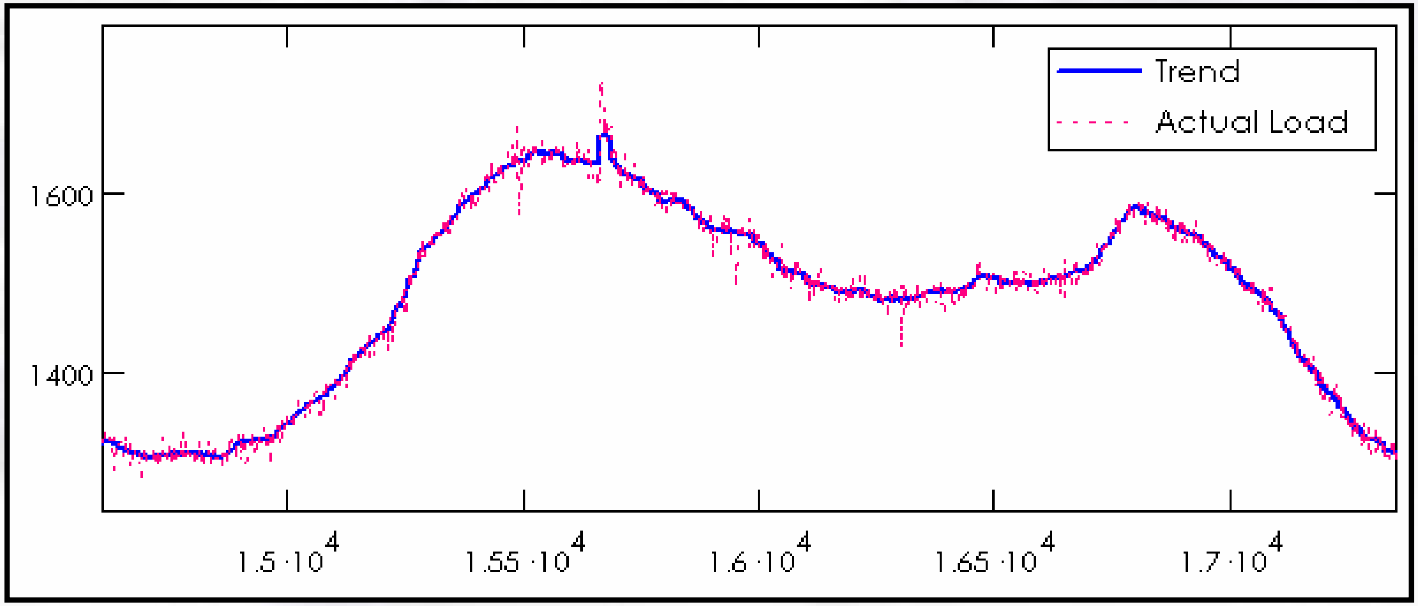
Regulating Reserves - #9

Does the study double-count regulation requirements?

Fast Fluctuations

– Load alone (MW load vs. time)



Regulating Reserves - #10

Need to investigate using an "all down-reg" methodology as proposed by RNP.

- Similar example
  - Forecast load = 2500 MW +/- 100 MW → [2400 MW, 2600 MW]
  - Hydro generation capacity = 2000 MW
  - Price of purchased power = P_{hlh}
  - Cost of operating hydro capacity = C_p
  - Assume reserve cost = $C_R = (P_{hlh} – C_p)$
  - Case I → Schedule hydro generation w/o load bias
  - Case II → Schedule hydro generation w/ load bias

- Case I ➔ Schedule hydro generation w/o load bias
  - Schedule 1900 MW hydro --- leaving 100 MW in reserve to cover up-reg
  - Schedule 600 MW purchase
  - Cost = $(1900\ MW)*C_p + (600\ MW)*P_{hlh} + (100\ MW)*C_R$

$$= (1900\ MW)*C_p + (600\ MW)*P_{hlh} + 100\ MW*(P_{hlh} - C_p)$$

$$= (1800\ MW)*C_p + (700\ MW)*P_{hlh}$$

- Case II ➔ Schedule hydro generation w/ load bias
  - Schedule as if load forecast is 2600 MW
  - No need to hold up-reg ← no practical chance load > 2600 MW
  - Schedule 2000 MW hydro --- leaving 0 MW in reserve
  - Schedule 600 MW purchase
  - Cost = (2000 MW)*C_p + (600 MW)*P_{hlh}

- Case I cost > Case II cost → scheduling hydro generation w/ load bias is economically advantageous
- Case I cost minus Case II cost

  $= (1800\ MW)*C_p + (700\ MW)*P_{hlh} - (2000\ MW)*C_p - (600\ MW)*P_{hlh}$

  $= (-200\ MW)*C_p + (100\ MW)*P_{hlh}$, which is positive for $P_{hlh} > 2*C_p$

- Identical result as wind scheduling example
- Not a common practice in industry to bias load forecast
- Base (flat wind) case could have derived benefit from biasing approach similar to smart wind scheduling proposed by RNP

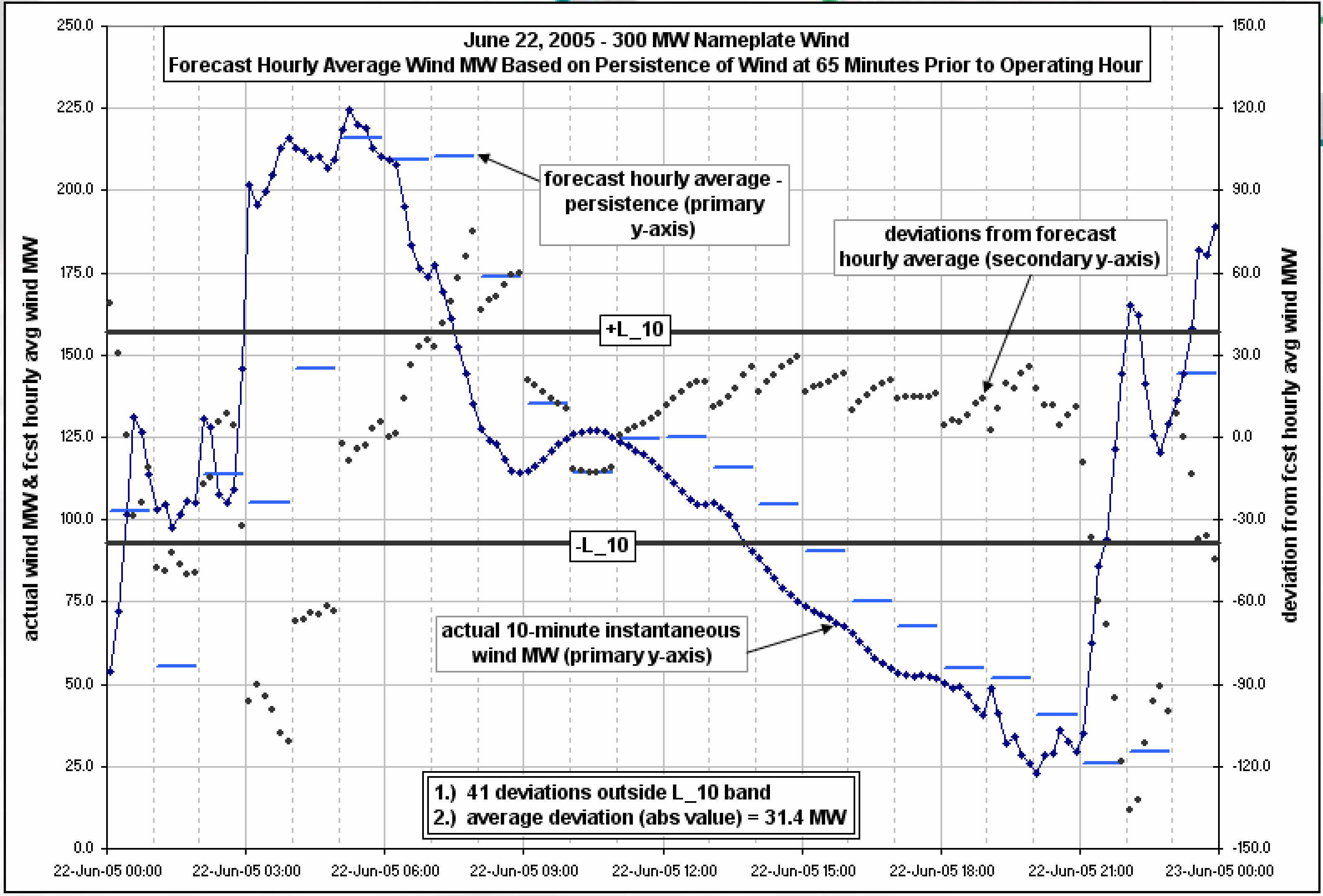
Regulating Reserves - #2

What additional reserves is Idaho Power carrying to meet 98% compliance with CPS 2?

Regulating Reserves - #17

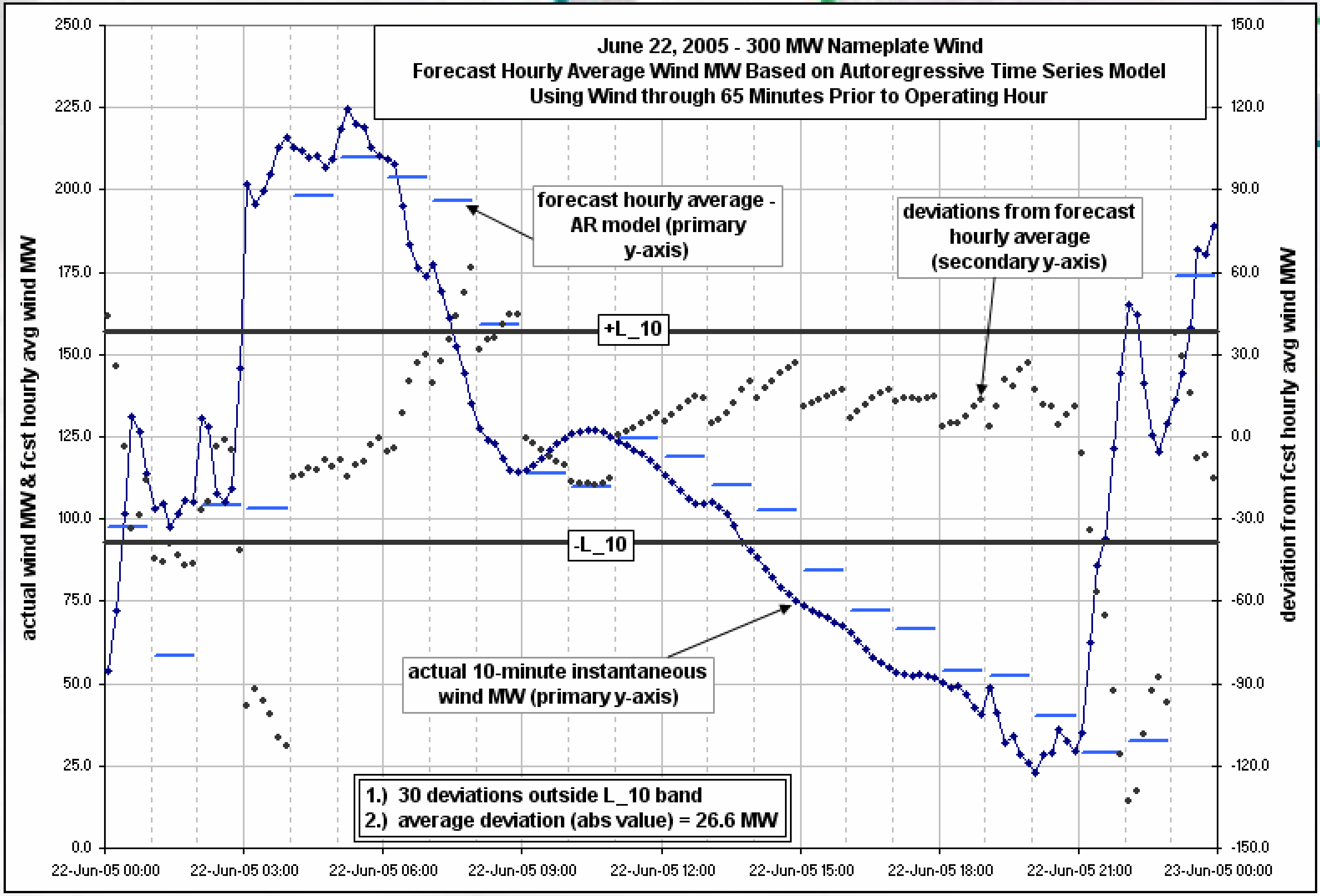
Can Idaho Power calculate the reg-down component of reserves? What about spilling wind? What about the impacts of using a 20-minute ahead forecast?

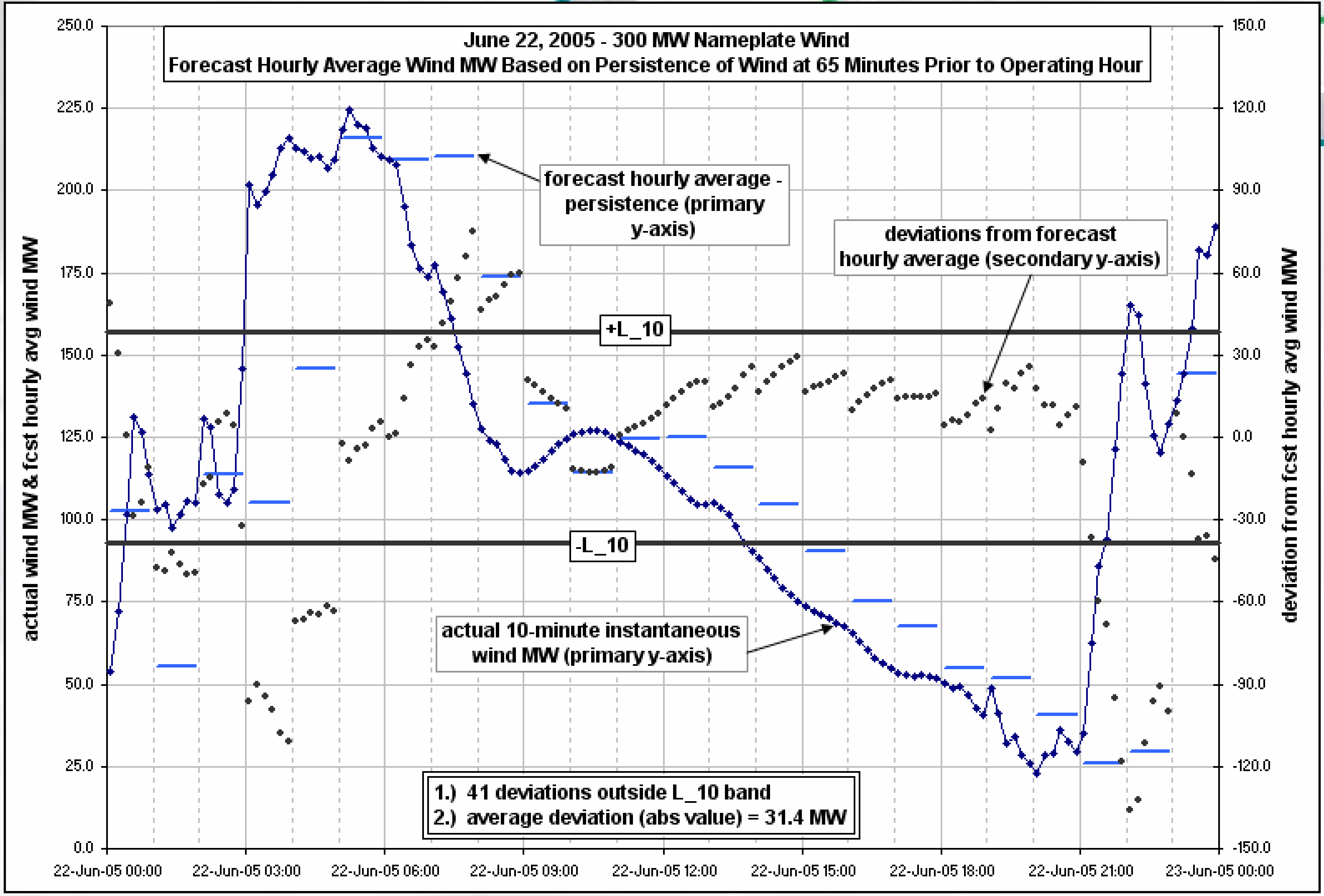
- Wind Forecasting
- Calculation of Regulating Reserves
- Spilling of wind

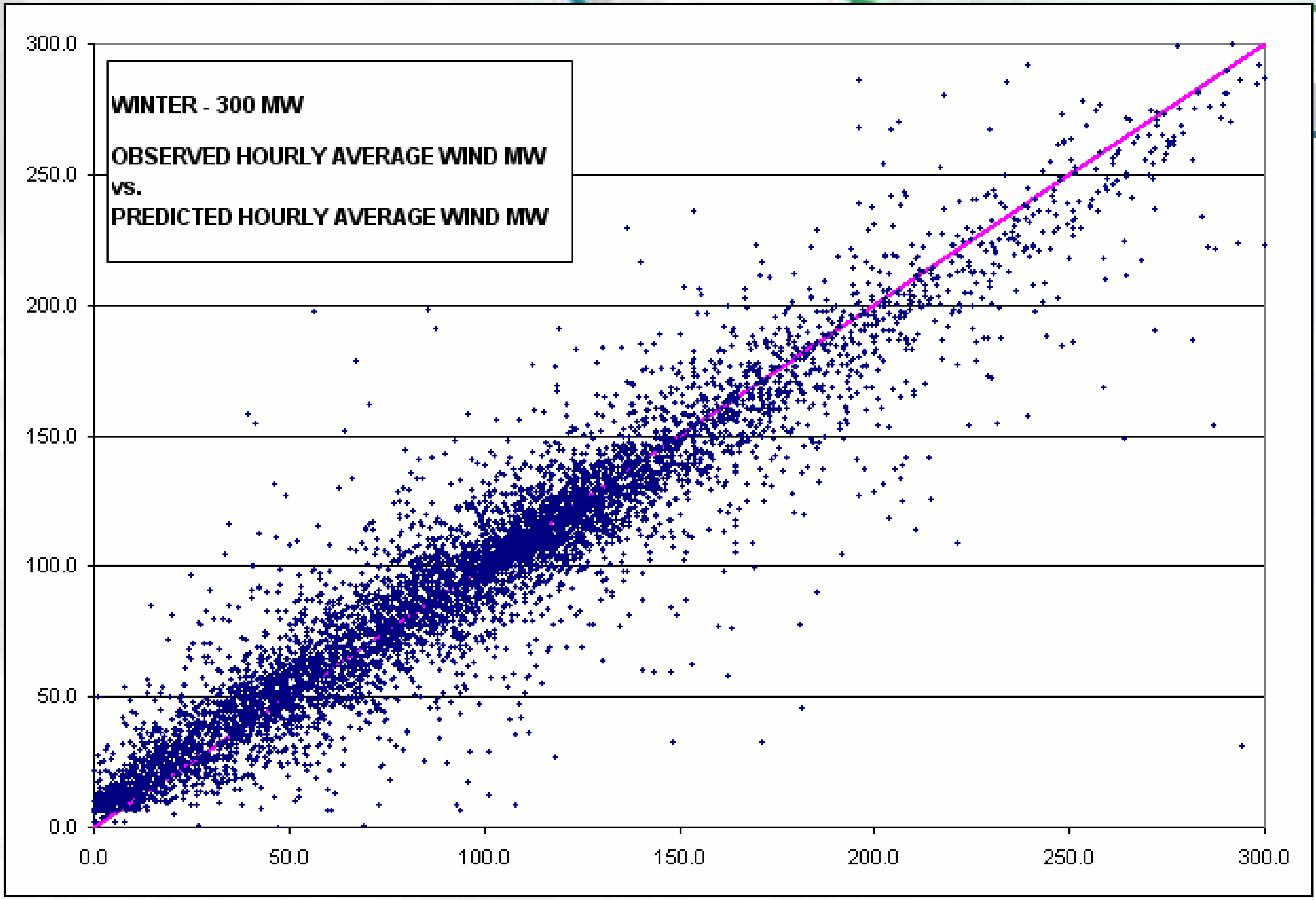

June 22, 2005 - 300 MW Nameplate Wind
Forecast Hourly Average Wind MW Based on Persistence of Wind at 65 Minutes Prior to Operating Hour
forecast hourly average - persistence (primary y-axis)
deviations from forecast hourly average (secondary y-axis)
+L_10
-L_10
actual 10-minute instantaneous wind MW (primary y-axis)
1.) 41 deviations outside L_10 band
2.) average deviation (abs value) = 31.4 MW
actual wind MW & fcst hourly avg wind MW
deviation from fcst hourly avg wind MW
250.0
225.0
200.0
175.0
150.0
125.0
100.0
75.0
50.0
25.0
0.0
150.0
120.0
90.0
60.0
30.0
0.0
-30.0
-60.0
-90.0
-120.0
-150.0
22-Jun-05 00:00
22-Jun-05 03:00
22-Jun-05 06:00
22-Jun-05 09:00
22-Jun-05 12:00
22-Jun-05 15:00
22-Jun-05 18:00
22-Jun-05 21:00
23-Jun-05 00:00

Wind Forecast

- Autoregressive Time Series Model
- Seasonal
  - DJF ←→ Winter
  - MAM ←→ Spring
  - JJA ←→ Summer
  - SON ←→ Fall
- hourly average wind = function of instantaneous wind at operating hour minus 65, 75, 85, 95, 105, & 115 minutes
- 300 MW penetration level
  - Winter – $R^2 = 0.900$
  - Spring – $R^2 = 0.876$
  - Summer – $R^2 = 0.824$
  - Fall – $R^2 = 0.899$

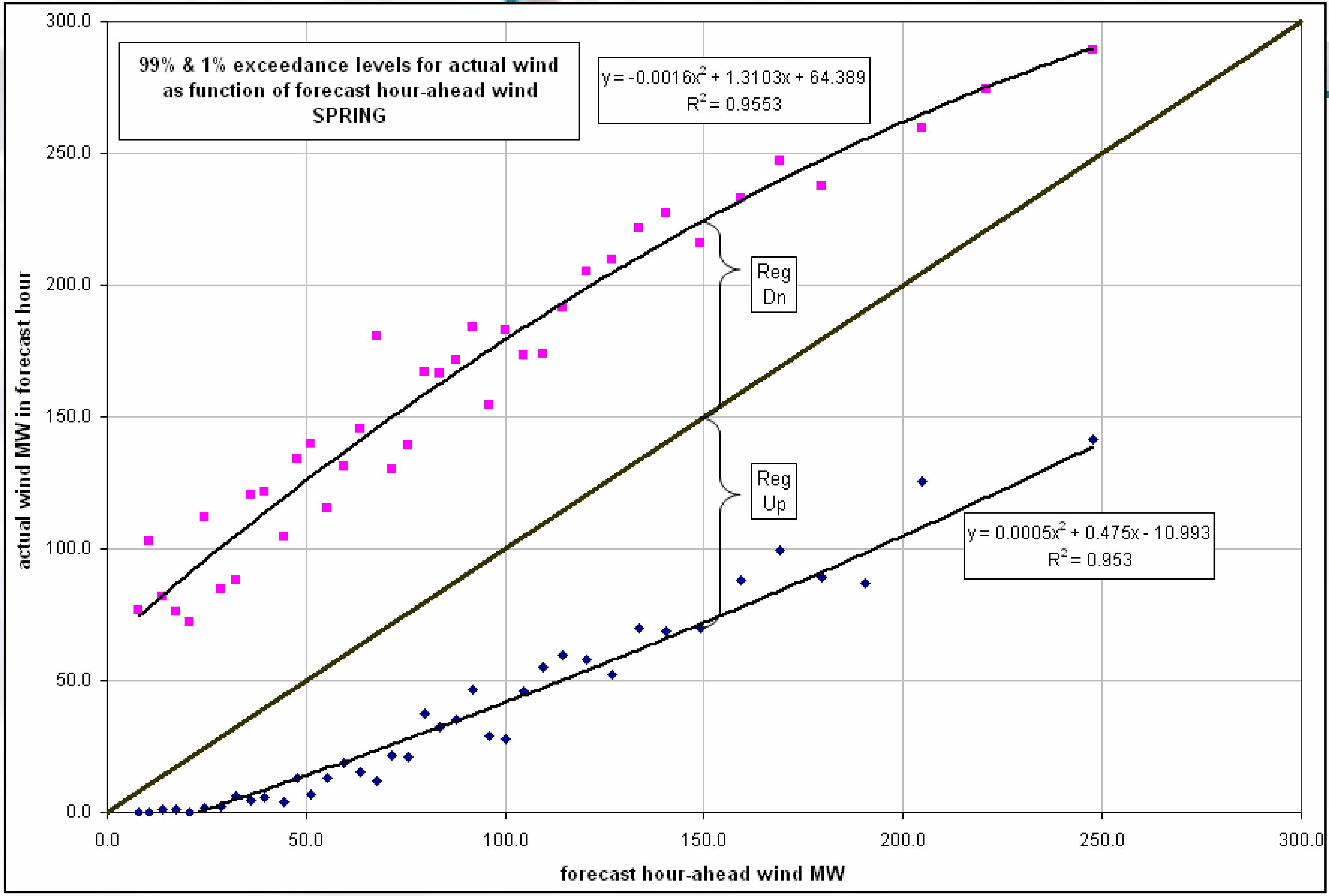

June 22, 2005 - 300 MW Nameplate Wind
Forecast Hourly Average Wind MW Based on Autoregressive Time Series Model
Using Wind through 65 Minutes Prior to Operating Hour
forecast hourly average - AR model (primary y-axis)
deviations from forecast hourly average (secondary y-axis)
+L_10
-L_10
actual 10-minute instantaneous wind MW (primary y-axis)
1.) 30 deviations outside L_10 band
2.) average deviation (abs value) = 26.6 MW
actual wind MW & fcst hourly avg wind MW
deviation from fcst hourly avg wind MW
250.0
225.0
200.0
175.0
150.0
125.0
100.0
75.0
50.0
25.0
0.0
150.0
120.0
90.0
60.0
30.0
0.0
-30.0
-60.0
-90.0
-120.0
-150.0
22-Jun-05 00:00
22-Jun-05 03:00
22-Jun-05 06:00
22-Jun-05 09:00
22-Jun-05 12:00
22-Jun-05 15:00
22-Jun-05 18:00
22-Jun-05 21:00
23-Jun-05 00:00


June 22, 2005 - 300 MW Nameplate Wind
Forecast Hourly Average Wind MW Based on Persistence of Wind at 65 Minutes Prior to Operating Hour
forecast hourly average - persistence (primary y-axis)
deviations from forecast hourly average (secondary y-axis)
+L_10
-L_10
actual 10-minute instantaneous wind MW (primary y-axis)
1.) 41 deviations outside L_10 band
2.) average deviation (abs value) = 31.4 MW
actual wind MW & fcst hourly avg wind MW
deviation from fcst hourly avg wind MW
250.0
225.0
200.0
175.0
150.0
125.0
100.0
75.0
50.0
25.0
0.0
150.0
120.0
90.0
60.0
30.0
0.0
-30.0
-60.0
-90.0
-120.0
-150.0
22-Jun-05 00:00
22-Jun-05 03:00
22-Jun-05 06:00
22-Jun-05 09:00
22-Jun-05 12:00
22-Jun-05 15:00
22-Jun-05 18:00
22-Jun-05 21:00
23-Jun-05 00:00



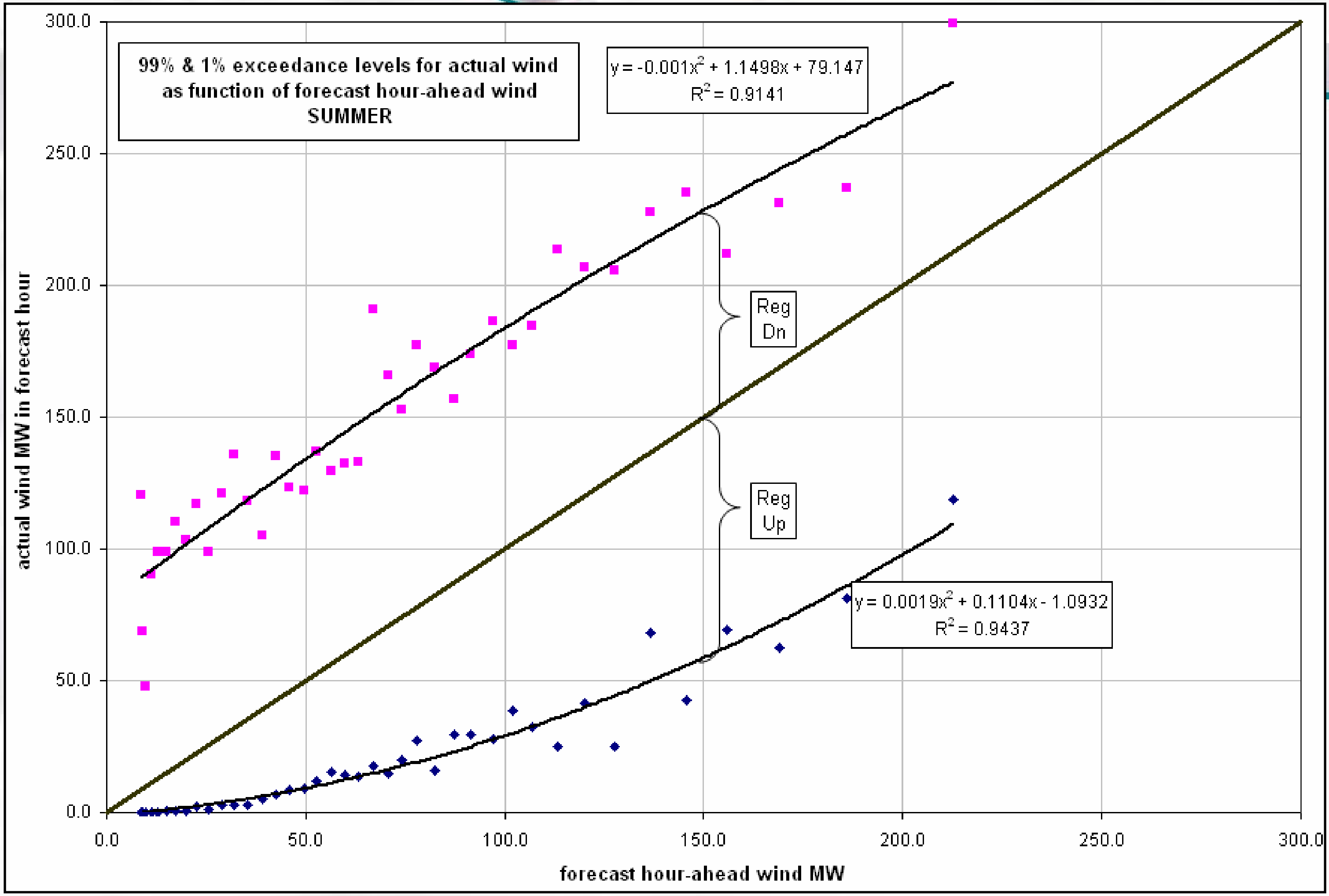
WINTER - 300 MW
OBSERVED HOURLY AVERAGE WIND MW
vs.
PREDICTED HOURLY AVERAGE WIND MW
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0.0
50.0
100.0
150.0
200.0
250.0
300.0

Spring – Wind Forecast Bands

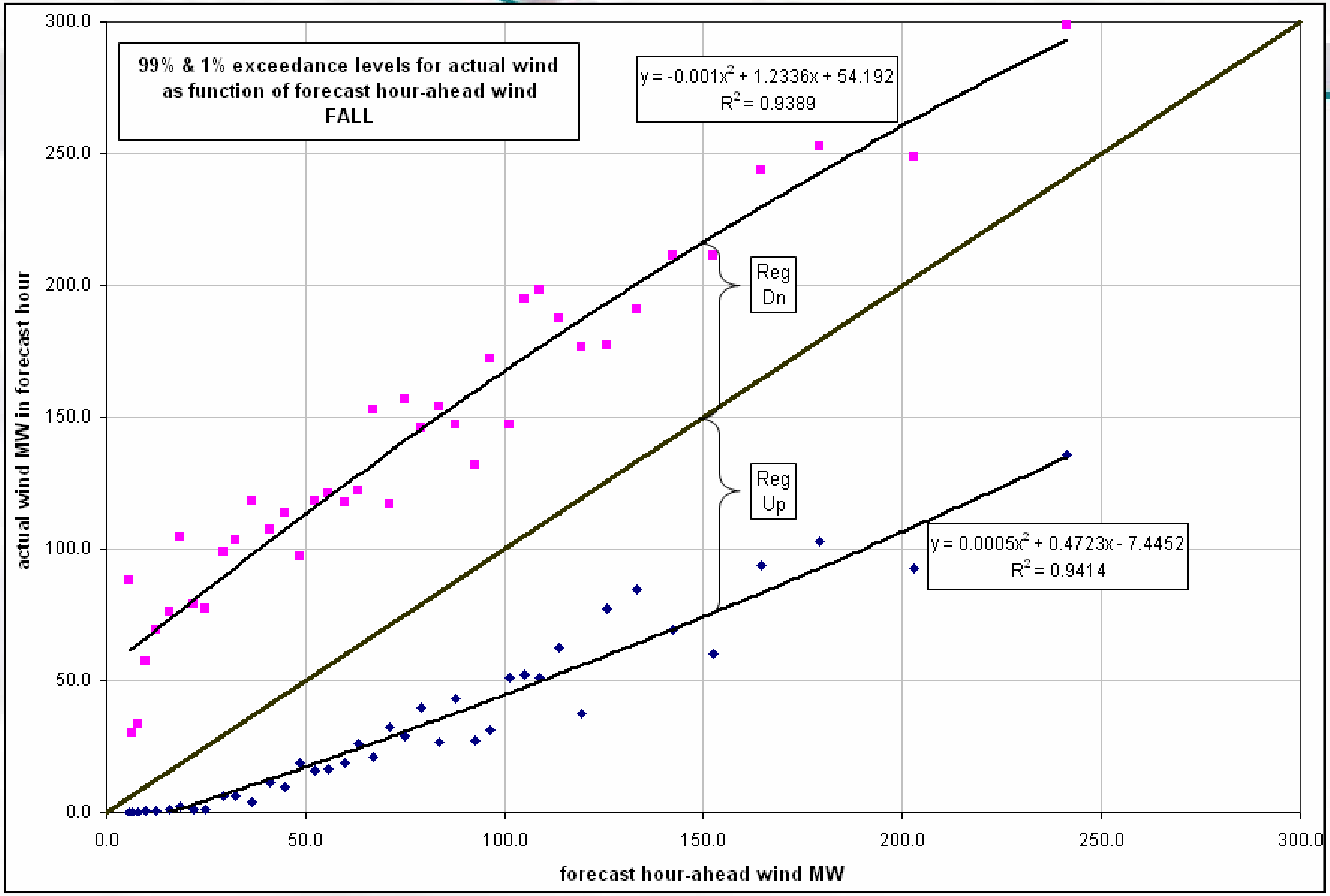


Summer –

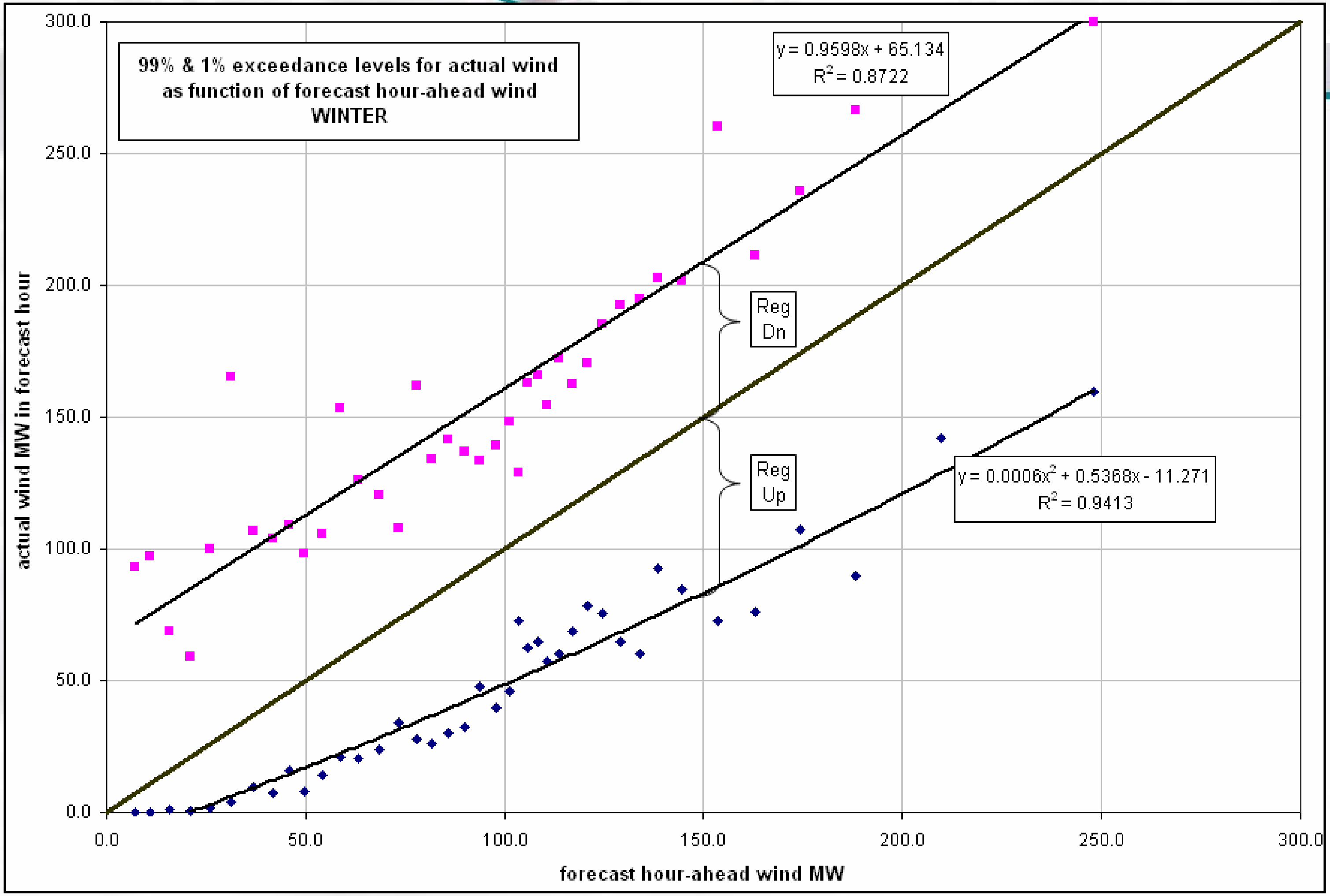
Wind Forecast Bands

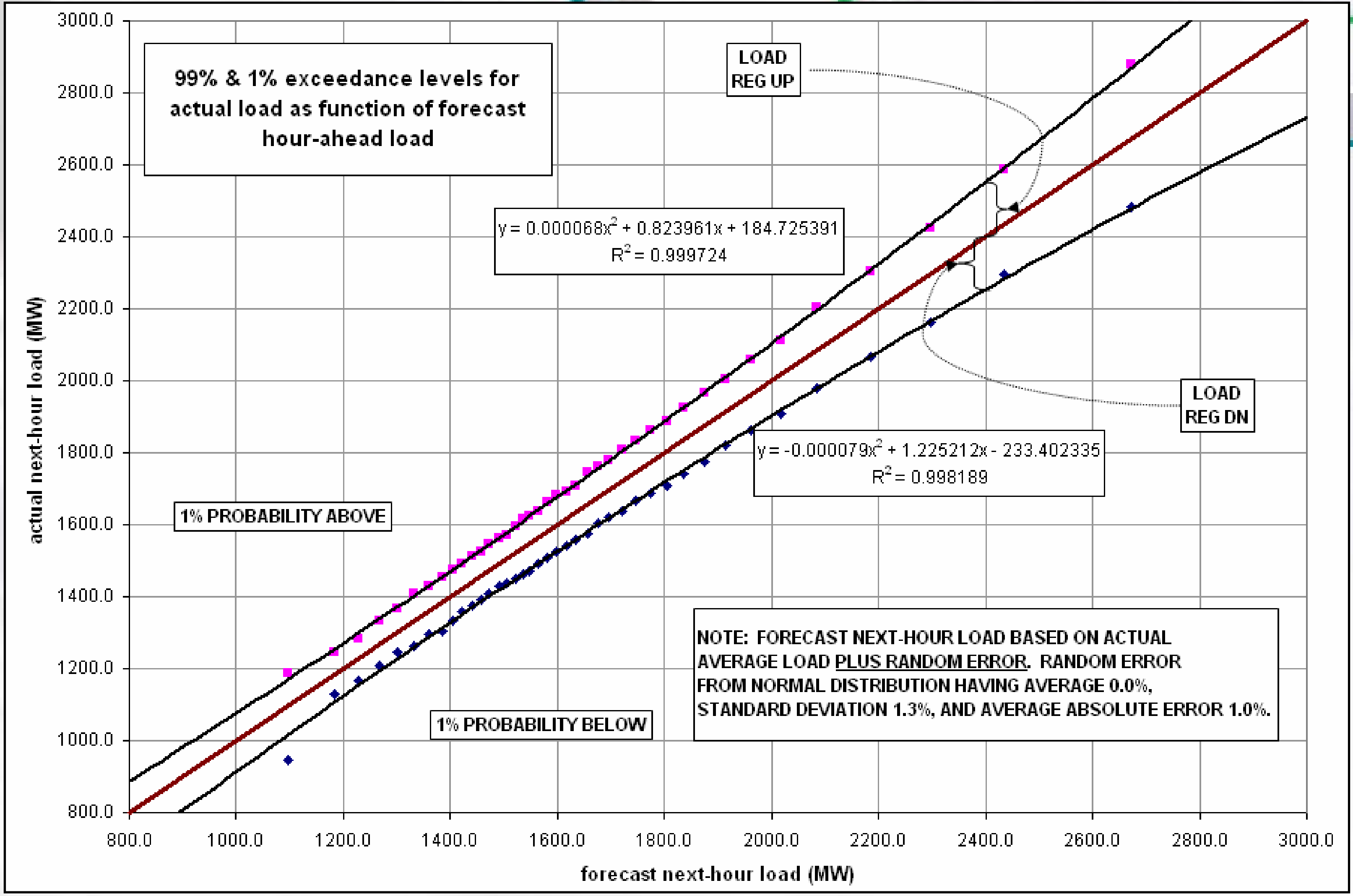


Fall – Wind Forecast Bands



Winter – Wind Forecast Bands



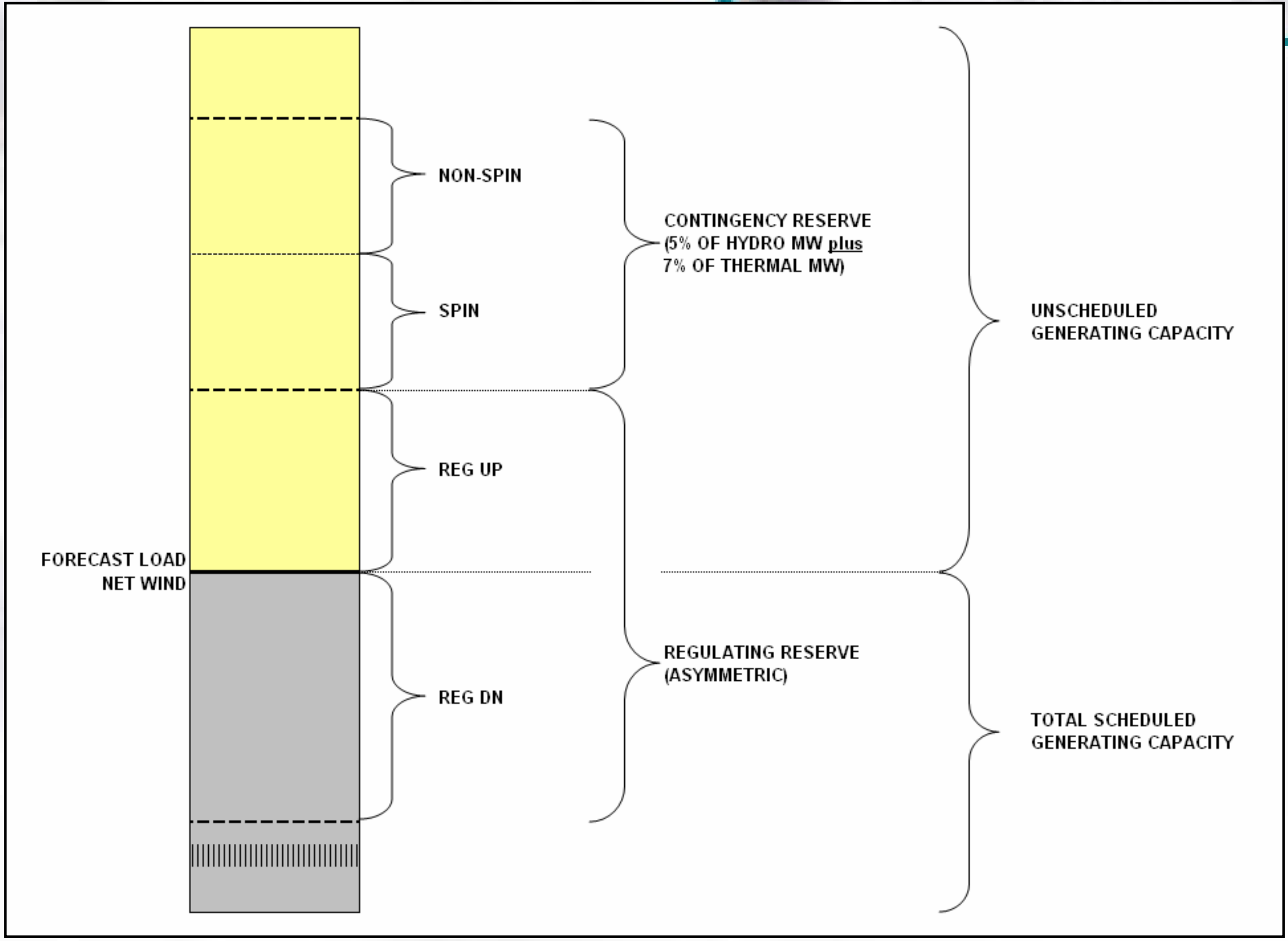


99% & 1% exceedance levels for actual load as function of forecast hour-ahead load
LOAD REG UP
y = 0.000068x2 + 0.823961x + 184.725391
R2 = 0.999724
LOAD REG DN
y = -0.000079x2 + 1.225212x - 233.402335
R2 = 0.998189
1% PROBABILITY ABOVE
1% PROBABILITY BELOW
NOTE: FORECAST NEXT-HOUR LOAD BASED ON ACTUAL AVERAGE LOAD PLUS RANDOM ERROR. RANDOM ERROR FROM NORMAL DISTRIBUTION HAVING AVERAGE 0.0%, STANDARD DEVIATION 1.3%, AND AVERAGE ABSOLUTE ERROR 1.0%.
actual next-hour load (MW)
forecast next-hour load (MW)
3000.0
2800.0
2600.0
2400.0
2200.0
2000.0
1800.0
1600.0
1400.0
1200.0
1000.0
800.0

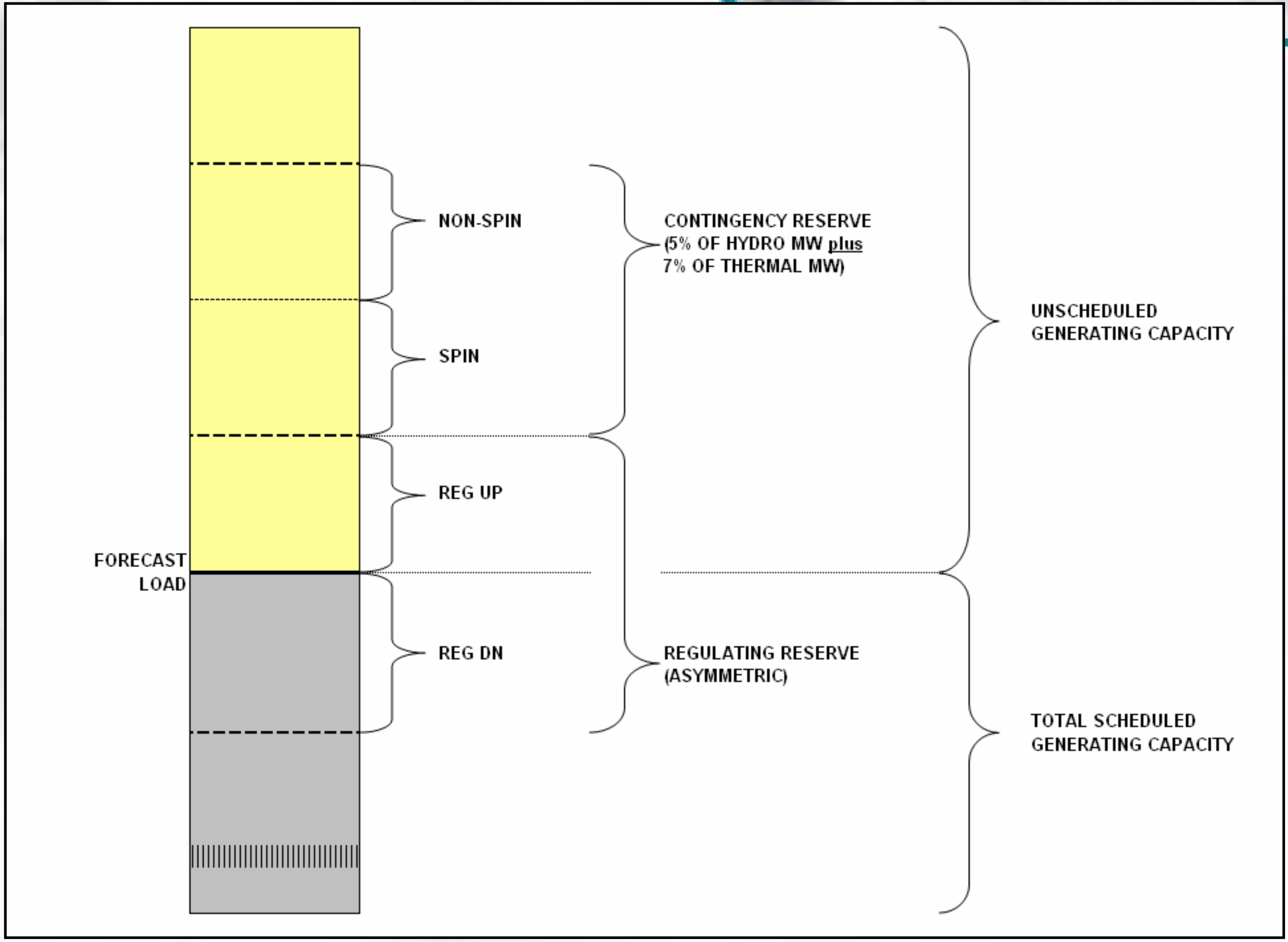
Regulating Reserve

- Asymmetric ➔ RegUp ≠ RegDown
- Dynamic ➔ Regulating reserve expressed as function of forecast load & wind
- Actual Wind Case
  - Total RegDown = SQRT (LOAD $RegDown^2$ + WIND $RegDown^2$)
  - Total RegUp = SQRT (LOAD $RegUp^2$ + WIND $RegUp^2$)
- Flat Wind Case
  - Total RegDown = (LOAD RegDown)
  - Total RegUp = (LOAD RegUp)

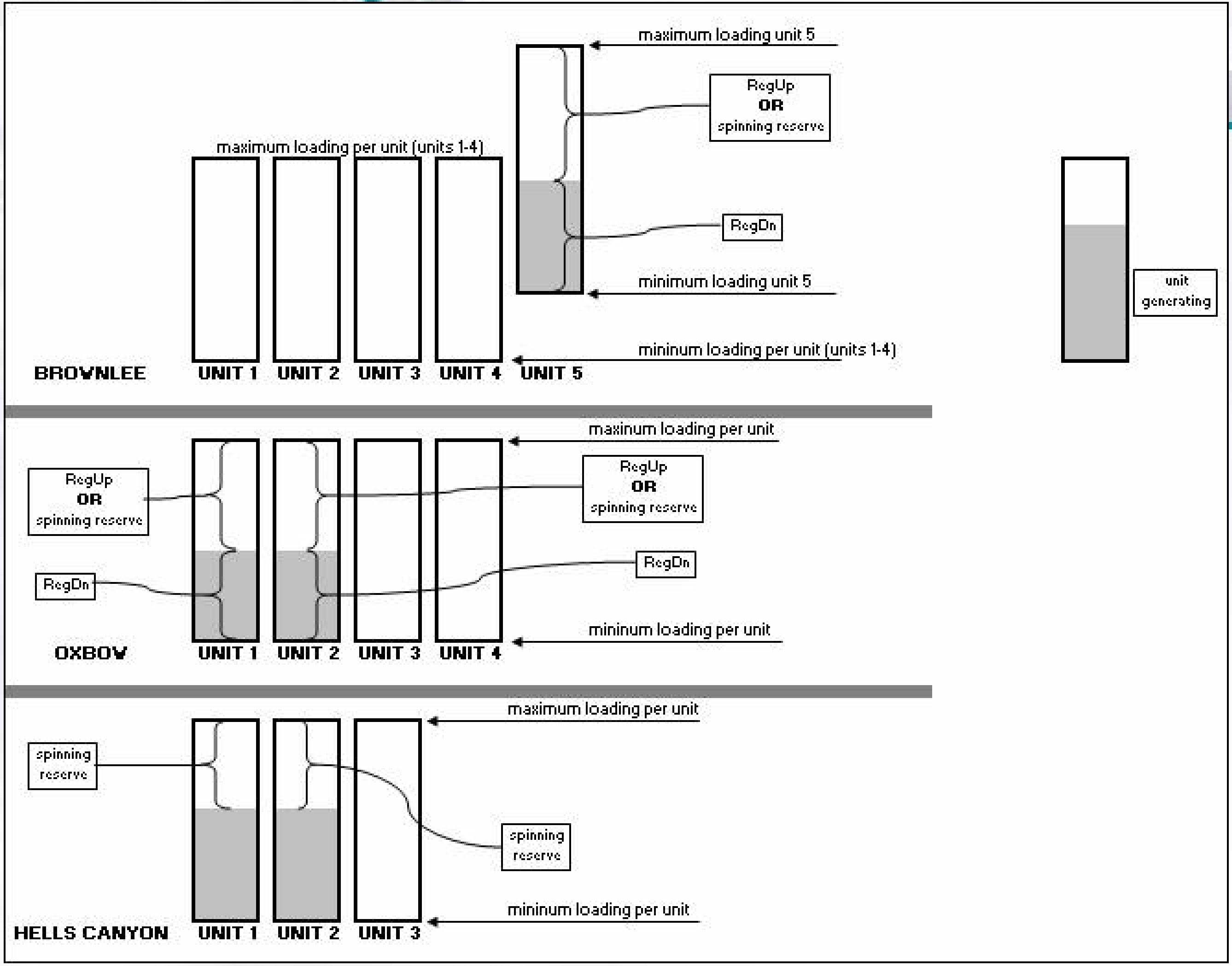
Reserves – Actual Wind Case



Reserves – Flat Wind Case

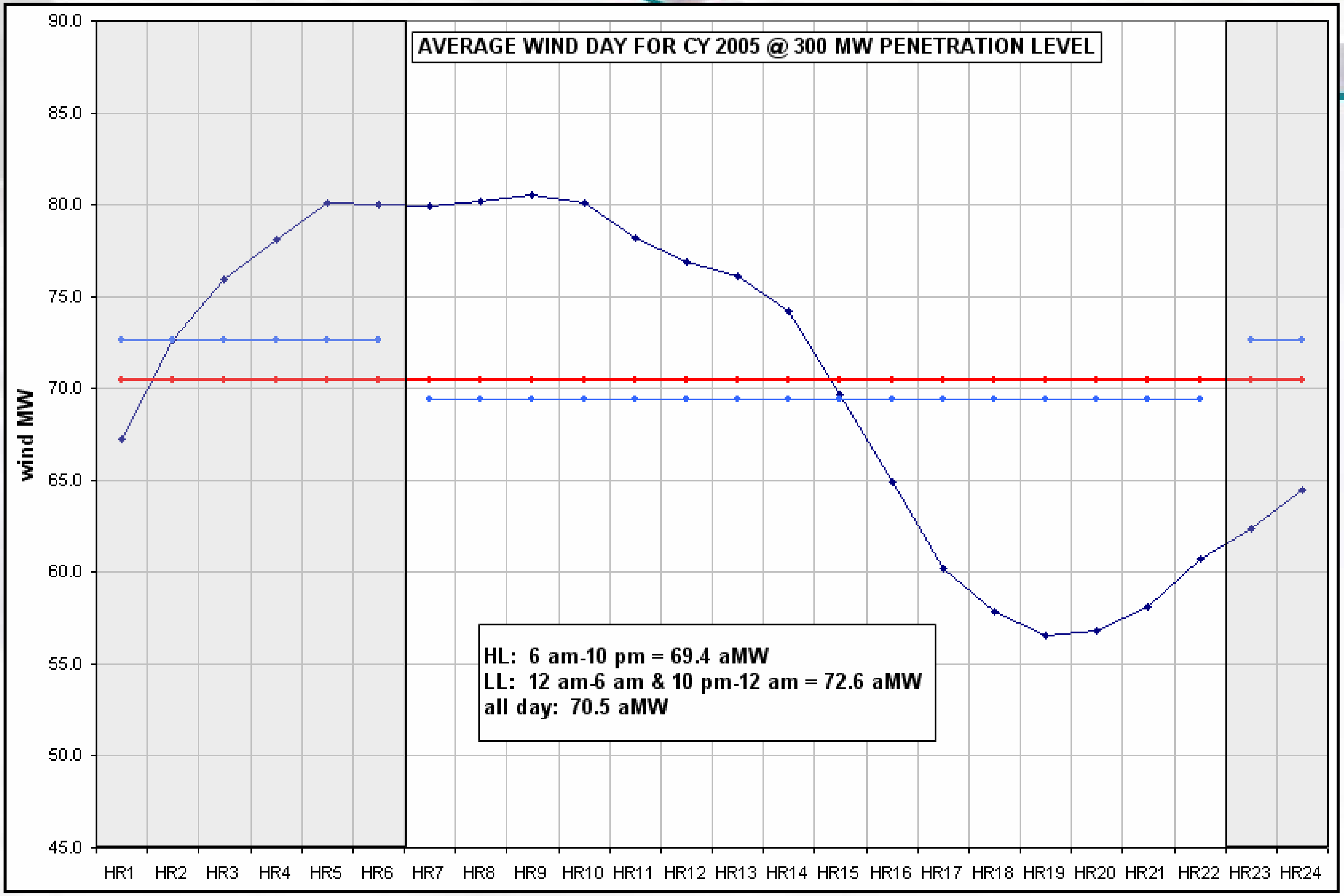


Reserves & HCC



General Questions - #16

The flat wind HL/LL bias should be removed from the model.



AVERAGE WIND DAY FOR CY 2005 @ 300 MW PENETRATION LEVEL
wind MW
90.0
85.0
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
HL: 6 am-10 pm = 69.4 aMW
LL: 12 am-6 am & 10 pm-12 am = 72.6 aMW
all day: 70.5 aMW
HR1 HR2 HR3 HR4 HR5 HR6 HR7 HR8 HR9 HR10 HR11 HR12 HR13 HR14 HR15 HR16 HR17 HR18 HR19 HR20 HR21 HR22 HR23 HR24

General Questions - #5

Moving wind remotely has built in a very high transaction cost. Needs to be investigated.

Idaho Power Co
Wind Intgration Study -June 2007 Workshop
Vista Reserves and Price Modeling Sensitivity
MWh Purchase and Sales Changes
Variable - Flat

Wind MWh	Transmission MWh		1998	2000	2005
700k	**300**	Purchases	7,906	69561	(506)
		Sales	(119,421)	5525	(23,310)
1.5mm	**600**	Purchases	9,779	54640	115,361
		Sales	(298,440)	25642	(8,303)
2.3mm	**900**	Purchases	12,326	79,119	174,104
		Sales	(459,289)	(21,056)	49,124

General Questions - #16

Can a further breakdown of the costs associated with the $10.72 be shown in regards to the amount attributed to the hour ahead wind forecast, the wind forecast error, reserves and transmission costs (delta between flat and variable case)?

Regulating Reserves

	Average			
	LOAD REG UP	LOAD REG DN	LNW REG UP	LNW REG DN
300MW	51.4	49.8	66.8	74.8
600MW	51.4	49.8	87.4	104.3
900MW	51.4	49.8	109.4	140.3
	Load Reg	LNW Reg	Incremental Reg	% of Installed Wind
300MW	50.6	70.8	20.2	6.7%
600MW	50.6	95.9	45.3	7.6%
900MW	50.6	124.9	74.3	8.3%

General Questions - #11

Market prices from year 2000 should not have been used. Need to investigate other pricing alternatives?

General Questions - #4

Can Idaho Power utilize the regional markets to integrate wind more economically?

General Questions - #15

Investigate "what-if's" associated with expanding the size of the control area.

CHANGES IN MODELING

- 1) Limited the Vista model's ability to take advantage of the price differential between the east and west-side markets. While Idaho Power is able to take advantage of this situation on occasion, Vista was going overboard on the amount of buying and selling it was doing. The elimination of this arbitrage opportunity had a significant impact and resulted in a reduction of the wind integration cost of approximately $1.40/MWh.

CHANGES IN MODELING

- 2) Since the original study was completed, Synexus Global has incorporated the ability to input asymmetric reserve requirements in the Vista model. This new feature coupled with the ability to specify dynamic reserves on an hourly basis has allowed the utilization of different levels of reg-up and reg-down reserve requirements on an hourly basis rather than the flat, bi-directional reserve requirement used in the original study. The impact of this change was also significant and reduced the wind integration cost by approximately \$1.63/MWh.

CHANGES IN MODELING

- 3) Removal of regulating reserves required due to fast fluctuations in system changes (30 seconds). This issue was debated at the first workshop and was believed to be "double counting" the amount of necessary reserves. This change had a small impact and reduced the wind integration cost by approximately $0.10/MWh.

CHANGES IN MODELING

- 4) The distribution of wind projects used to model the 300 MW penetration level was updated to reflect selection of the Elkhorn Wind Project (Horizon) in our recently concluded wind RFP. Overall, 100 MW from the Elkhorn project was added and 100 MW from the Cotterel site was removed from the 300 MW penetration level. This change provided a greater diversification of the wind resource and resulted in a reduction in the wind integration cost of approximately $0.15/MWh.

CHANGES IN MODELING

- 5) The wind forecasting methodology used in the model was improved by utilizing a seasonal, autoregressive method rather than a persistence forecast taken at 65 minutes before the hour. This change reduced the wind integration cost by approximately $0.25/MWh.

CHANGES IN MODELING

- 6) In the flat wind or base case, wind was originally input as a flat block for the entire day. In the updated model, wind generation has been separated into flat blocks for both heavy-load and light-load hours. This change was recommended at the first workshop and resulted in lowering the wind integration cost by approximately $0.25/MWh.