Wind Capacity Meeting

December 12, 2007

Borismetrics

www.borismetrics.com

Goals

- Develop a “simulated” wind generation database by hour by year for a historical record who’s generation level represents current operating and current construction
- Compare wind data base to load “events” data base for normal and extreme conditions to develop capacity factor
- Wind database can be used in hourly production simulation modeling similar to a hydro year record on an hourly basis

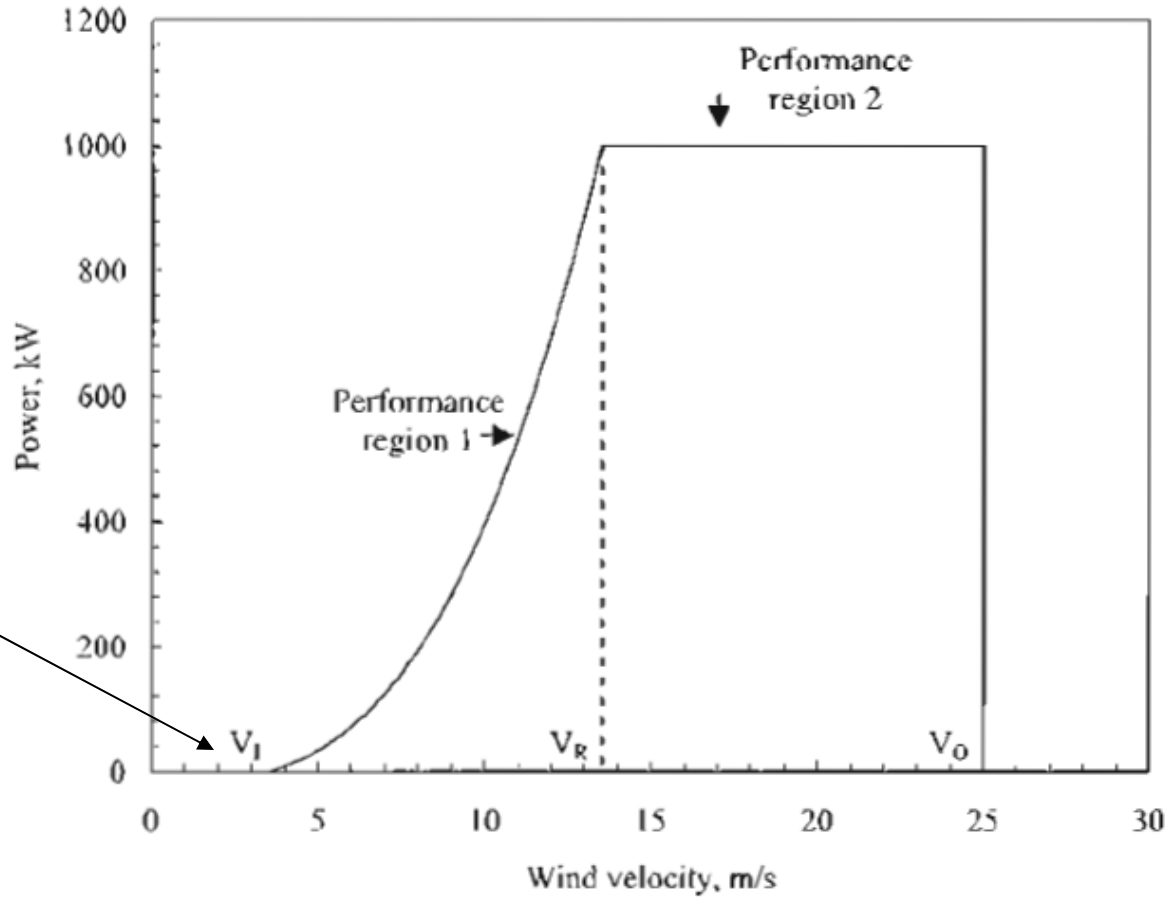
General Methodology

- Develop econometric model from recent data that can be applied for desired historical period
- Apply Econometric Model to Historical Data to develop “backcasted generation”
- Econometric Model:
  - Utilize Power Curve Functional Form (See next page)
  - Wind Generation is dependent variable as a function of wind speed (standard econometric approach, (1)
  - Wind Generation = Function[Wind Speed @ lags/leads, Wind Direction for lead/lag set, and other dummies]
  - Estimate on recent data (Gen Data only back 4 years at most)
  - Utilize NOAA site data that is as close to generation sites & long history
  - Temperature not considered
  - Recognize “regions” of power curve by piecewise linear/3rd degree polynomial
  - “Y Intercept” is critical
- Econometric Model Flaws
  - Model Period estimated on may be too short to reflect “full” wind generation distribution
  - Econometric models by their nature have errors & explain only so much variation in dependent variable (R-square)
  - “Y Intercept” is critical
- Econometric Model Advantage
  - Measures direct relationship between Generation and usable historical wind
  - Leverages actual historical wind using recognized approach

  - (1)“Wind Energy” by Sathyajith Mathew, 2006, Springer: Chapter 5 has discussion of econometric methodology approach

Power Curve Example Theoretical

Region where no gen @ low wind speed

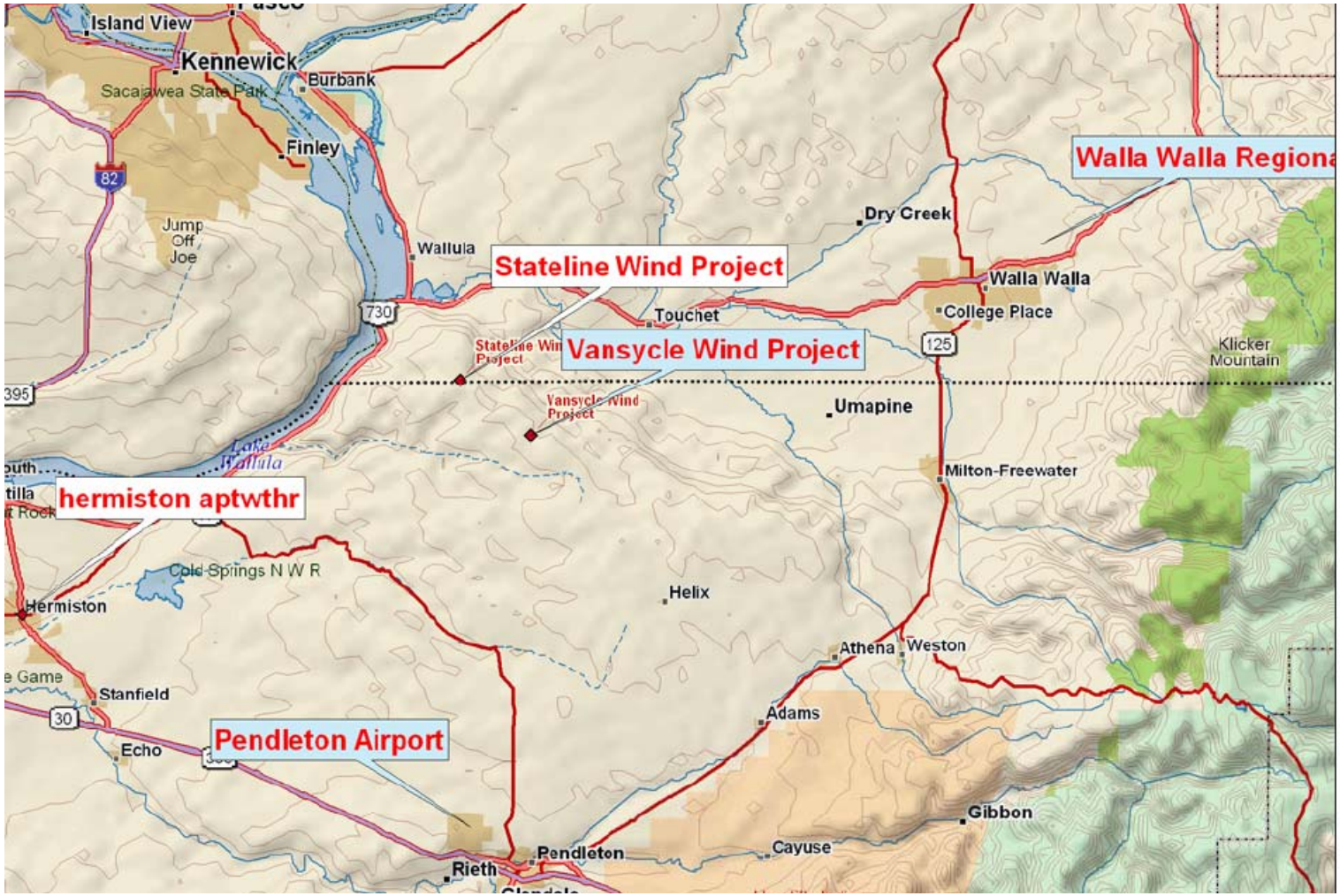


Power Curve From “Wind Energy” by Sathyajith Mathew, 2006, Springer: Chapter 5 has discussion of econometric methodology approach

Tasks & Data Issue

- BPA Data is in as of 11/20/07 See next table
- Map generation and wind measurement sites using Delorme Map software (location, location, location)
- NOAA Hourly Wind Speed/Wind Direction Data back ***to 1973*** within 40 miles (see maps)
  - Walla Walla , the Dalles, Moses Lake, Cheyenne Airport, Hermiston
- Pendleton Hourly (WS/WD) ***back to 1938***
- Monthly/Annual wind data available back to 1938
- Decision Trade Off : need for long history vs nearness of sites vs resource/time
- Look at Pendleton for ease: Use Pendleton for Gorge (80% of NW wind) to develop backcast model
- Look at annual wind by year/Month & map to recent history for non-Gorge & full history
- Database backcast & Compare to “System Events”

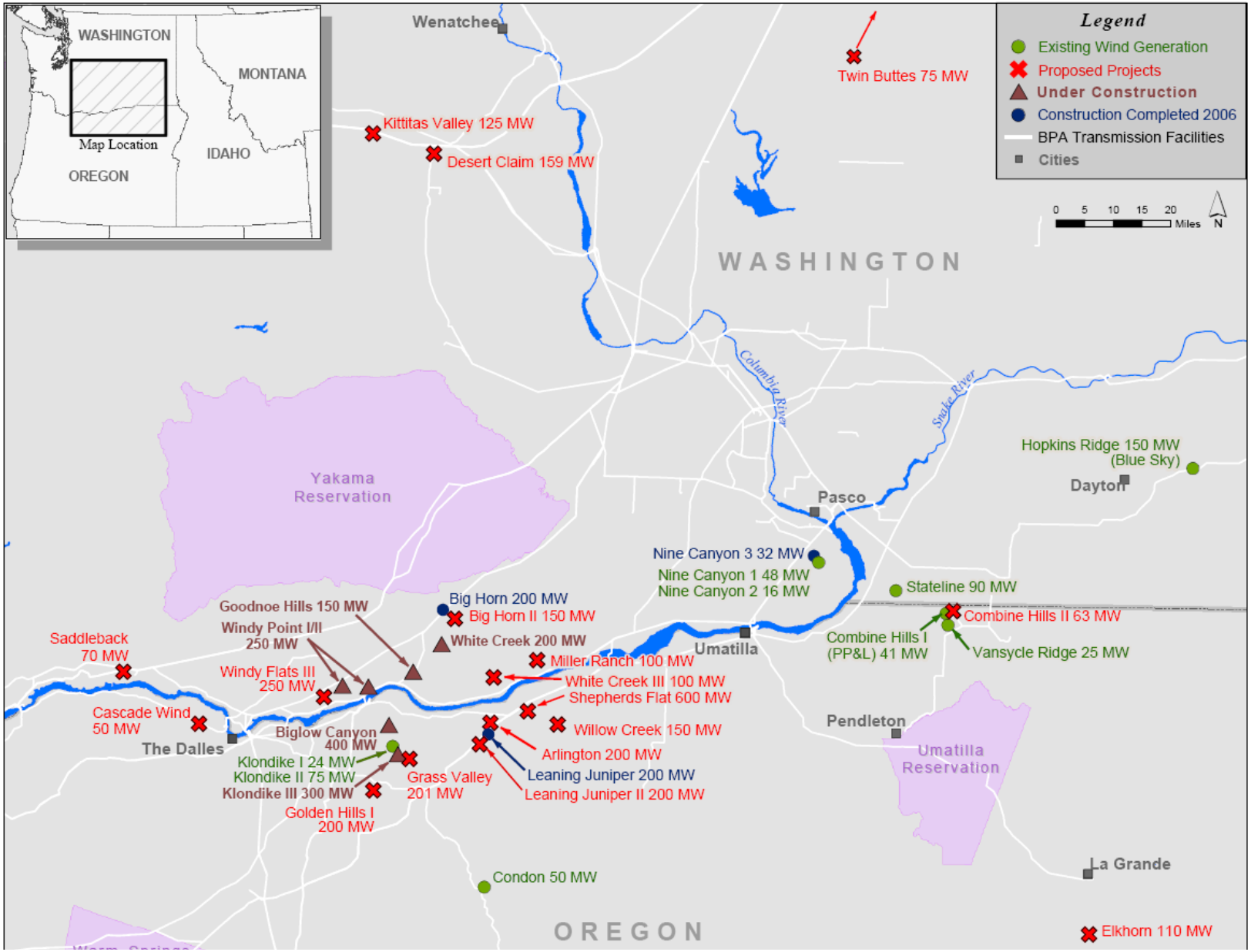
Delorme Map Example of East Gorge

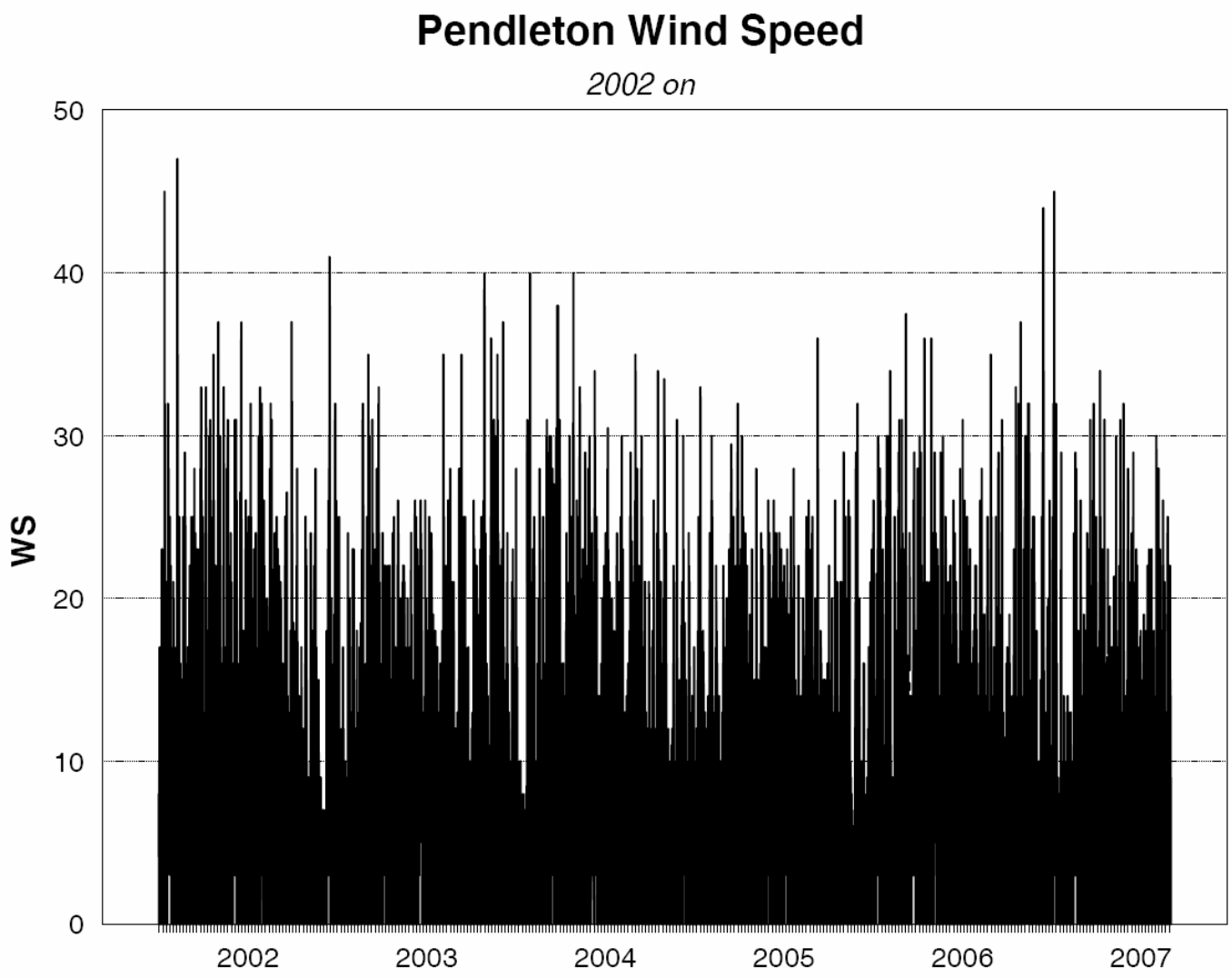


List of Wind Sites with Data Received

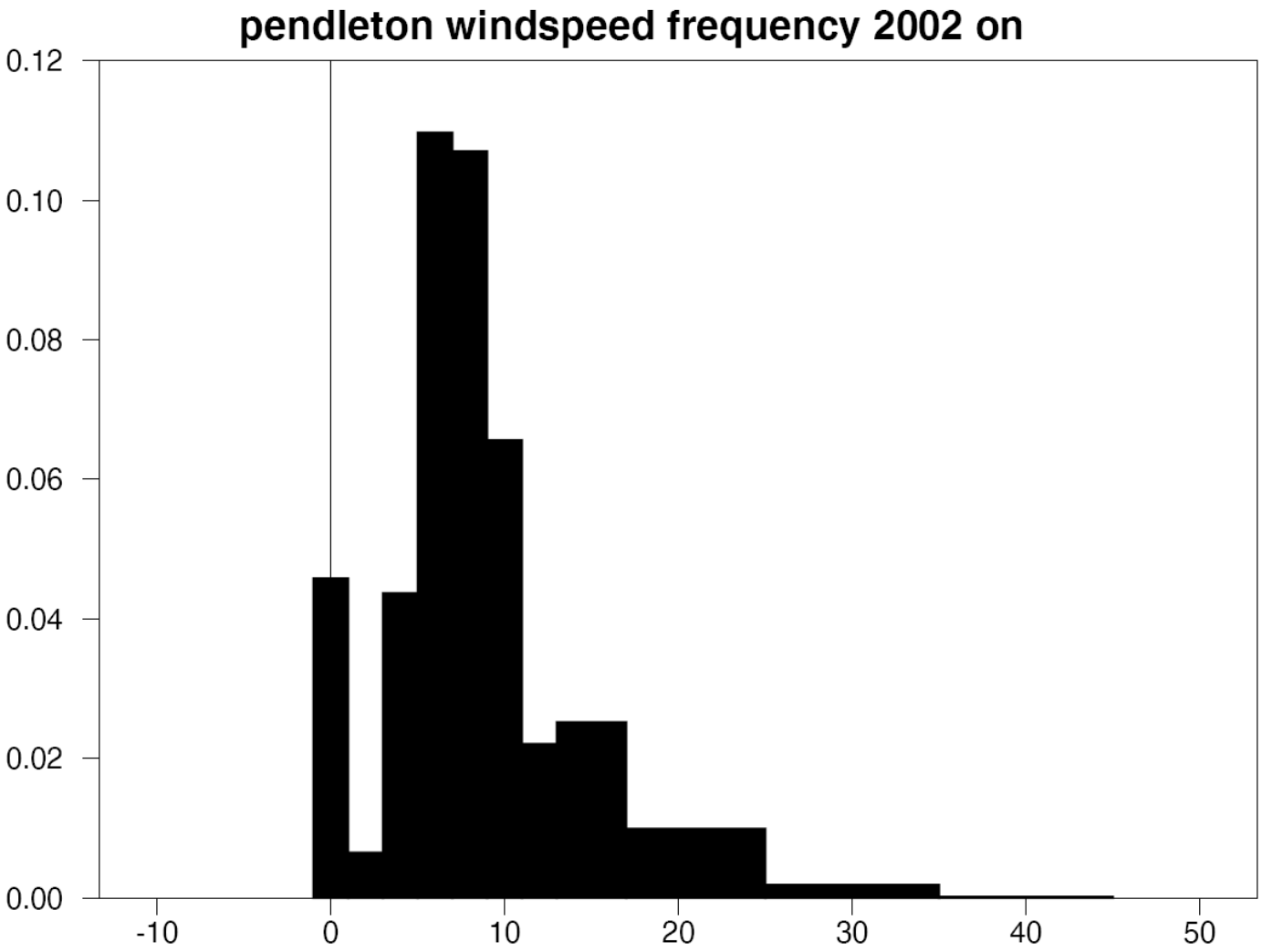
Data Recd	PROJECT	Data in MW	Ncap in MW	Status	STATE
No	Golden Valley		10.5	Construction	ID
Yes	Biglow Canyon Ph I	125.4	125.4	Construction	OR
No	Elkhorn		100.0	Construction	OR
Yes	Klondike III	221.0	221.0	Construction	OR
Yes	Goodnoe Hills/Canyon done	94.0	94.0	Construction	WA
No	Marengo I		140.4	Construction	WA
No	White Creek		204.7	Construction	WA
No	Fossil Gulch	0	10.5	Operating	ID
No	Lewandowski Farms	0	0.2	Operating	ID
No	Wolverine Creek	0	64.5	Operating	ID
No	Horseshoe Bend	0	9.0	Operating	MT
No	Judith Gap n on 191 of 12 20 miles	0	135.0	Operating	MT
No	Martinsdale (Two Dot)	0	2.8	Operating	MT
No	Two Dot	0	0.9	Operating	MT
No	Combine Hills I	0	41.0	Operating	OR
BPA	Condon	49.8	49.8	Operating	OR
BPA	Klondike I	24	24.0	Operating	OR
BPA	Klondike II	75	75.0	Operating	OR
BPA	Leaning Juniper	100.5	100.5	Operating	OR
BPA	Vansycle Wind Energy Project	24.9	24.9	Operating	OR
BPA	Stateline	300	300.0	Operating	OR/WA
BPA	Big Horn	199.5	199.5	Operating	WA
Yes	Goodnoe Hills Small Windpark/Cannon Avista	0.285	0.3	Operating	WA
BPA	Hopkins Ridge	150	150.0	Operating	WA
	Nine Canyon	63.7	63.7	Operating	WA
Yes	Wild Horse Wind	228.6	228.6	Operating	WA
Yes	Foote Creek 1	41.4	41.4	Operating	WY
Yes	Foote Creek 2	1.8	1.8	Operating	WY
Yes	Foote Creek 4	16.8	16.8	Operating	WY
	Rock River I	50	50.0	Operating	WY
	Total MW Operating	**1,326**	**1,590**		
	% of Total	**83%**			

Current and Proposed Wind Project Interconnections to BPA Transmission Facilities





Hourly Wind Speed in Miles per Hour 2002 to 2007



Count %

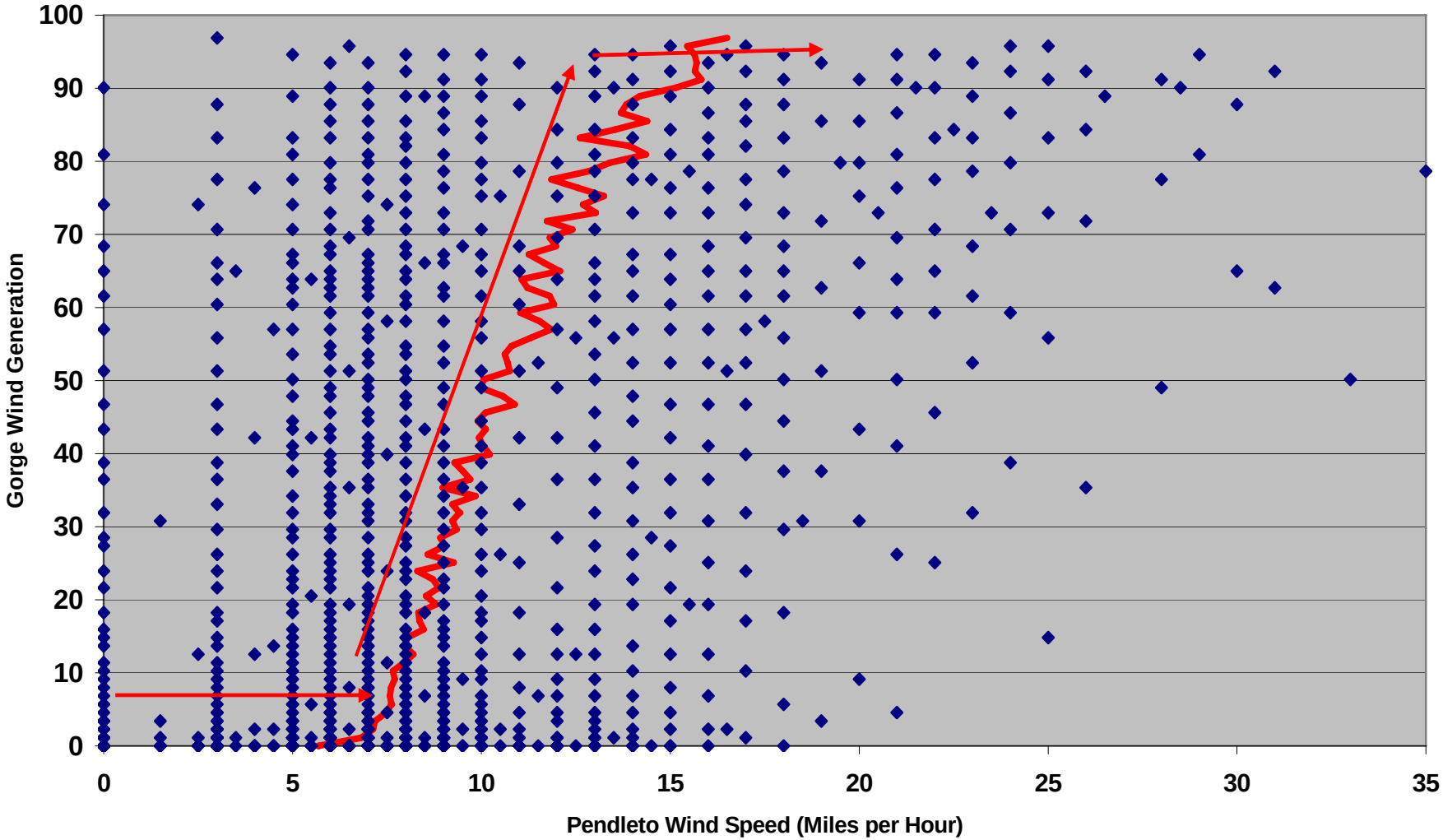
Wind Speed in Miles Per Hour

8.5 M/H is average

Simplified Non-Econometric Analysis
See Slide 12

- Simple Look at data relationship of Wind generation from Two sites in Gorge to Pendleton Wind Speed.
- Generation is Net generation “normalized at 100 MW net ,not nameplate
- Wind is in Miles per Hour
- Standard Functional Form: Y axis is dependent variable; X axis is explanatory variable; Wind Gen = F[WS & other]; Y = F[x]
- Scatter of sample of data 2002 on actual wind speed vs generation
  - Lots of scatter : no modeling, no leads/lags
- Jagged red line is average wind speed by Generation Level
  - Compress scatter
  - Arrow lines represent the “three regions” of the power curve & ***are not*** the econometric model but indicative
- Still finalizing econometric model
  - Lead/lag of wind speed critical
  - Intercept term which reflects “region” of no generation @ low wind speeds

Scatter Plot of Gorge Wind in MW against Wind Speed at NOAA Pendleton (Miles per Hour)
Jagged Red Line represents Average Wind Speed vs Actual Generation
No data lags or leads



Non-econometric Event Analysis

- Still finalizing econometrics but how was wind speed & temperature at Pendleton?
- Utilize recent BPA event definition: Top Table on next page represent three days per event
- Table below on next page represents average wind speed & temperature for Pendleton's hour wind speed & temperatures.
  - Note Average wind speed is below average for whole period 1985 to 2007 & near the "cut in average speed" from graph on page 12.
    - Intercept of econometric model will be critical
  - Temperature at Pendleton appears to be uncorrelated to events as expected
  - Time of Event matters in model

BPA Event Analysis: Non-Econometric

	Weighted 3-Day Average Temp	Weighted 3-Day Minimum Temp	Weighted Absolute Minimum Temp	Total Days Weighted Min < 20 degrees
Feb 1 - 3, 1989	11.7	5.4	3.6	7
Dec 21 - 23, 1990	12.9	7.3	5.6	7
Jan 31 - Feb 2, 1996	16.0	7.2	6.3	7
Dec 21 - 23, 1998	17.3	12.3	11.2	5
Dec 11-13, 2000	27.1	23.6	21.6	0
Jan 5 - 7 , 2004	17.9	13.4	7.9	3
Dec 14-16, 2005	26.6	20.9	18.6	2
Nov 27-29, 2006	26.5	20.5	16.3	2
Jan 12-14, 2007	19.7	13.9	13.0	5

Summary of BPA Events

Pendleton NOAA data

Average Wind Speed & Temperature

Start	Finish	Wind Speed Miles/hr	Temperature degrees F	
1/12/2007	1/14/2007	4.3	14.5	
11/27/2006	11/29/2006	7.9	23.2	
12/14/2005	12/16/2005	0.5	18.3	
1/5/2004	1/7/2004	2.9	3.6	
12/11/2000	12/13/2000	9.2	40.5	
12/21/1998	12/23/1998	4.1	10.7	
1/31/1996	2/2/1996	3.9	-0.1	
12/21/1990	12/23/1990	5.9	-1.9	30% missing
2/1/1989	2/3/1989	8.8	5.3	
Event Average		*5.3*	*12.7*	
Period Average		7.60	30.5	
Winter Temp Minimum			-7	

Schedule From Here

- Finalize Products by Jan 17th meet
- Direction from NWPCC on final product