Preliminary Assumptions for On-Shore Wind Technologies

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At the last meeting…

- Discussed current status of wind development in PNW
- Reviewed recent trends in development and technology
- Discussed future regional wind build-out and potential
  - Reviewed potential E. MT wind monthly capacity factors vs. BPA demand

Today's Discussion

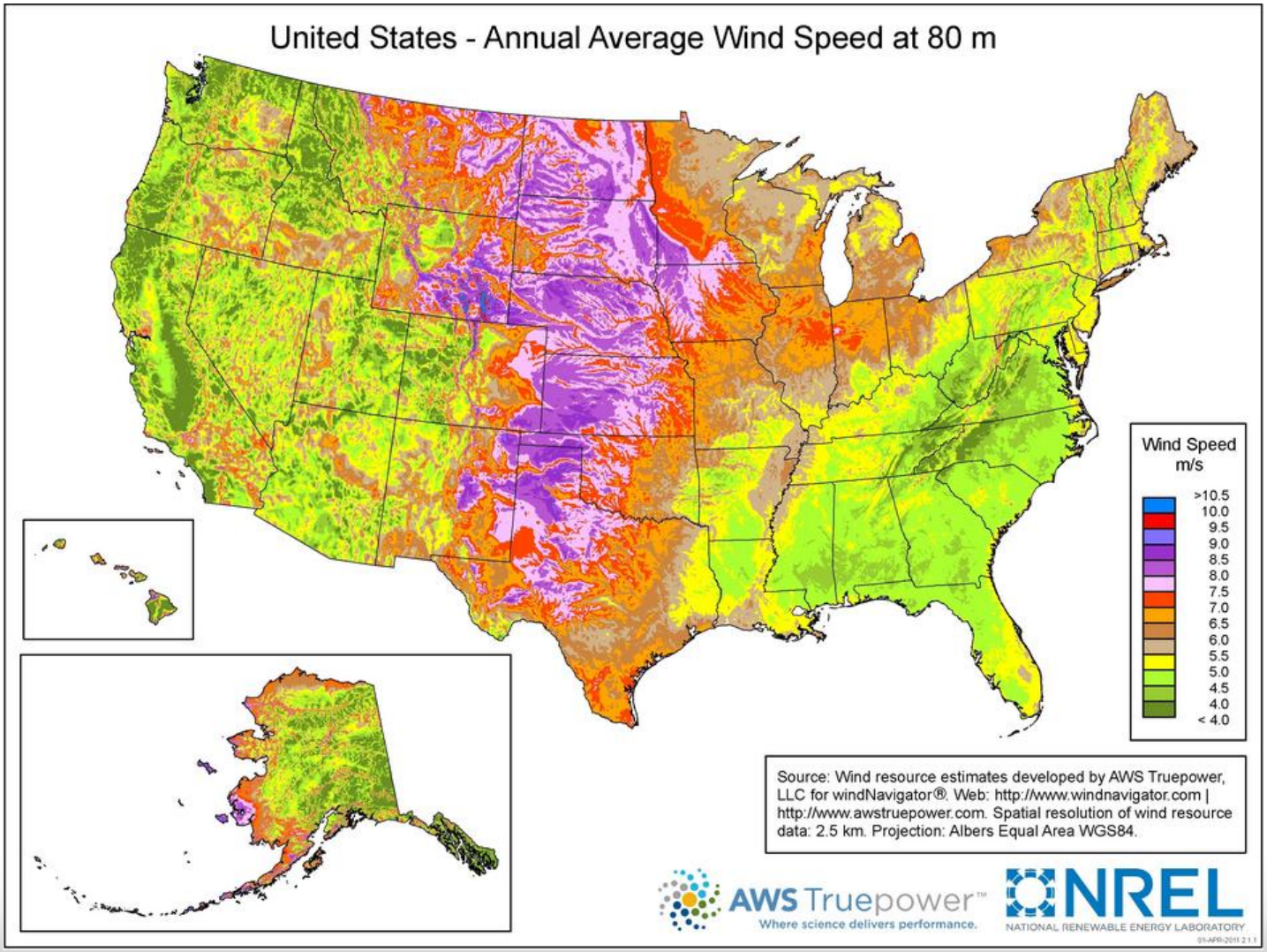
- Revisit overall trends in cost, technology, and development
- Discussion of capacity factors
- Introduce preliminary reference plant, preliminary capital cost, and O&M
- Discuss future of financial incentives and introduce preliminary levelized cost

Technology Trends

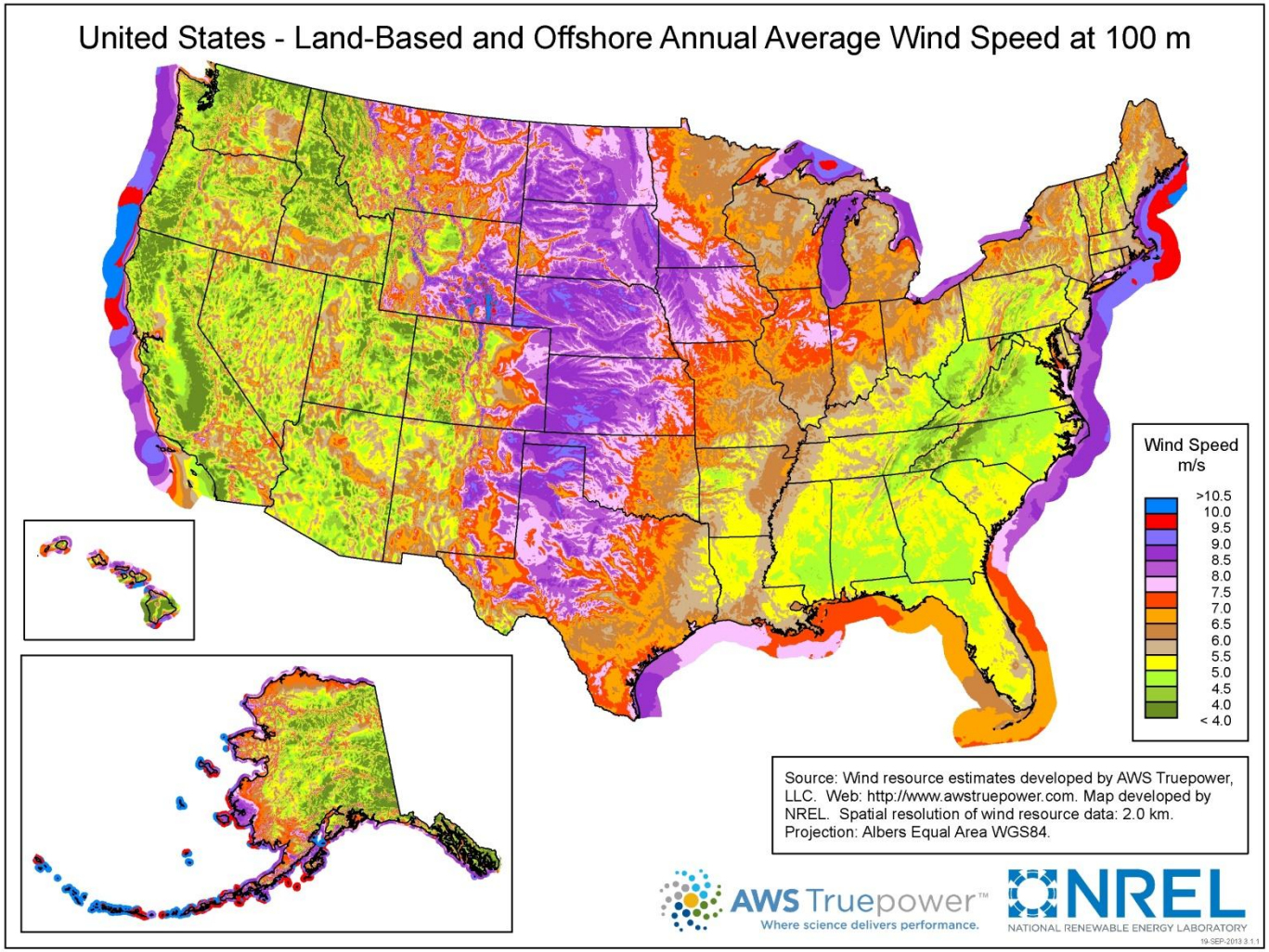
- Increased: Turbine nameplate capacity, hub height, and rotor diameter
  - Avg. turbine nameplate in 2013 was 1.87 MW
  - Growth in average rotor diameter has outpaced other advances
- Class 2 and 3 turbines (designed for lower speed areas) are being developed in both lower and higher wind speed sites
  - Capturing lower quality wind resource areas

Source: 2013 Wind Technologies Market Report, LBNL for US DOE

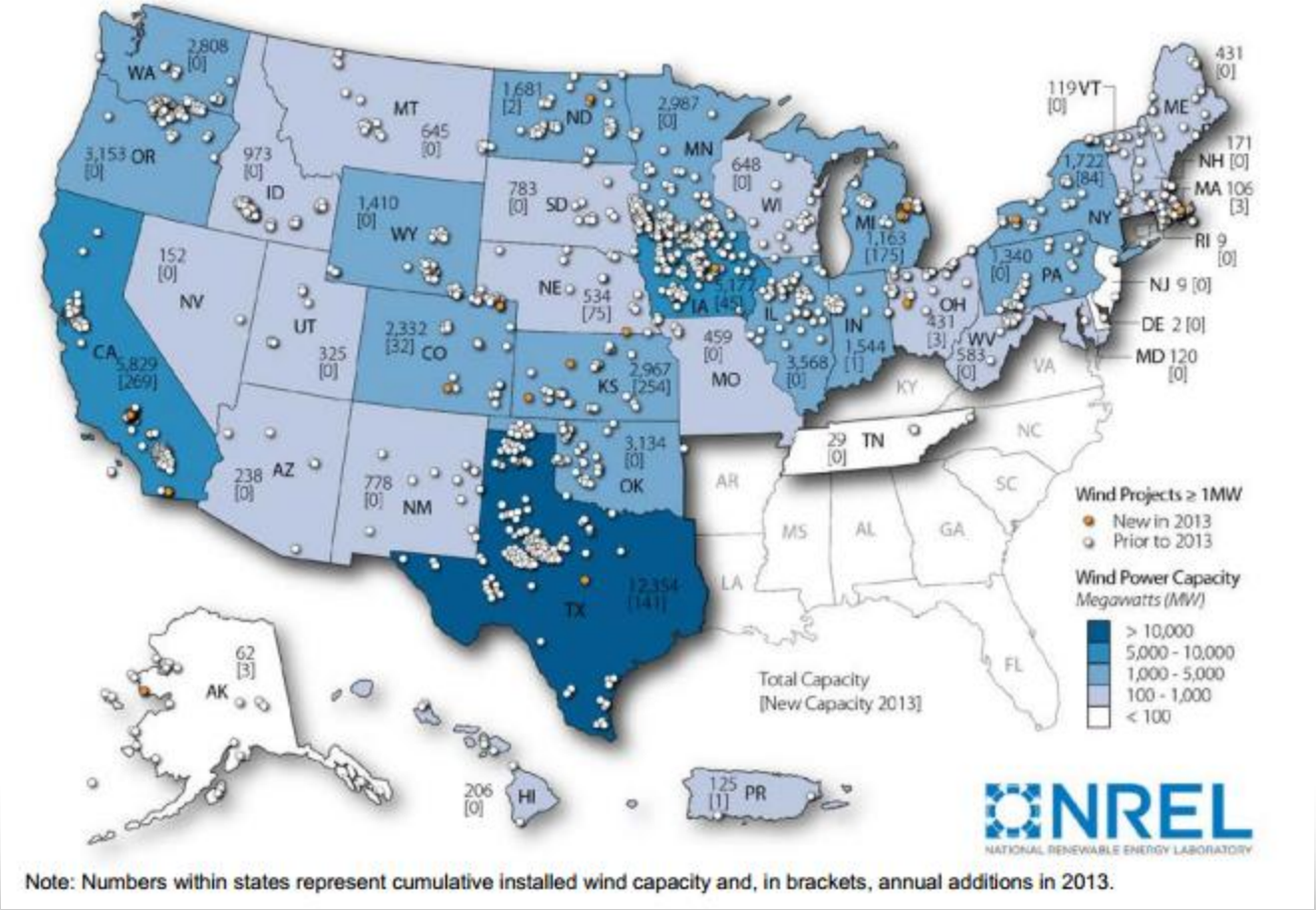
Wind Power Classifications – 80m



Wind Power Classifications – 100m



NREL: Location of Wind Power Development in the US



Note: Numbers within states represent cumulative installed wind capacity and, in brackets, annual additions in 2013.

Cost Trends

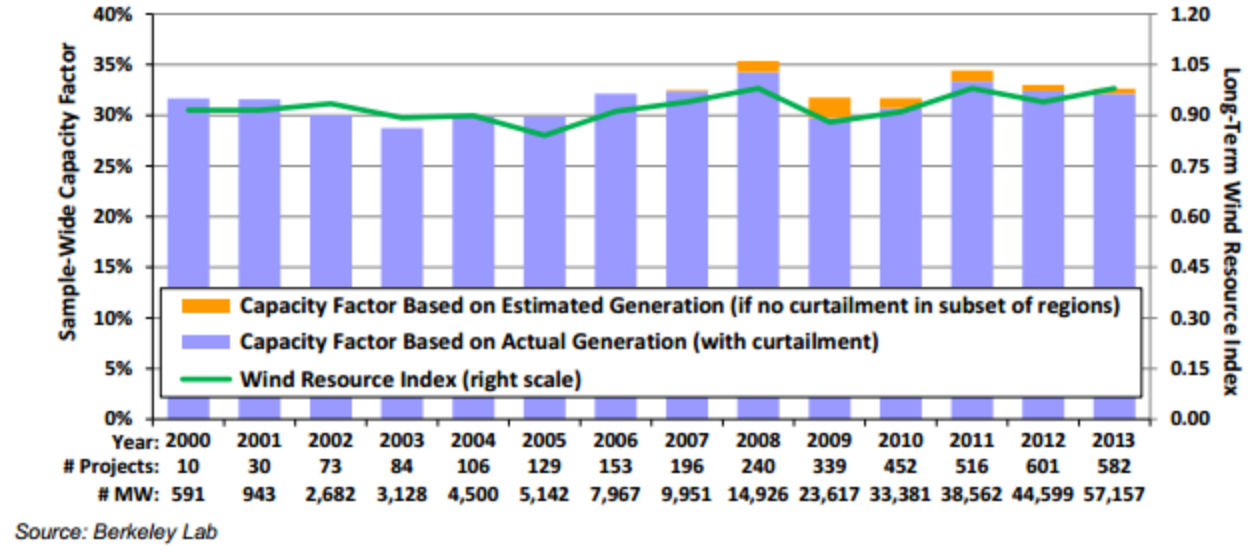
- Installed project costs continuing to decrease from 2009/2010 peaks

- Wind Power Purchase Agreement (PPA) prices dropped significantly over past 5 years
  - Notable: installed project costs haven't dropped as significantly comparatively

Source: 2013 Wind Technologies Market Report, LBNL for US DOE

Capacity Factors (1)

- Based on project-level capacity factors compiled by Berkeley Lab, trend shows general increase in recent years…
  - However, trend is not as significant or consistent as would be expected with technological advancements



Source: Berkeley Lab

Capacity Factors (2)

- Much of the high quality, easy access to transmission wind resource areas have been developed
- However, manufacturers are modifying their technology to improve capture of wind resource at lower quality sites
  - Taller turbines, longer blades, greater sweep area
- What does this do to capacity factors?
  - Are they improving? Declining? Staying the same?

Capacity Factors (3)

Sixth Power Plan

Wind Resource Area	Columbia Basin	S. Idaho	Central Montana	S. Alberta	E. Wyoming
Avg annual capacity factor	32%	30%	38%	38%	38%

Updated Hourly Wind Profiles for Aurora – 2008-2010

Wind Resource Area	BPA	S. Idaho	E. Montana	Alberta	Wyoming
Avg annual capacity factor	30%	25%	34%	35%	32%

EIA Annual Generation Data – 2008-2012

Wind Resource Area	OR/WA	Idaho	Montana		Wyoming
Avg annual capacity factor	29%	28%	35%		39%

A few updated definitions

Price Year – The vintage of the technology, overnight capital cost, and operating cost

Year Dollars – Reference year for setting dollar value; used consistently throughout power plan assumptions

Construction Lead Time (months) - amount of time it takes from conception to commissioning; Two phases for purposes of current Regional Portfolio Model (RPM):

- Planning and Development – Identification of need (e.g. IRP) to establishment of EPC contract (includes all siting and licensing, environmental assessments, preliminary engineering)
- Construction – From Notice to Proceed to complete construction and commissioning

Selection of Recent Wind Projects in PNW

Project	In Service	Technology (# units, MW/unit, rotor diameter, vendor)	Capacity	Location
Tucannon River Wind Farm	Est. 2015	(116) 2.3 MW, 108m Siemens G2	267 MW (101MWa)	Columbia Cty, WA
Lower Snake River	Mar 2012	(149) 2.3 MW, 101m Siemens G2	343 MW	Garfield Cty, WA
Palouse	Dec 2012	(58) 1.8 MW, 100m Vestas V100	104 MW	Whitman Cty, WA
Rockland	Jan 2012	(44) 1.8 MW, 100m Vestas V100	80 MW	American Falls, ID
Shephard's Flat	Aug 2012	(338) 2.3 MW, 100m GE	845 MW	Morrow/Gilliam Cty, OR
PaTu	Dec 2010	(6) 1.5 MW, GE	9 MW	Sherman Cty, OR
Spion Kop	Nov 2012	(25) 1.6 MW, 82.5M GE	40 MW	Geyser, MT

Preliminary Reference Plant

Year Dollars	2012 $
Price Year	2015

Technology & Configuration base	(40) 2.5MW GE Wind Turbine Generators
Output Total (MW)	100 lifecycle avg*
Capacity Factor	TBD based on discussion, location
Economic Life (Years)	20
Construction Lead Time (Months)	24 planning & development 30 construction (54 months total, ~4.5 years)

* Assuming 0% derate over lifetime of plant, based on insufficient information. Is this the right assumption?

Estimating Capital Cost Assumptions and Normalizations

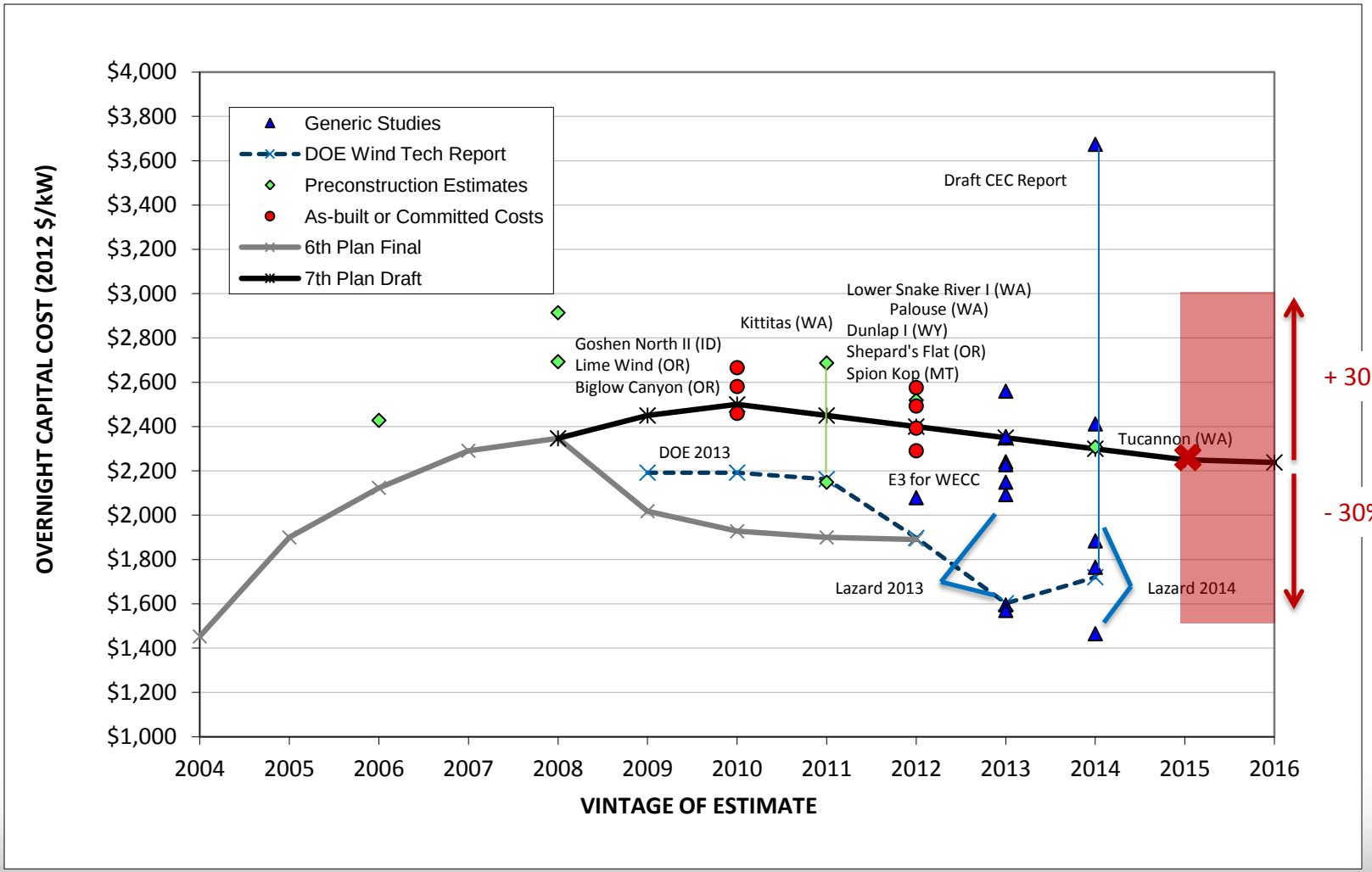
Normalization – Establishing comparable estimates by adjusting source data to common year dollars, vintage/price years, plant configuration, etc.

1. Reference sources – reported plant data, generic reports
2. Objective - normalize to draft Seventh Plan reference plant design
   - Overnight capital costs in $2012
   - Site-specific adjustments to capacity and heat rate
   - Site-specific labor costs
   - Typical configuration for PNW
3. Look for outliers, trends; forecast future 20 year trend line

Estimating Escalation and Hi/Lo Bound for RPM

- Council's planning period is 20 years – need to establish a cost escalation to project future costs from the base year
  - Estimation based on reference sources, trends
- Council uses high/low bounds to develop a probability function of capital cost → RPM
  - Hi/Low bounds capture the uncertainty range +/- the capital cost estimate
  - Estimation is based on capital cost distribution of resources (see next slide)

Preliminary Capital Cost of Wind



Preliminary Capital Cost & Escalation Estimate of Wind

Year Dollars	2012 $
Price Year	2015

Capital Cost (MM)	$225MM (lifecycle)
Capital Cost ($/kW)	$2,250 (lifecycle)
Hi Bound ($/kW)	$2,925 (30% above)
Lo Bound ($/kW)	$1,575 (30% below)
Capital Cost Escalation	-0.5% annual after 2015*

* Is this an appropriate estimate of future capital costs? Should it be more aggressive? More conservative? Future seems uncertain based on recent reports.

Council Plant O&M Costs

- NPCC plant O&M estimates are intended to include the following:
  - Routine operating labor and materials
  - Routine maintenance labor and materials
  - Scheduled and unscheduled major maintenance labor and materials (including equipment replacement costs that are normally capitalized)
  - Startup costs (may be separated if feasible, for some analyses)
  - Consumables (water, chemicals, lubricants, catalysts)
  - Rents and royalties
  - Administrative costs
- NPCC plant O&M estimates exclude:
  - Property taxes and insurance
  - Emission offsets, allowances or taxes
  - Non-plant O&M costs (e.g. transmission costs)
  - These are included elsewhere in the Council's analyses.
- To the extent allowed by available information, plant O&M costs are separated into fixed and variable components.
  - Fixed costs affect only plant build and retirement decisions (lifecycle cost-effectiveness)
  - Variable costs affect dispatch as well as build and retirement decisions

Estimating plant O&M costs

- Locate published data sources
- Normalize data
  - Year dollars
  - Vintage (price year)
  - Derated ISO lifecycle capacity
  - Scope of source data (e.g. add estimated admin costs if omitted)
  - Scaling factor (e.g., one vs. multiple turbines)
  - Regional cost indices
  - Plot as common metric ($/kW-yr) (requires capacity factor assumption)
- Considering quality, representativeness and timeliness of sources, select values for fixed ($/kW-yr) and variable ($/MWh) O&M for the base price year (2015)
- Considering prospects for technological improvement, project future trends

Considerations

- Relatively few published sources of O&M data.
- Scope of published O&M data tends to be inconsistent, often incomplete and not fully documented.
- Allocation of fixed and variable costs is inconsistent and often not documented.
- No single timely and well-documented source addresses all major technologies.
- Normalized values tend to be spread over a wide range.
- Plant O&M (excluding property tax and insurance) comprises a modest portion of overall resource revenue requirements:
  - GT plant: 8 – 11%
  - Reciprocating engine plant: 16%
  - Wind plant: 18%

Preliminary O&M Estimate for Wind Reference Plant

Year Dollars	2012 $
Price Year	2015

Capital Cost (MM)	$225MM (lifecycle)
Capital Cost ($/kW)	$2,250 (lifecycle)
Hi Bound ($/kW)	$2,925 (30% above)
Lo Bound ($/kW)	$1,575 (30% below)
Capital Cost Escalation	-0.5% annual after 2015

Fixed O&M	$35.00 *(Sixth Plan $35.80)*
Variable O&M	$2.00 *(Sixth Plan $2.20)*

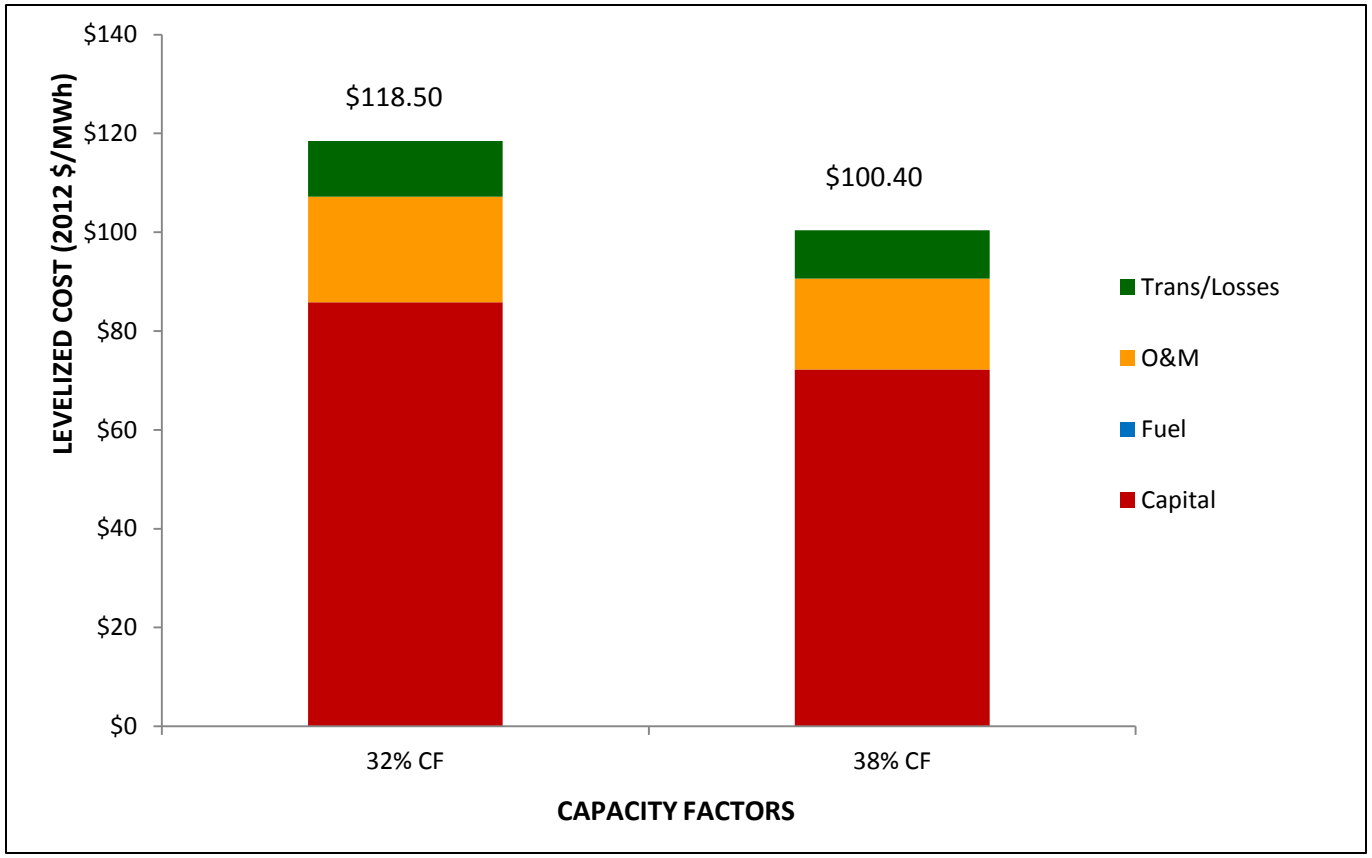
Financial Incentives

- Production Tax Credit (PTC) expired in 2013, future unknown
  - Projects that began construction before end of 2013 eligible
- Investment Tax Credit (ITC)
  - Ability to take 30% ITC in lieu of PTC now expired

Draft Seventh Plan Proposal:

- No financial incentives included in levelized costs

Preliminary Levelized Cost of Wind



Assumptions:

- FY14/15 BPA Transmission Rate Schedule
- Main grid location – specific locations and potential additional transmission costs will come next time
- IOU financing , 2012$, 2015 Operation

Next Steps

- Refine estimates as necessary, based on feedback today
  - Settle on capacity factors for regions
- Once environmental methodology is developed for draft plan, incorporate into estimates
- Update transmission estimates to model wind in various parts of the region