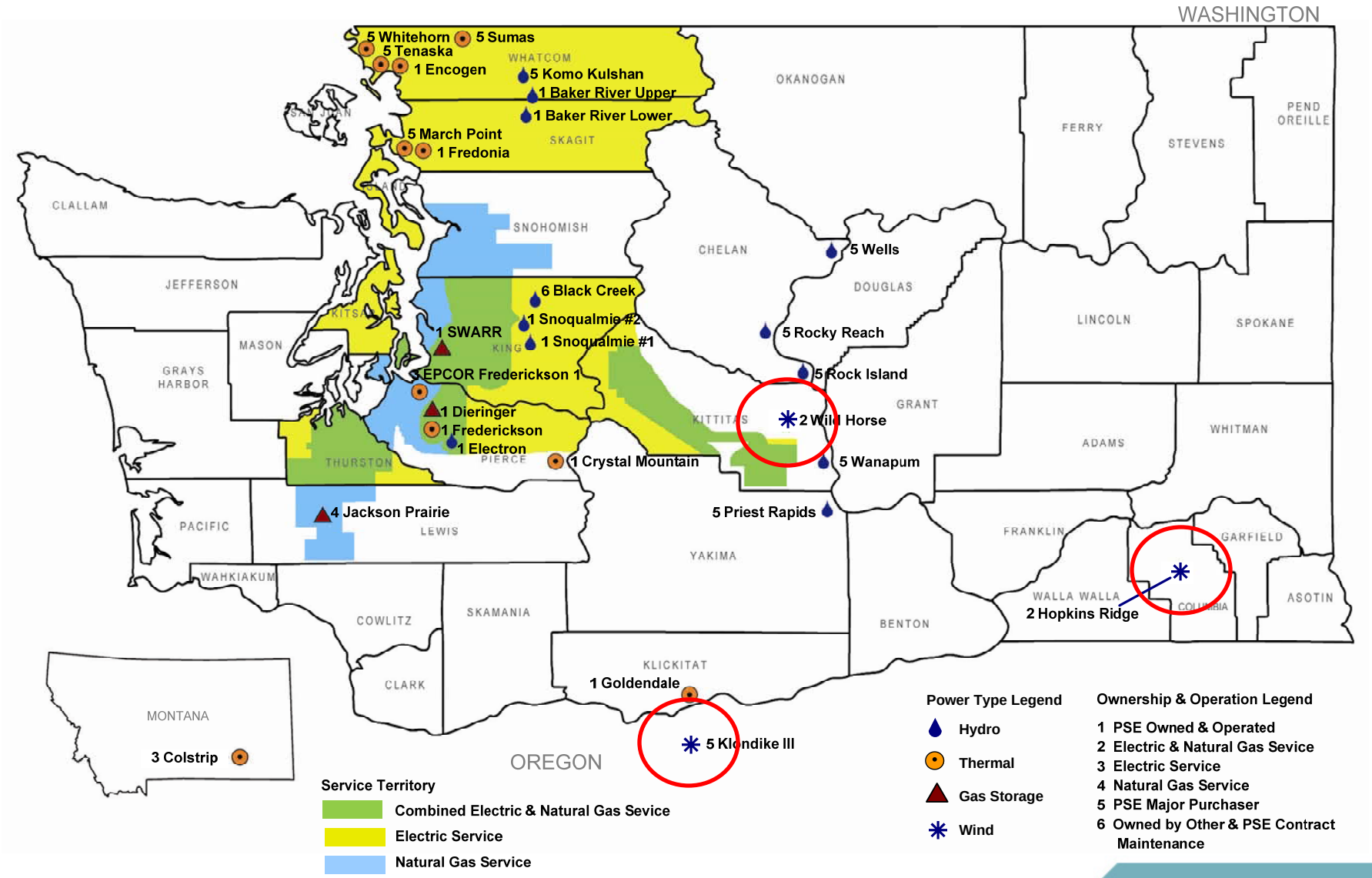
2013



5,211 MW
57% Owned

6,075 MW
68% Owned

PSE Existing Resources



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Hydroelectric Resources

PSE Owned	Baker River	170 MW
	Snoqualmie	44 MW
	Electron	22 MW
		236 MW
	Mid-Columbia	1,073 MW
	Other Hydro PPAs	168 MW

- New licenses for Baker & Snoqualmie Projects
- Decreased Mid-Columbia Contract rights
- Increased reliance on hydroelectric attributes

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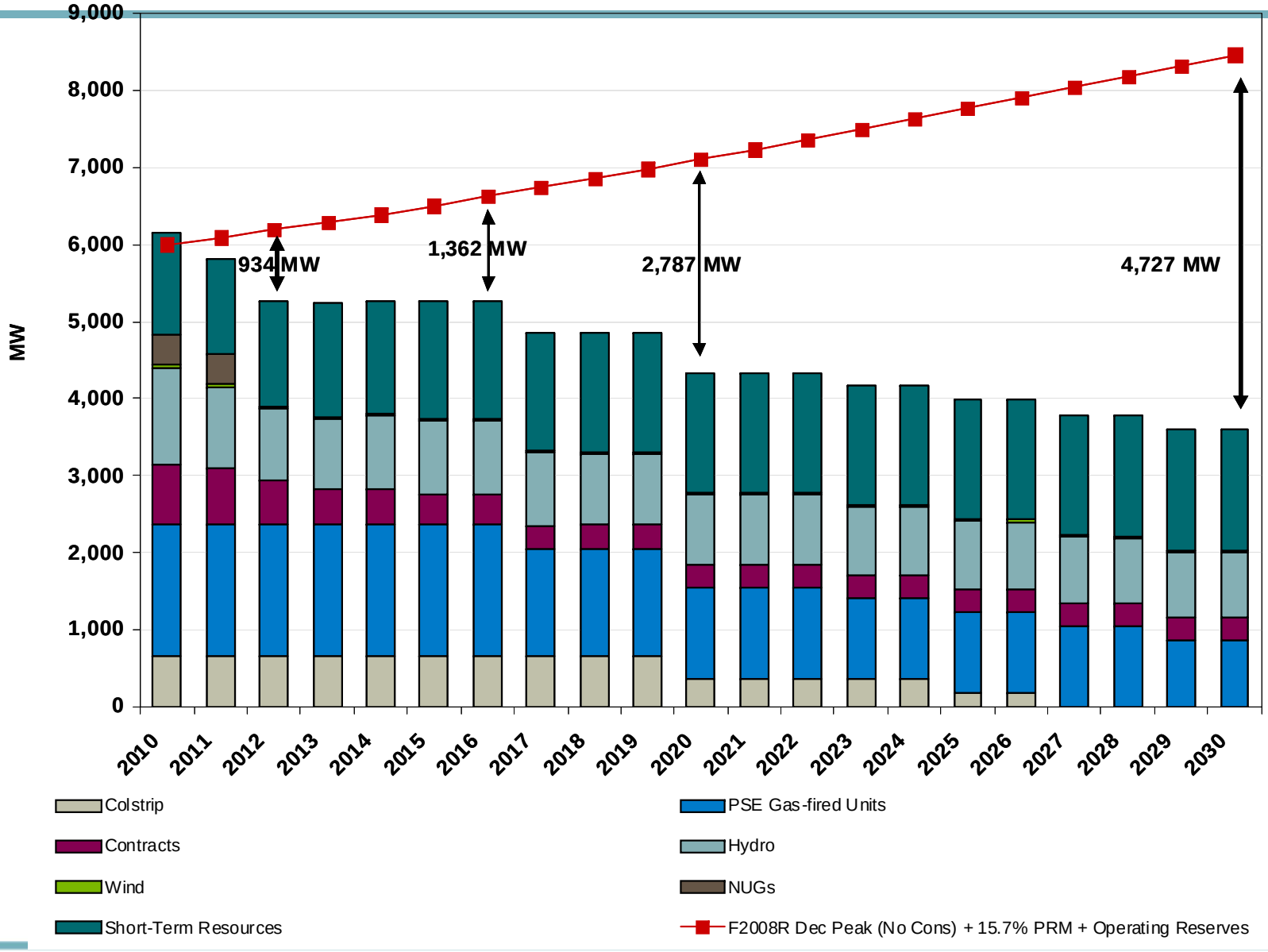
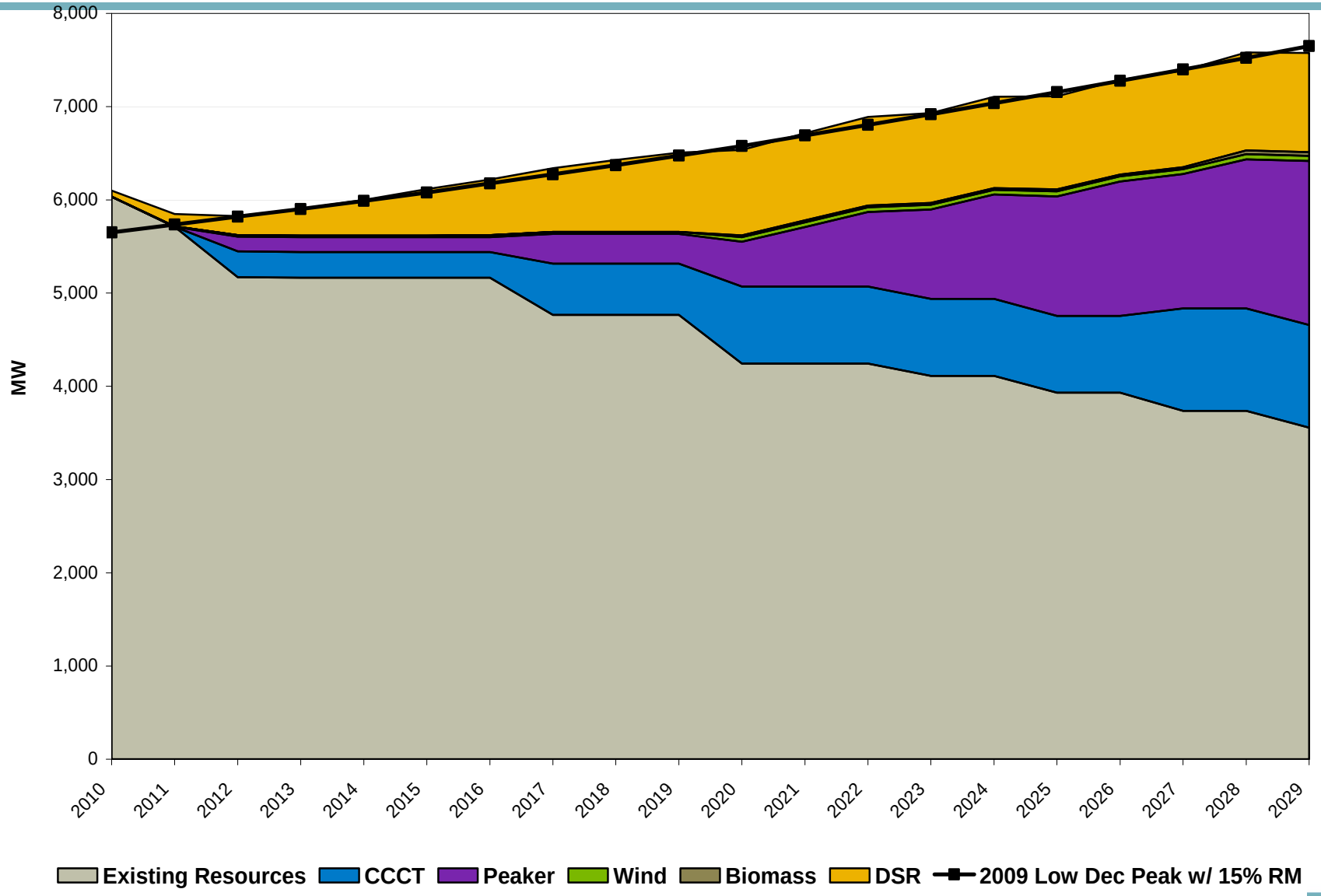
2009 IRP Addendum Resource Need



Peak Capacity Electric Resource Plan, 2009 IRP

Cumulative Resource Additions (MW)



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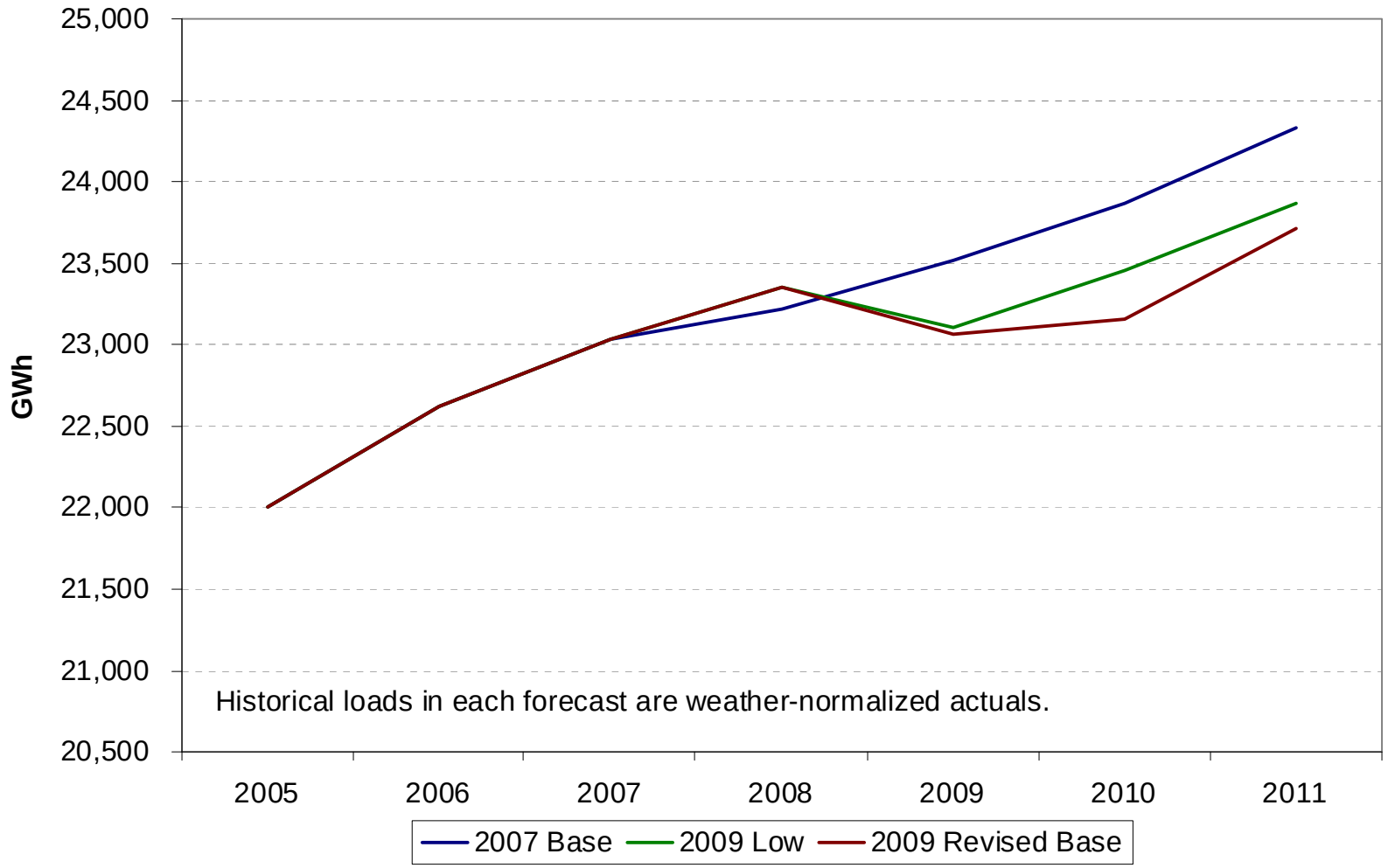
Near-term Electric Load Forecast



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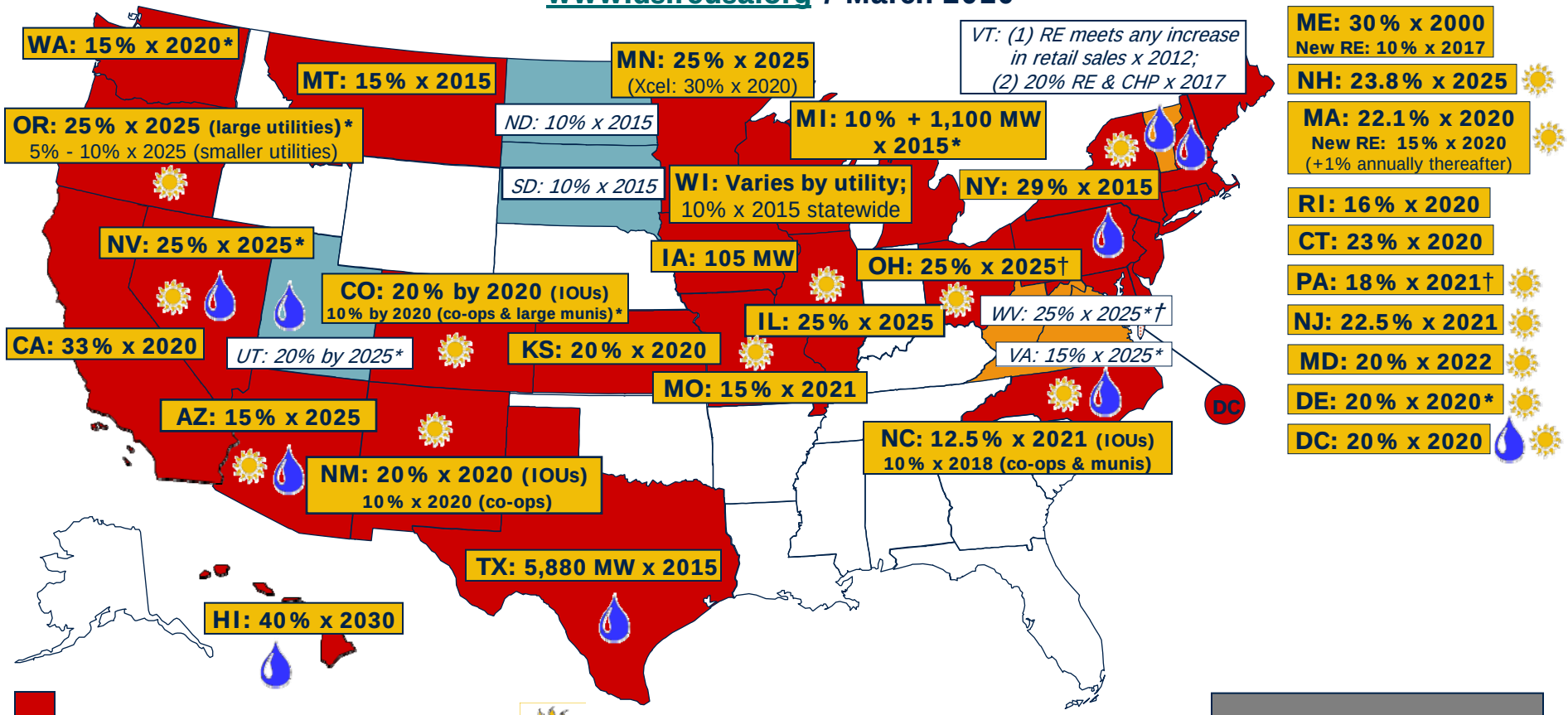
Renewable Portfolio Standards

www.dsireusa.org / March 2010



State renewable portfolio standard

State renewable portfolio goal

Solar water heating eligible

Minimum solar or customer-sited requirement

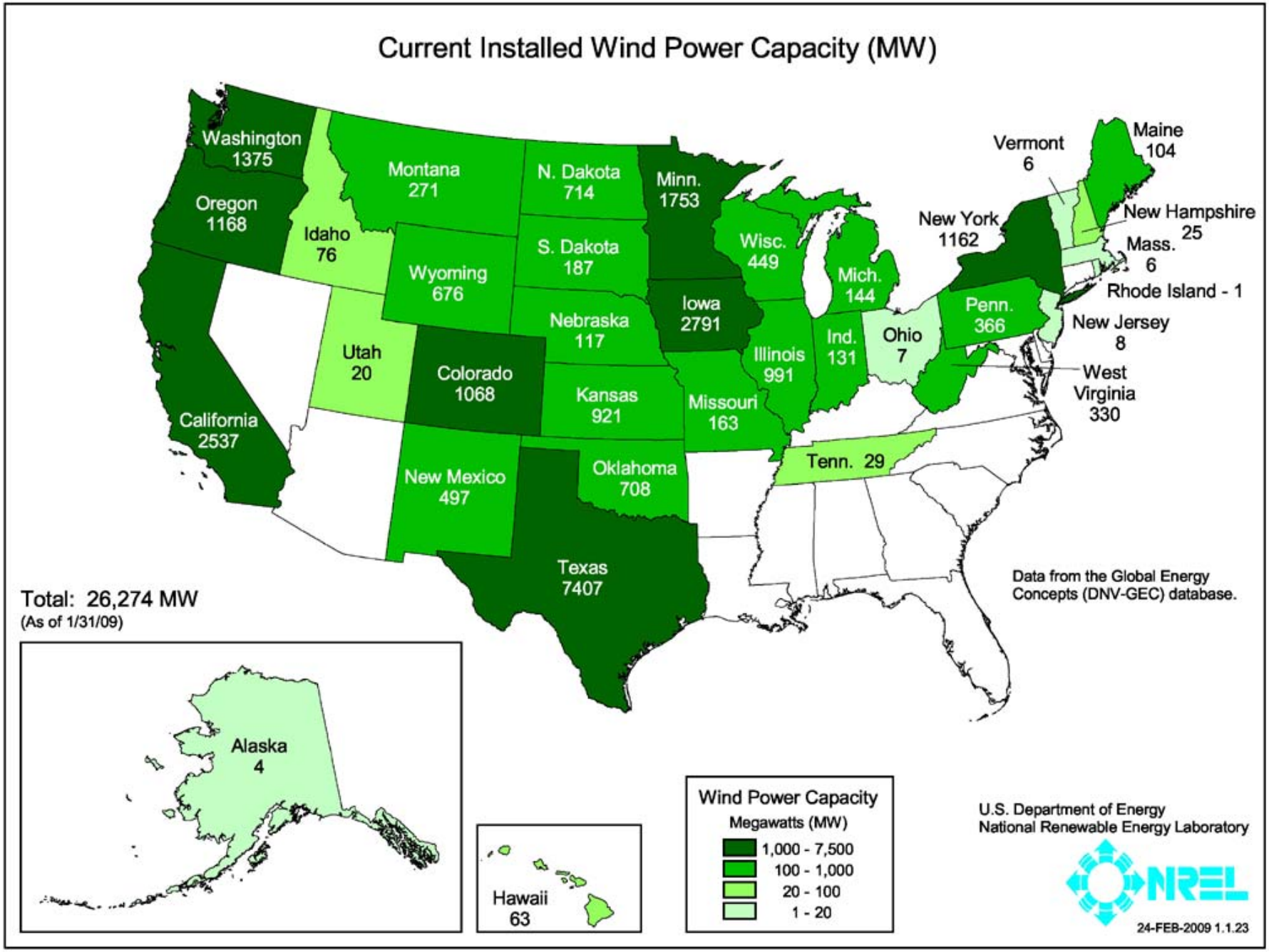
* Extra credit for solar or customer-sited renewables

† Includes non-renewable alternative resources

29 states + DC have an RPS

(6 states have goals)

Current Installed Wind Power Capacity (MW)



Total: 26,274 MW
(As of 1/31/09)

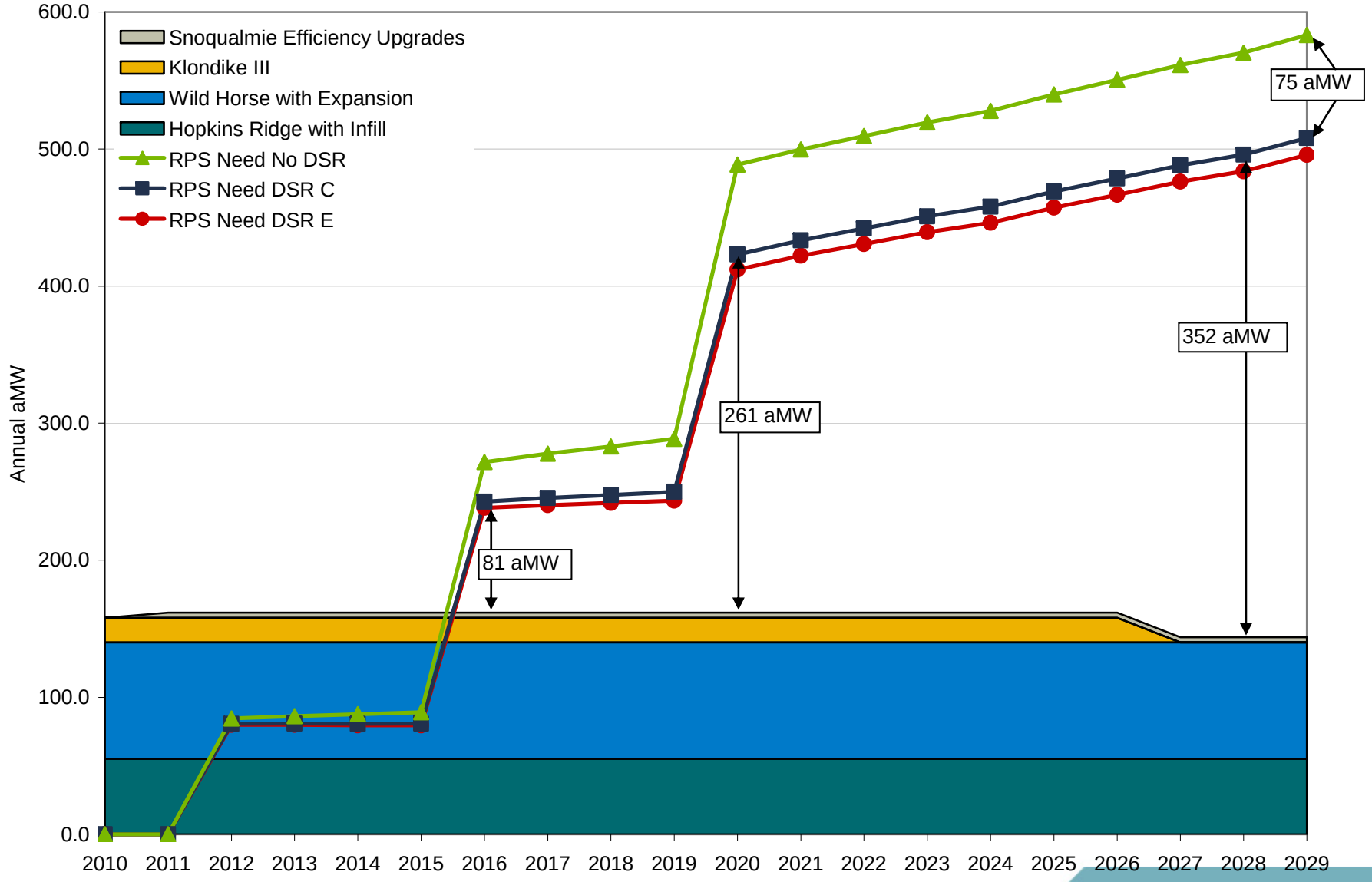
Data from the Global Energy Concepts (DNV-GEC) database.

U.S. Department of Energy
National Renewable Energy Laboratory

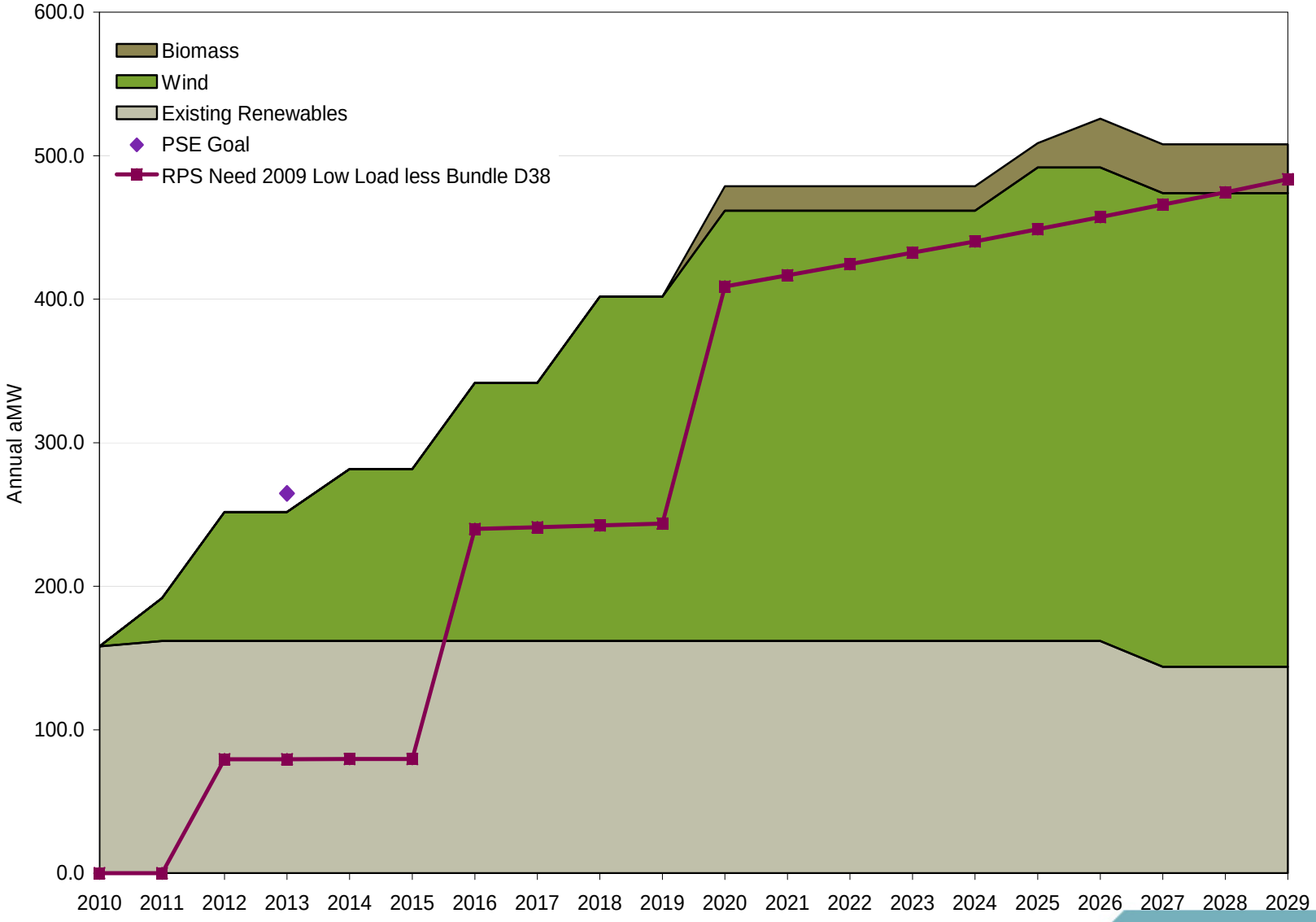
NREL

24-FEB-2009 1.1.23

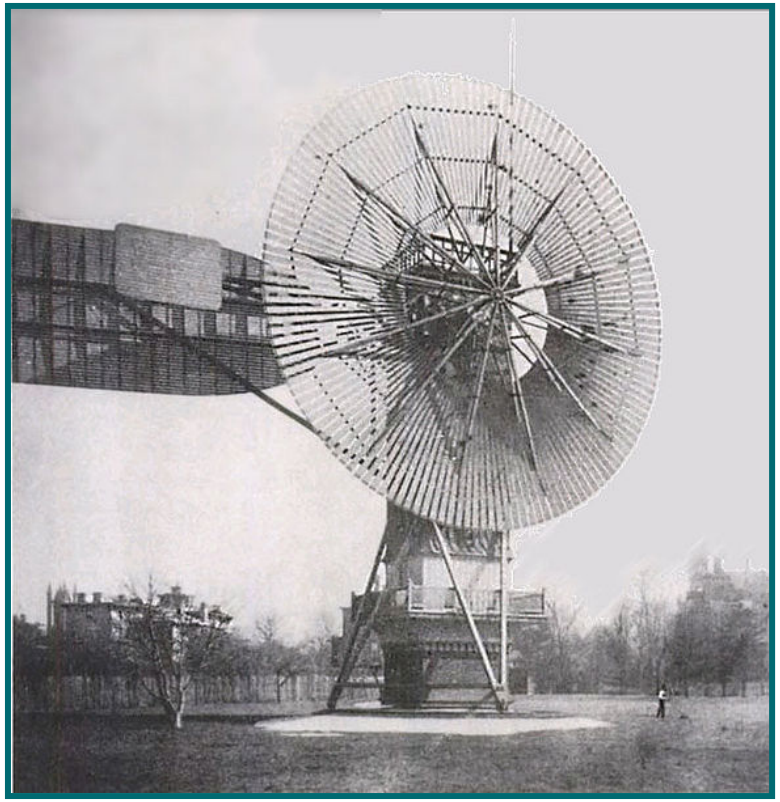
2009 IRP: Renewable Resource Need



Filling the Gap

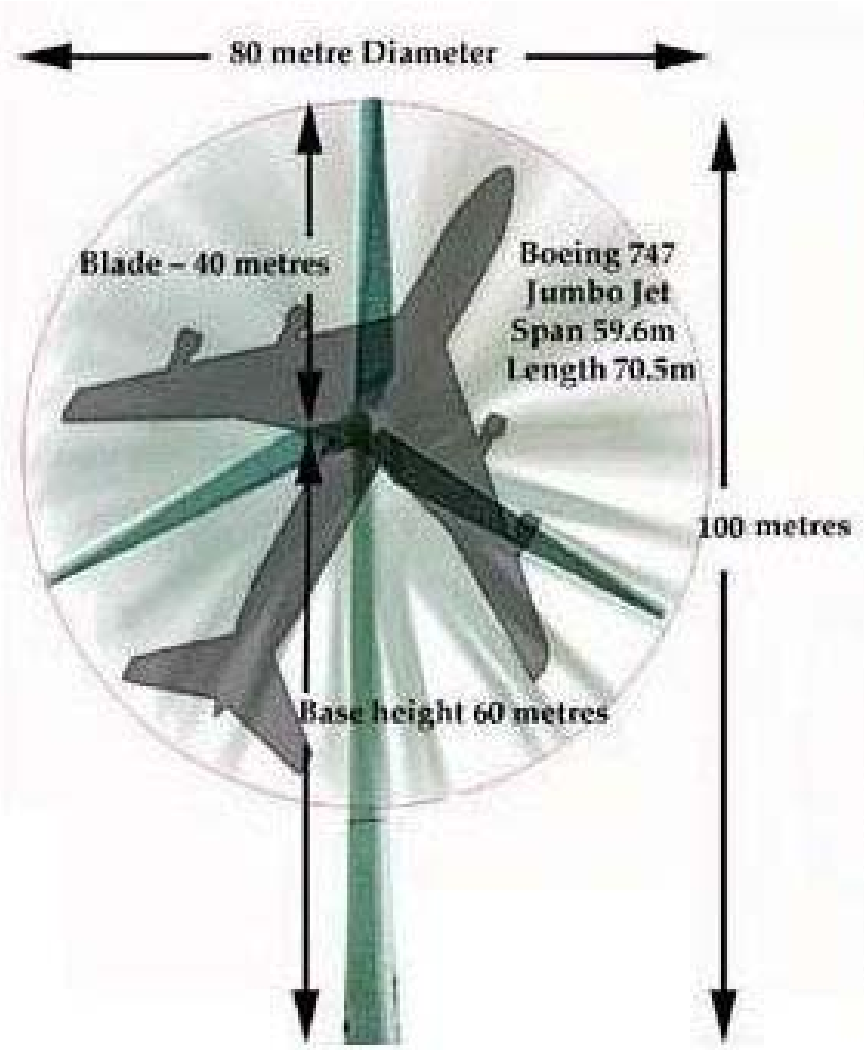


Old and New



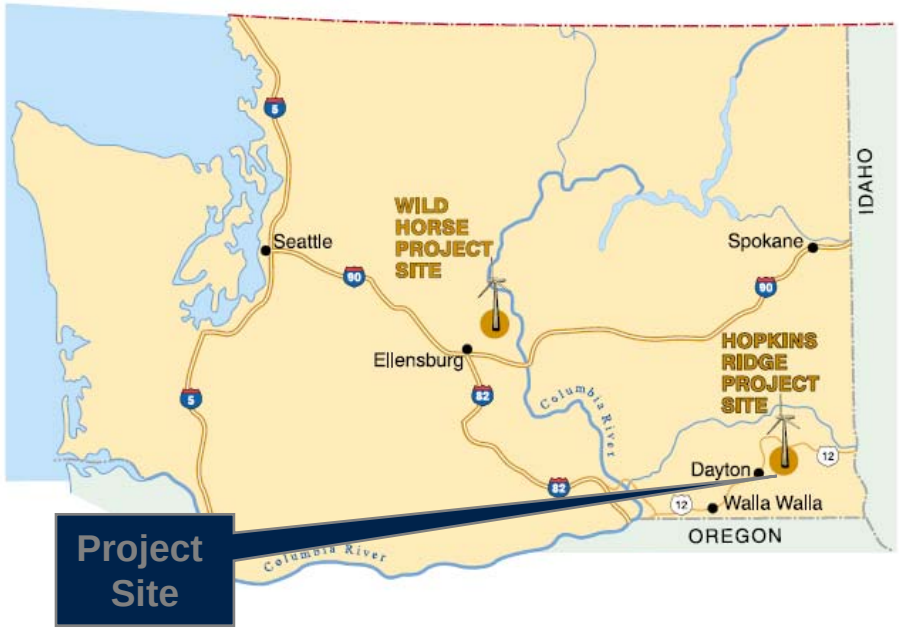
- Generates at wind speeds between 9-56 mph produce electricity
- Nacelle and rotor turns 360° on top of tower to follow wind
- Generator produces 690 volts AC that is stepped up to 34.5 kV collection system voltage, then stepped up to grid voltage
- Turbines connected together in strings

Basic Wind Turbine Specifications



- Rotor Dia = 80 meters
- Swept Area = 5,026 m^2
- Rotation = 15.5-16.5 RPM
- Gen Voltage = 690 Volts
- Capacity = 1,800-2,000 kW
- Nacelle Weight = 77 tons
- Rotor Weight = 41 tons
- Tower Weight = 105 tons
- Total Weight = 223 tons

Hopkins Ridge Wind Project



- **Commercial Operations Date**
  - **Nov 22, 2005**

- **All-in cost of $200 million**
- **150 MW**
- **35% capacity factor**
- **1.8 MW Capacity**
- **220 feet tall at hub**
- **320 feet to tip of blade**

Wild Horse Wind Project

- **11 miles east of Ellensburg in Kittitas County, Washington**
- **Shrub steppe habitat - primarily grazi land**
- **8-mile 230kV transmission line to PSE IP Line at new Wind Ridge Substation**
- **230 MW**

- **All-in cost of $380 million**
- **Commercial Operation Dec 22, 2006**

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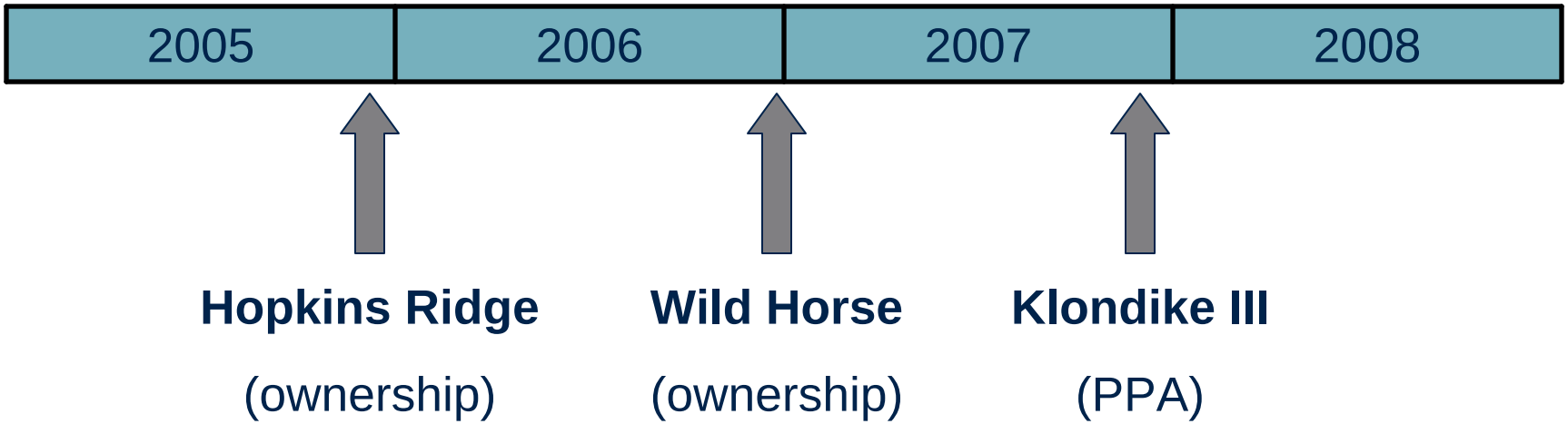
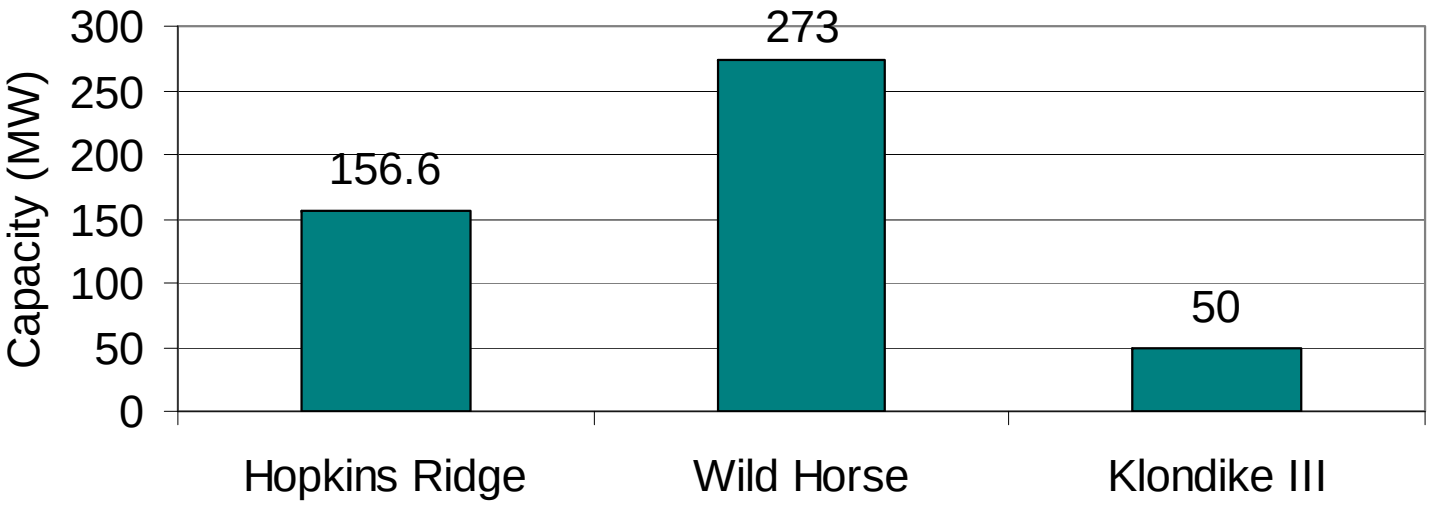
PSE Wind Assets





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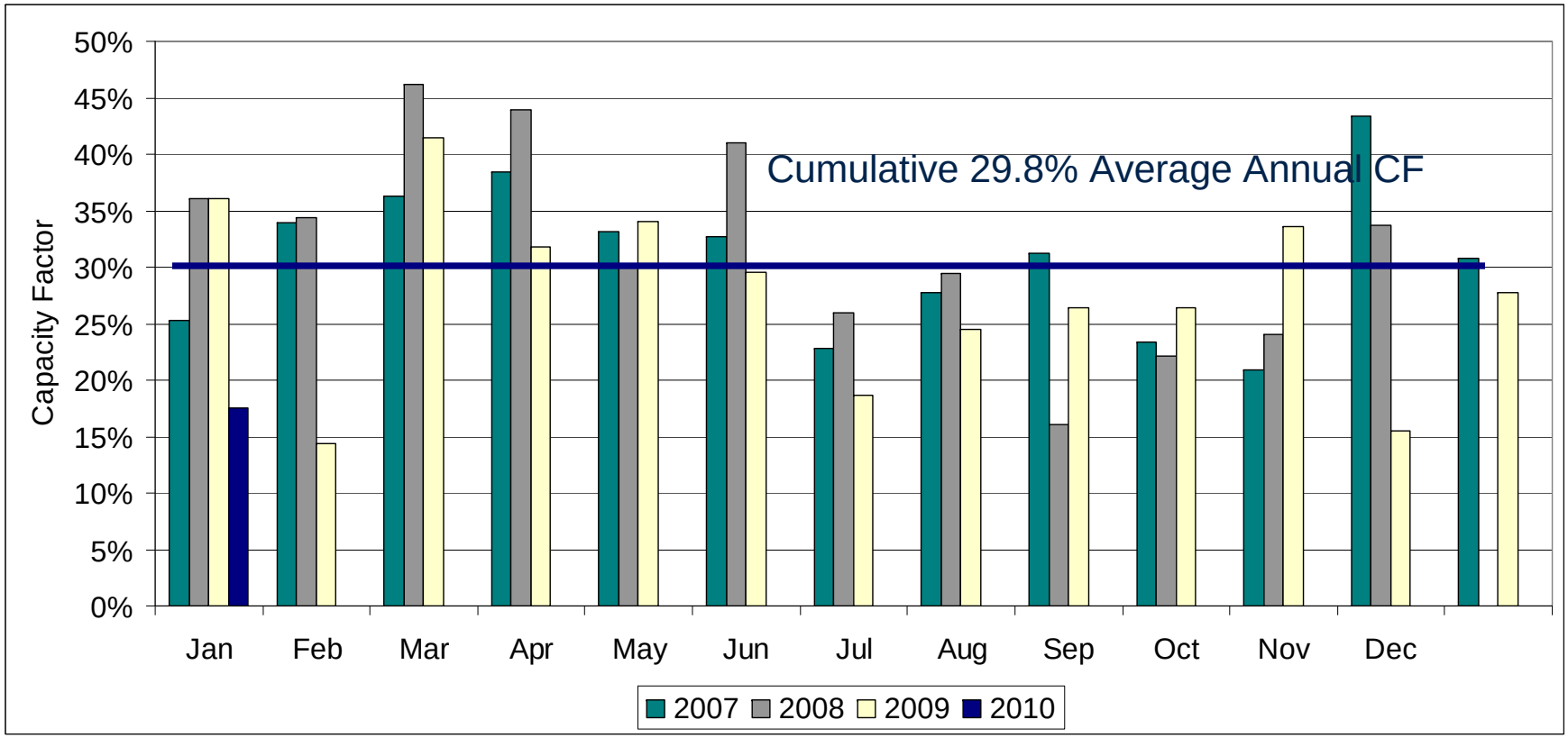
Integrating Wind Projects

- **Hopkins Ridge**
  - Integrated in BPA's balancing authority
- **Wild Horse**
  - Integrated in PSE's balancing authority
- **Klondike III**
  - Integrated through power purchase agreement (estimates and true-ups)

Hopkins Ridge Wind Project Capacity Factors

- January 2010 capacity factor is 17.5%
- February 2010 capacity factor is 12%



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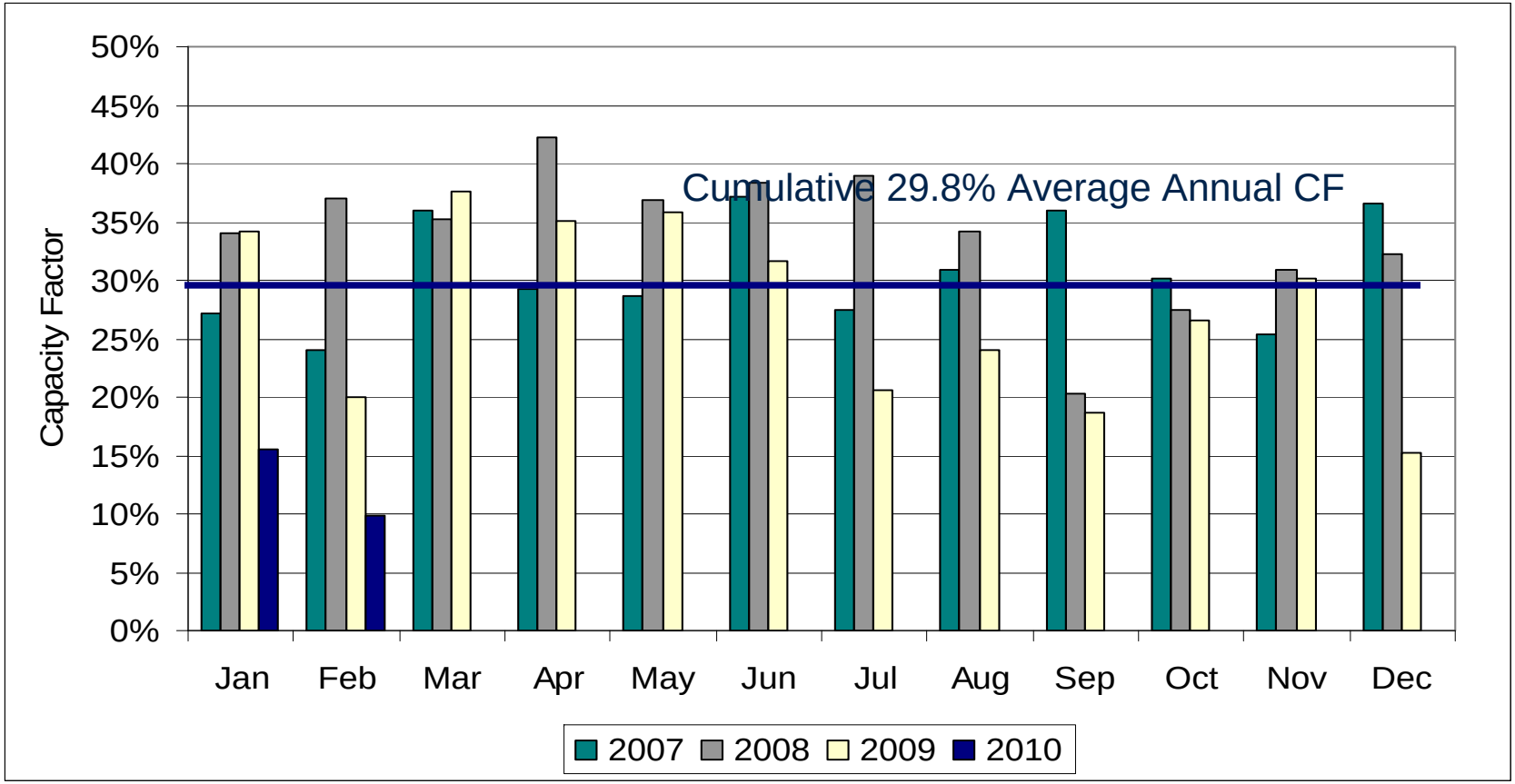
Wild Horse Wind Project Capacity Factors

- January 2010 capacity factor is 15%
- February 2010 capacity factor is 10%



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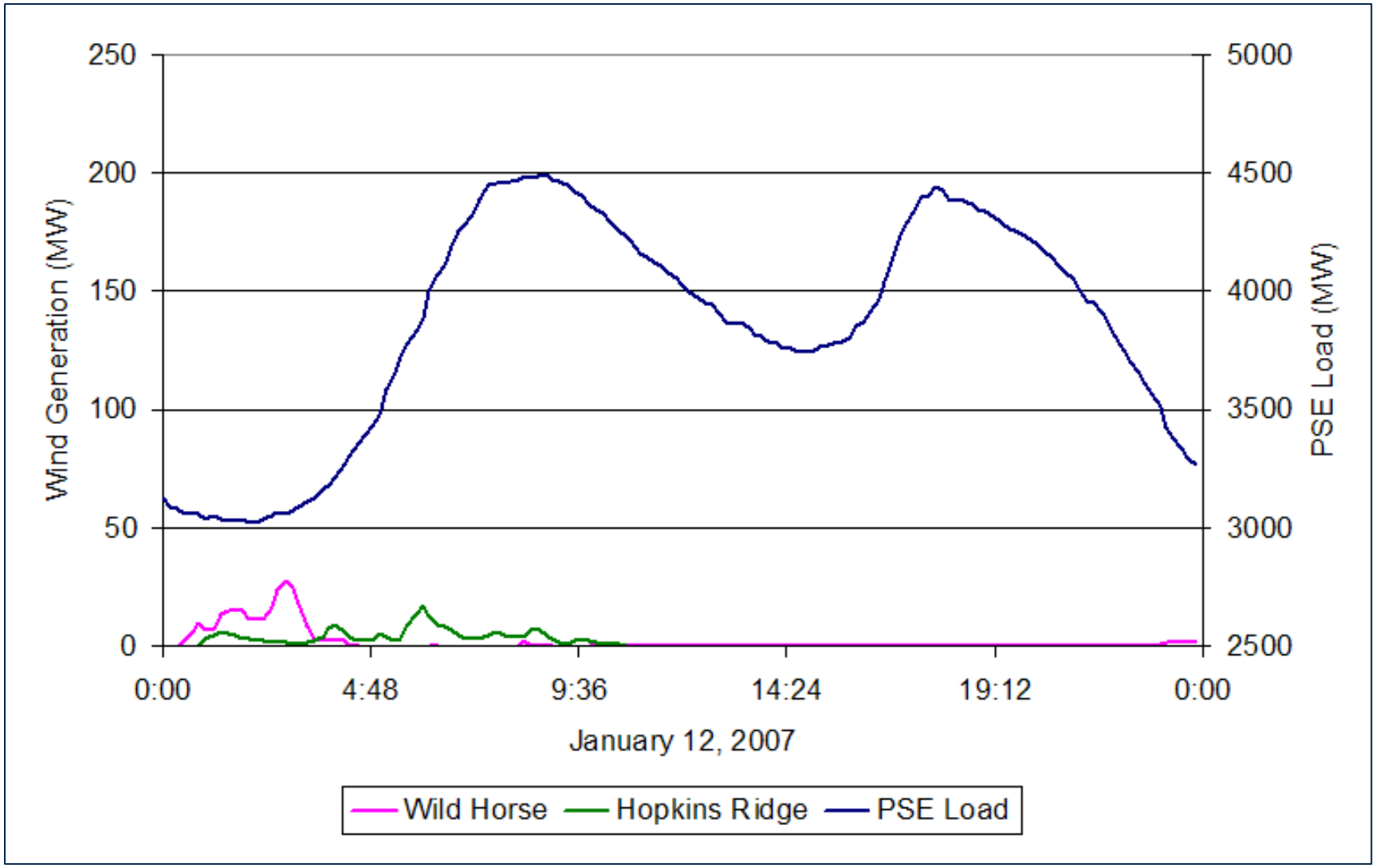
On the coldest day, wind is usually not blowing



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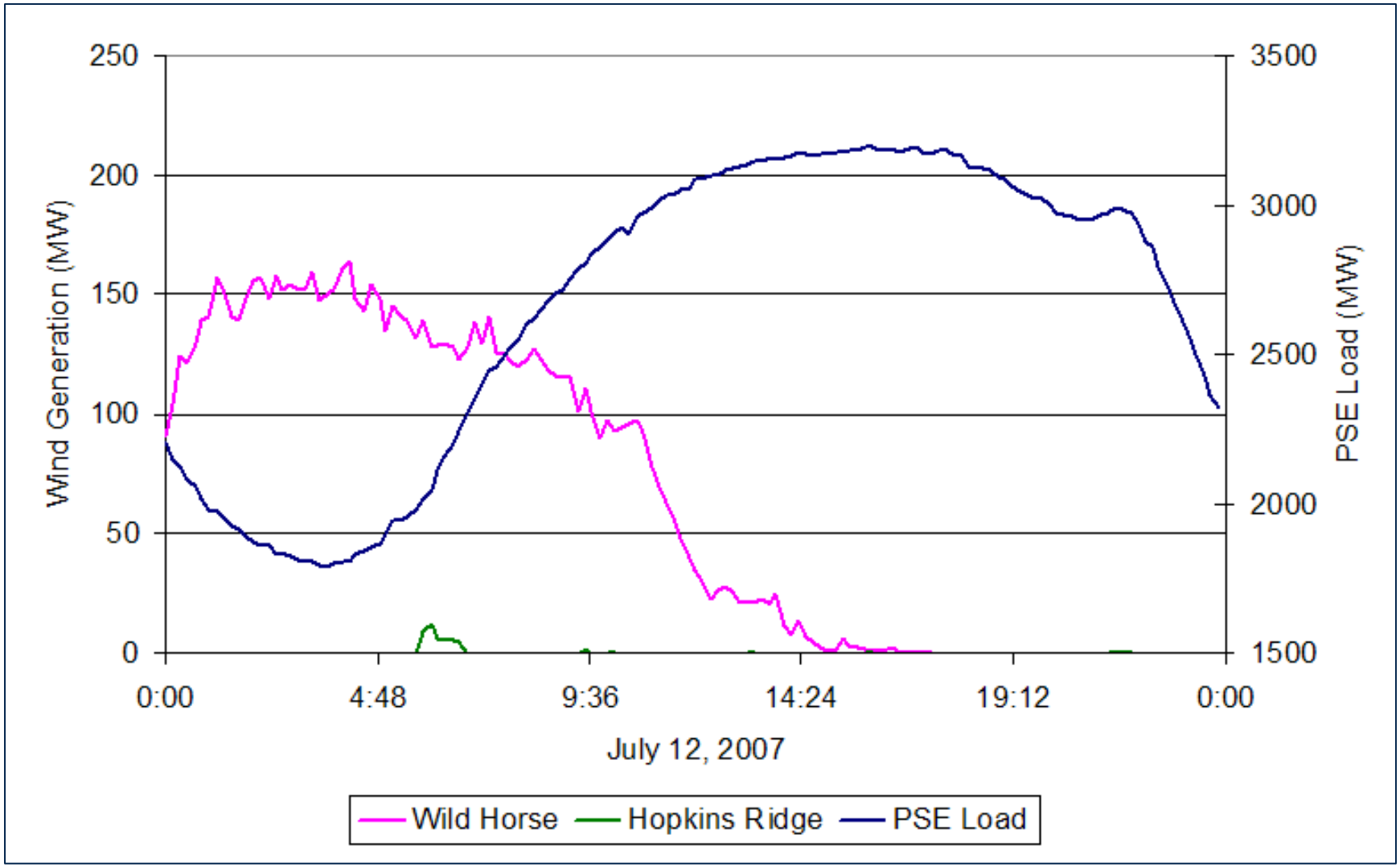
On the hottest day, wind is usually not blowing



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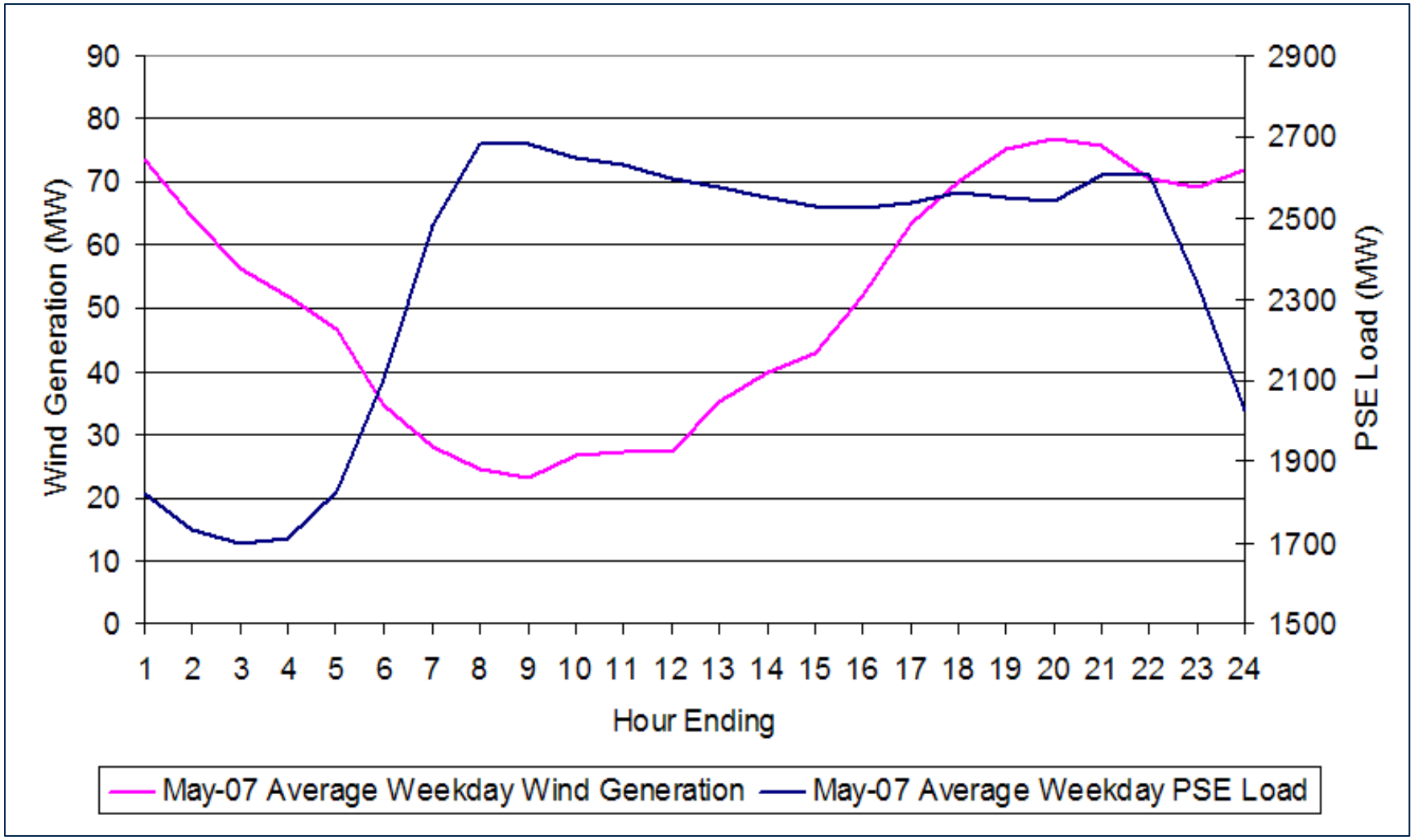
When load is ramping up, wind is usually falling off



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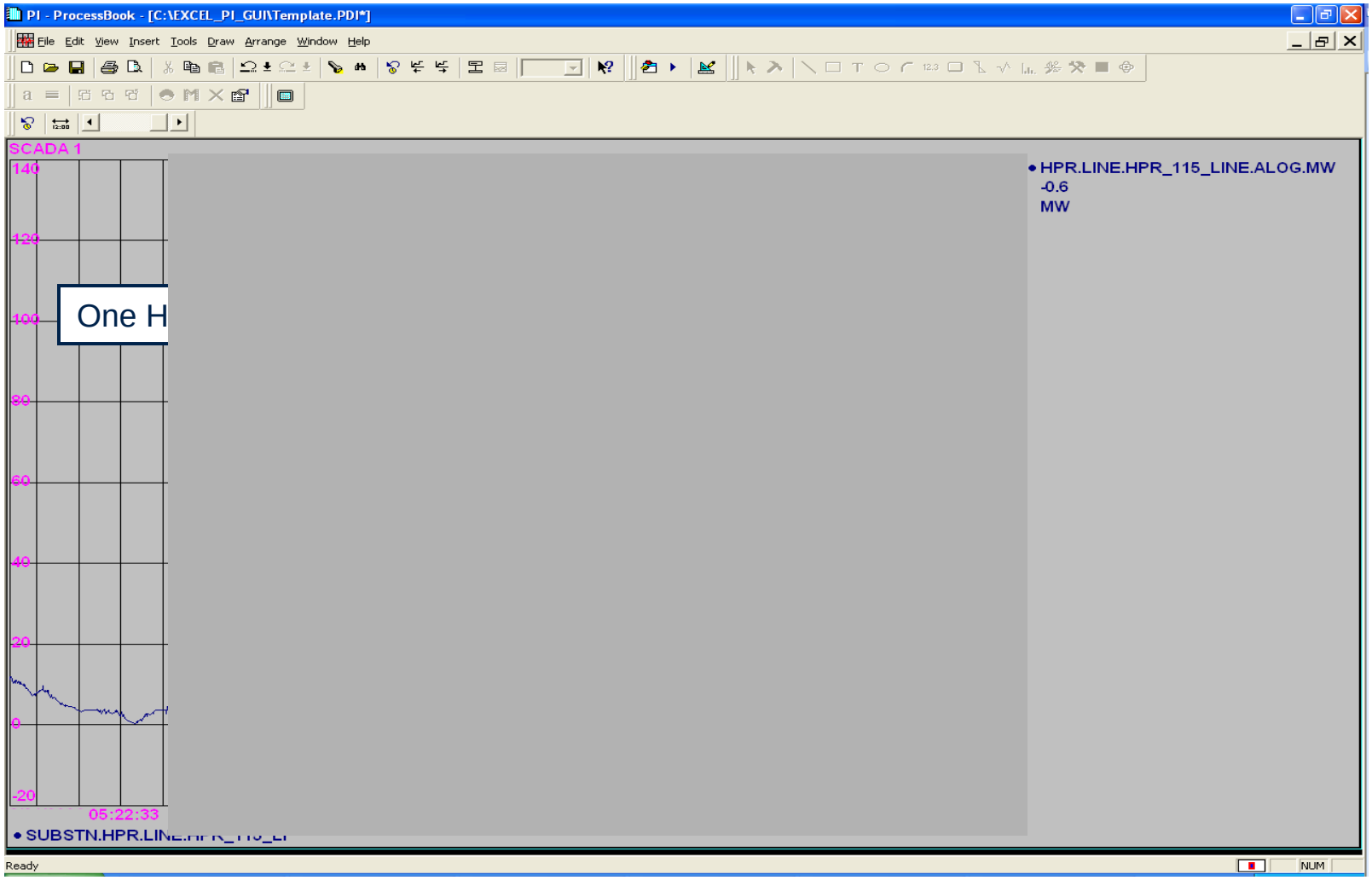
A Day in the Life…

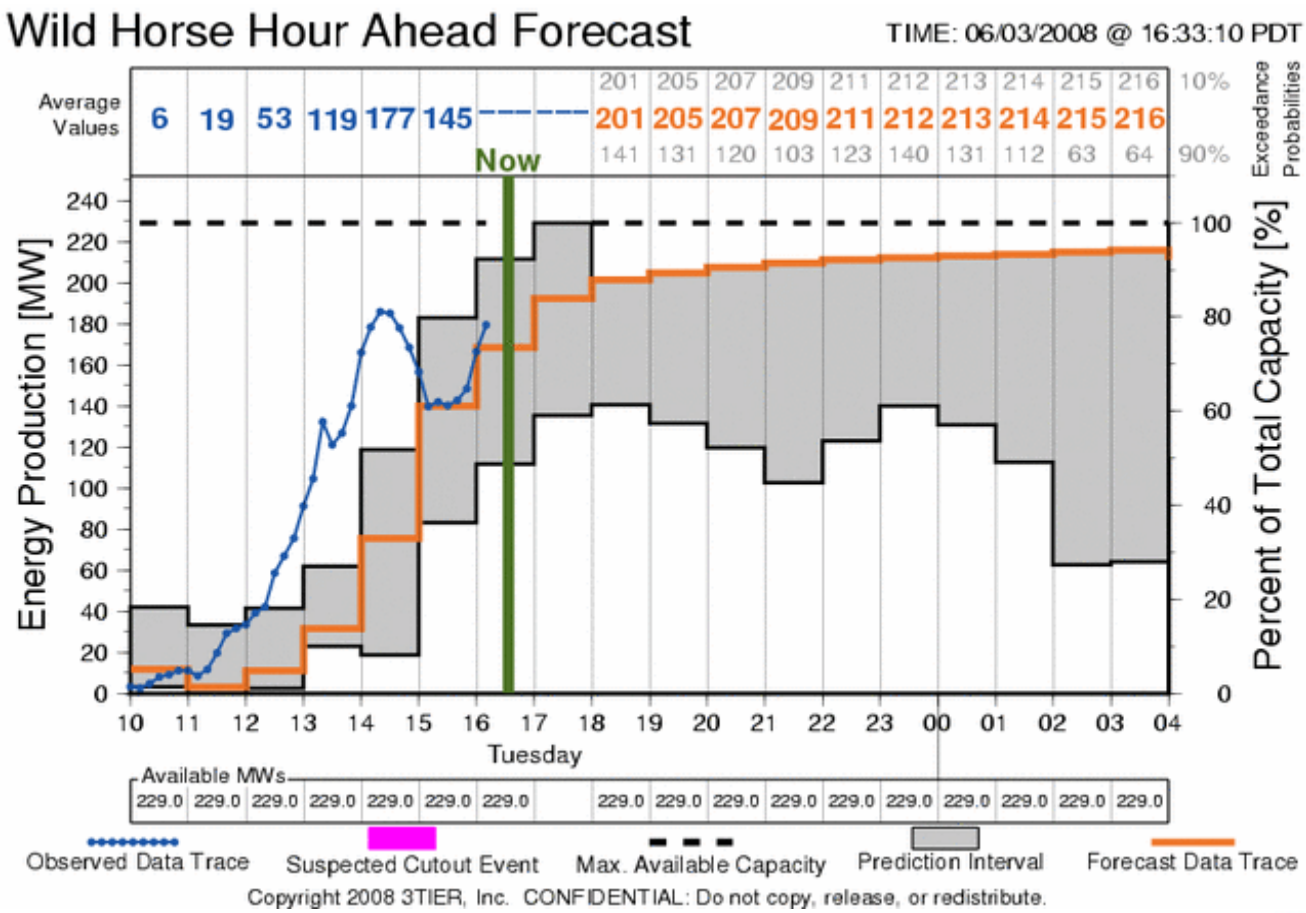


Integration Capabilities

- Manage PSE's portfolio based on wind forecast to ensure required operating flexibility
  - Primary reliance on PSE's Mid-C rights
  - Expanded reliance on PSE's west-side, more highly constrained hydro projects
  - Expanded reliance on simple and combined cycle combustion turbines
  - Market reserve purchases (if available)
  - Wind curtailment (spill) and only as last resort
- Wind forecast accuracy is paramount and an evolving science

Wind Generation Forecasting

- 3Tier provides hourly, daily, and weekly forecasts



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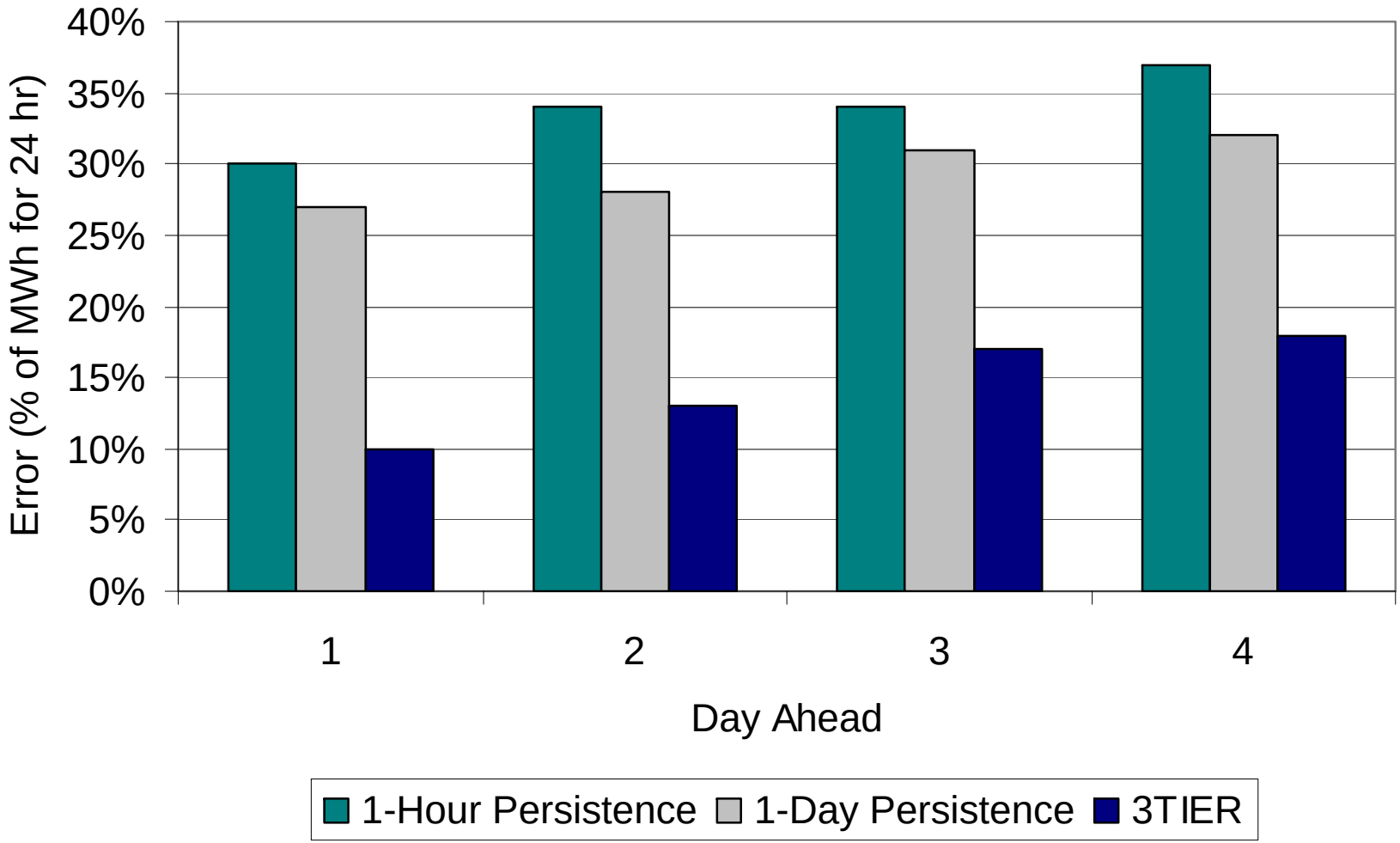
Wind Generation Forecast Error



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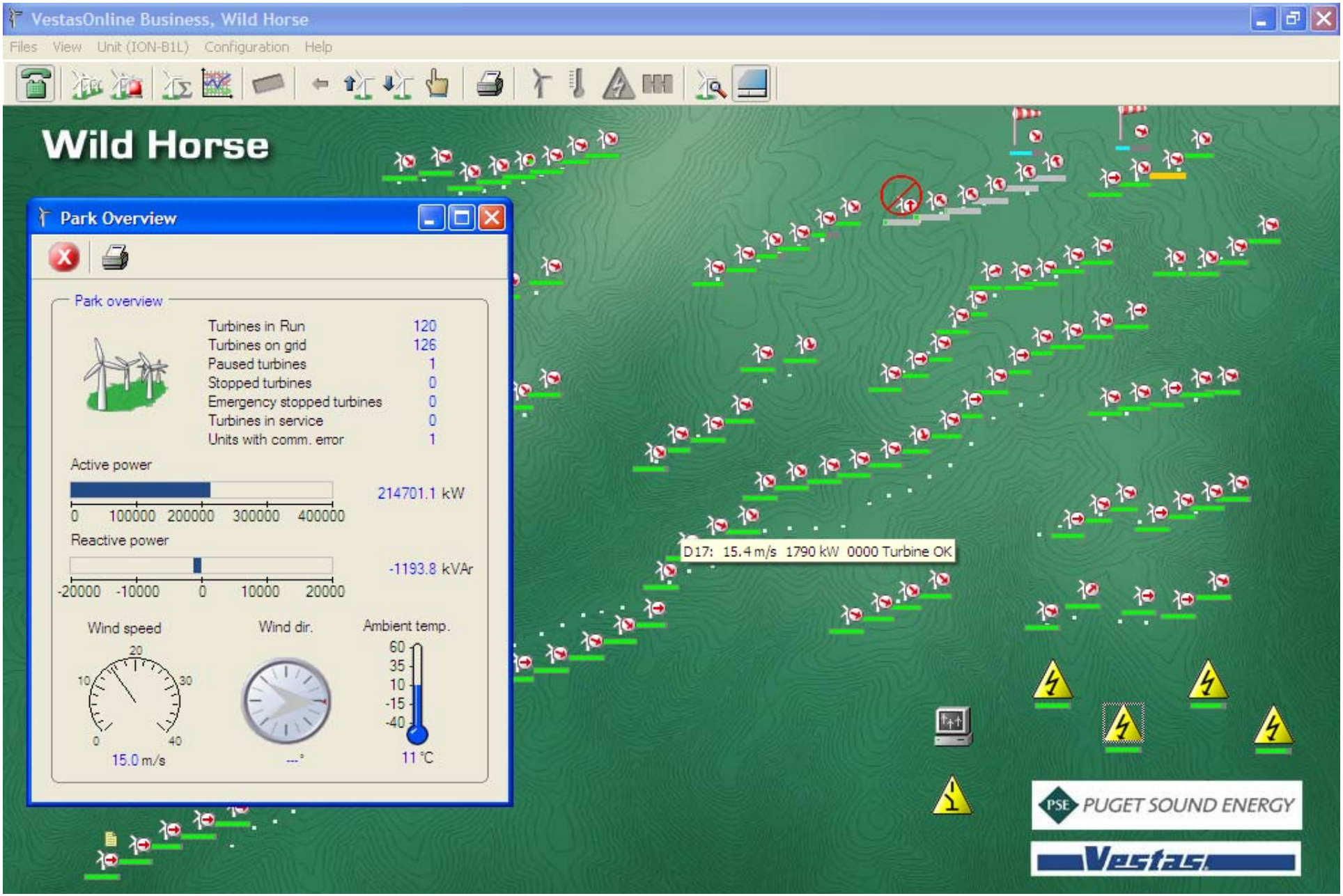
Real-Time Control



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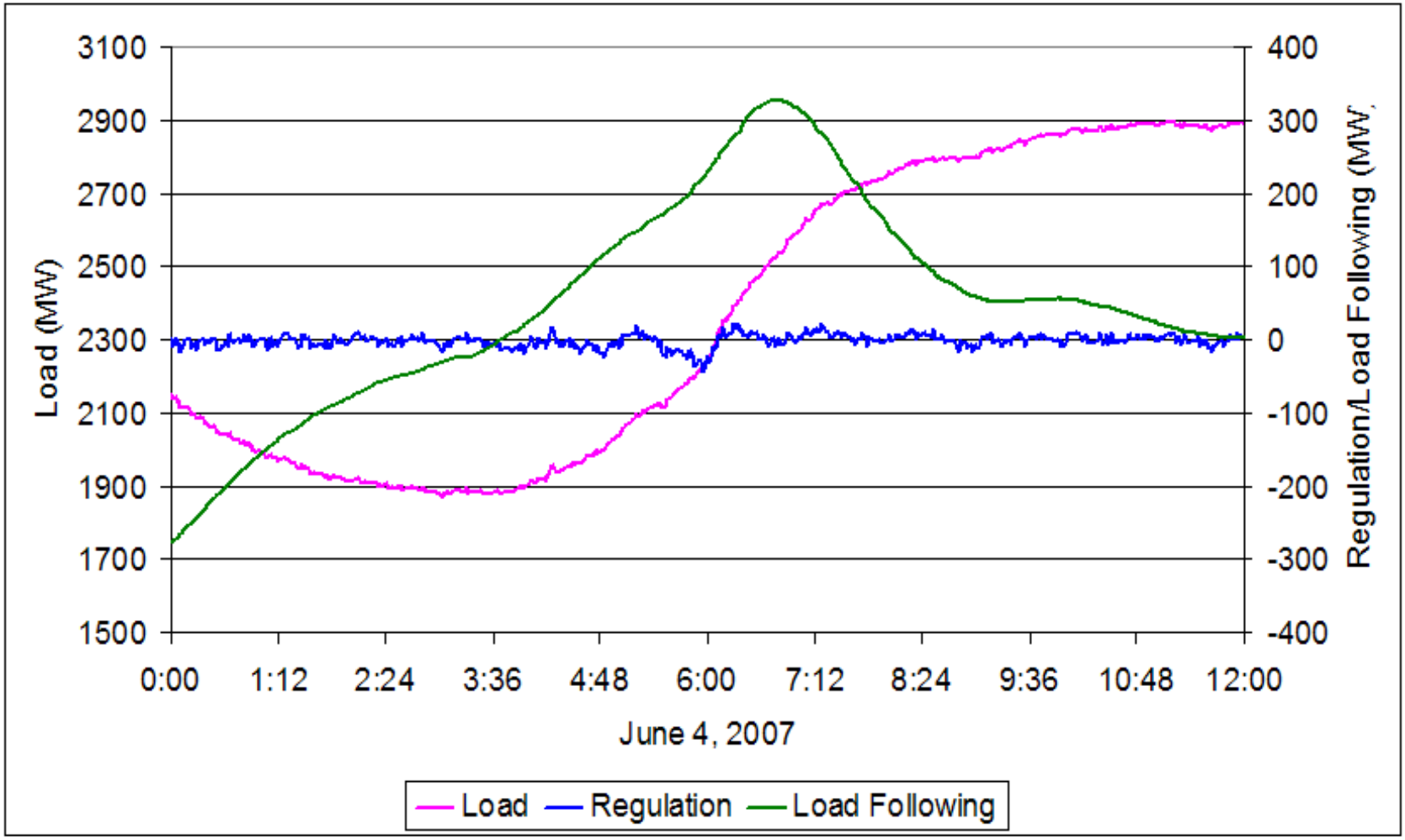
Intra-Hour Balancing of Load without Wind



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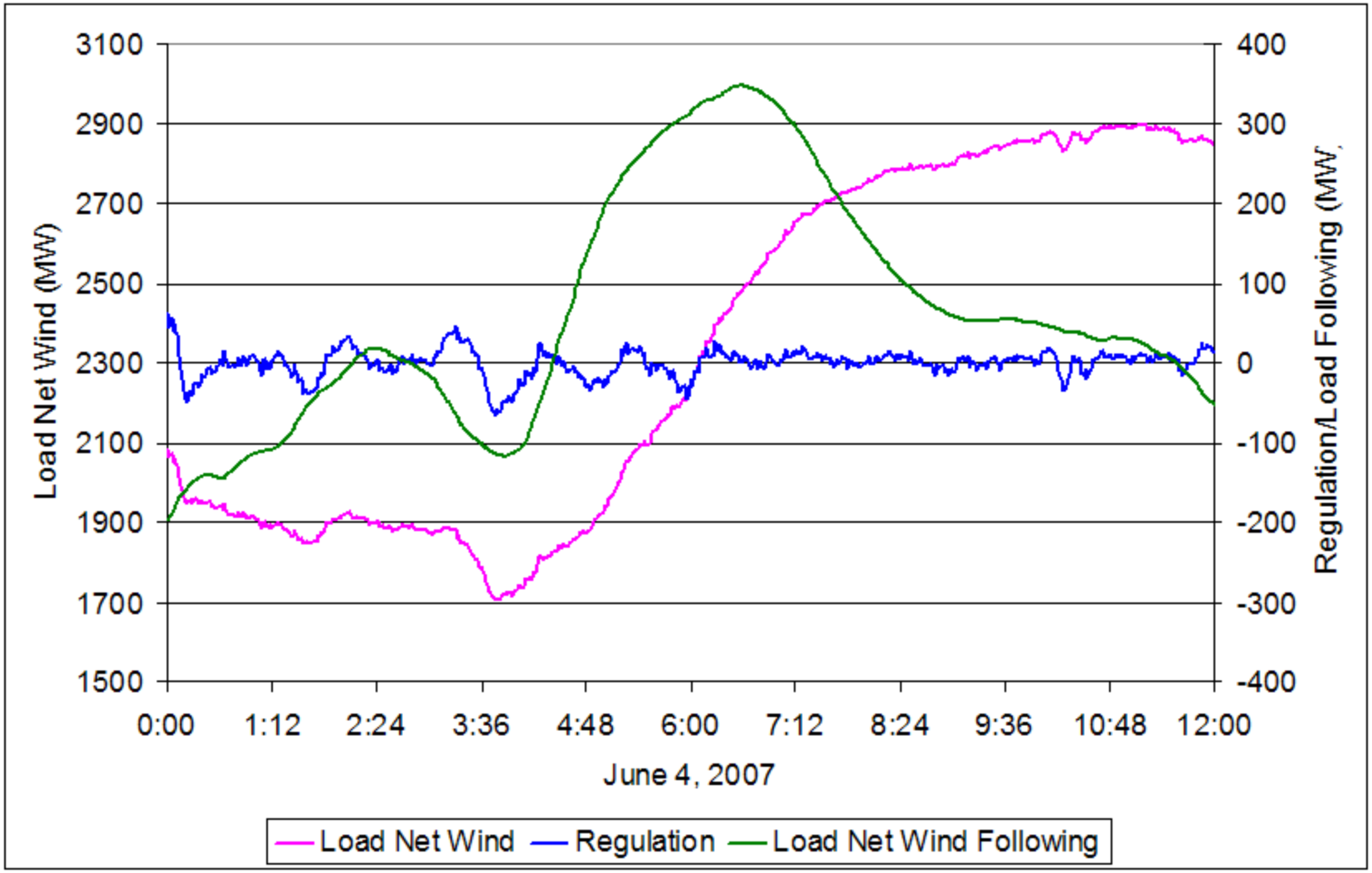

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Uncertainties Drive Integration Costs

- Within Hour – variability and uncertainty affects the allocation of reserves for regulation and load following
- Longer time-steps – wind forecasts drive unit commitments across the entire generation portfolio
- Opportunity Costs
  - Hydro operation is not optimal – generate more hydro during off-peak hours and less during on-peak hours to balance wind
  - Flexibility is set aside in the day-ahead time frame, some of which may be recovered in the hour-ahead time frame
- Direct Costs
  - Incremental O&M and Capex associated with units designed for base load operation being dispatched in cycling mode
  - Fuel cost attributed to unit dispatch for reserve operation and heat rate efficiency losses

Legacy Assets

- Unit Dispatch Changes
  - Reserves
  - Minimum loading
  - O&M and fuel cost implications
- New Investments
  - Re-powering legacy assets to accommodate new operating needs
  - Evaluating pump storage applications

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Future Challenges and Opportunities

- Cost of Wind Integration
  - Direct costs are more easily known and measurable, but carry investment and recovery risk
  - Opportunity costs are more difficult to quantify
  - Lack of mature/fluid ancillaries market in Pacific Northwest hinders understanding of longer-term integration costs
- Regulatory Opportunities
  - Full cost of integration needs to be understood as part of tariff development to integrate NUGs into utility balancing authority
  - Easier to determine short-term than long-term marginal costs – the latter requiring incorporation of ALL costs of integration (direct, opportunity, etc.)
- Emerging needs will be incorporated into PSE's IRP updates; e.g., "flexibility" resources

Conclusion

- Accurate wind generation forecasts are critical to cost-effective wind integration in highly constrained resource portfolios
- As more data becomes available, we continue to learn about the operational impacts and better understand the cost of integration
- Supply side operational implications need to be fully understood and integrated into resource planning processes

Questions?

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