

Day-ahead output forecasting OWEZ

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Motivation

- Monitoring and Evaluation Programme NSW-MEP
 - * Organised learning by measurement and evaluation
- Task 1.7.2 “Short-term Output Prediction”
 - * Sub-contracted to ECN by NoordzeeWind
- Objectives:
 - * To produce daily overviews of measured and forecasted power, as well as imbalance energy and imbalance cost
 - * To assess
 - (i) The value of wind power forecasting on project basis, and
 - (ii) The use of such forecasts at events like storms

Summary

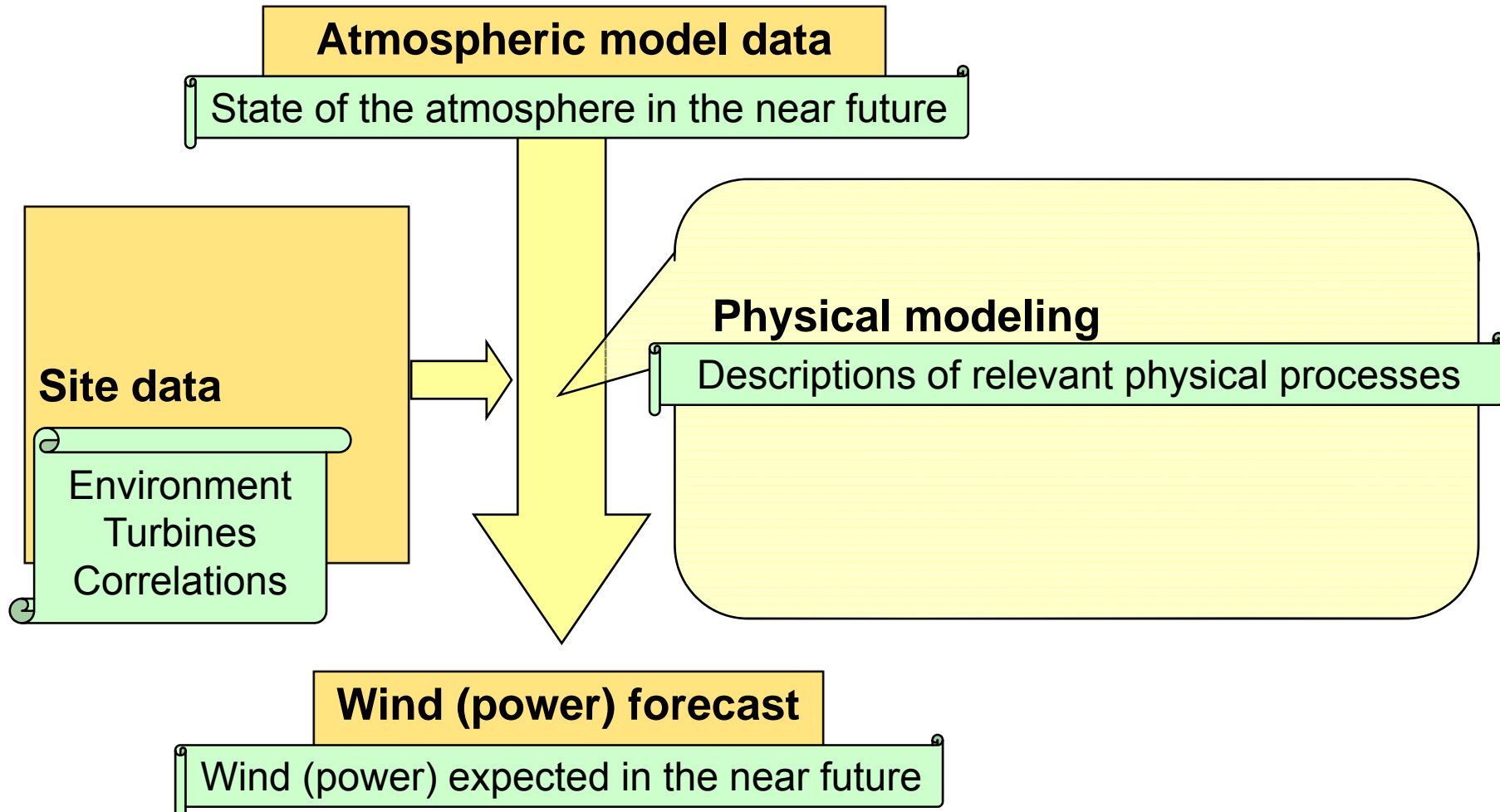
- ❑ OWEZ is better of with imbalance payments
- ❑ Optimized day-ahead forecasts are the more economic
- ❑ At a day-ahead notice:
 - * Predictability of exceedances is low
 - * Predictability of extremes is poor
 - * Some evidence for the ability to serve as an early warning

Outline

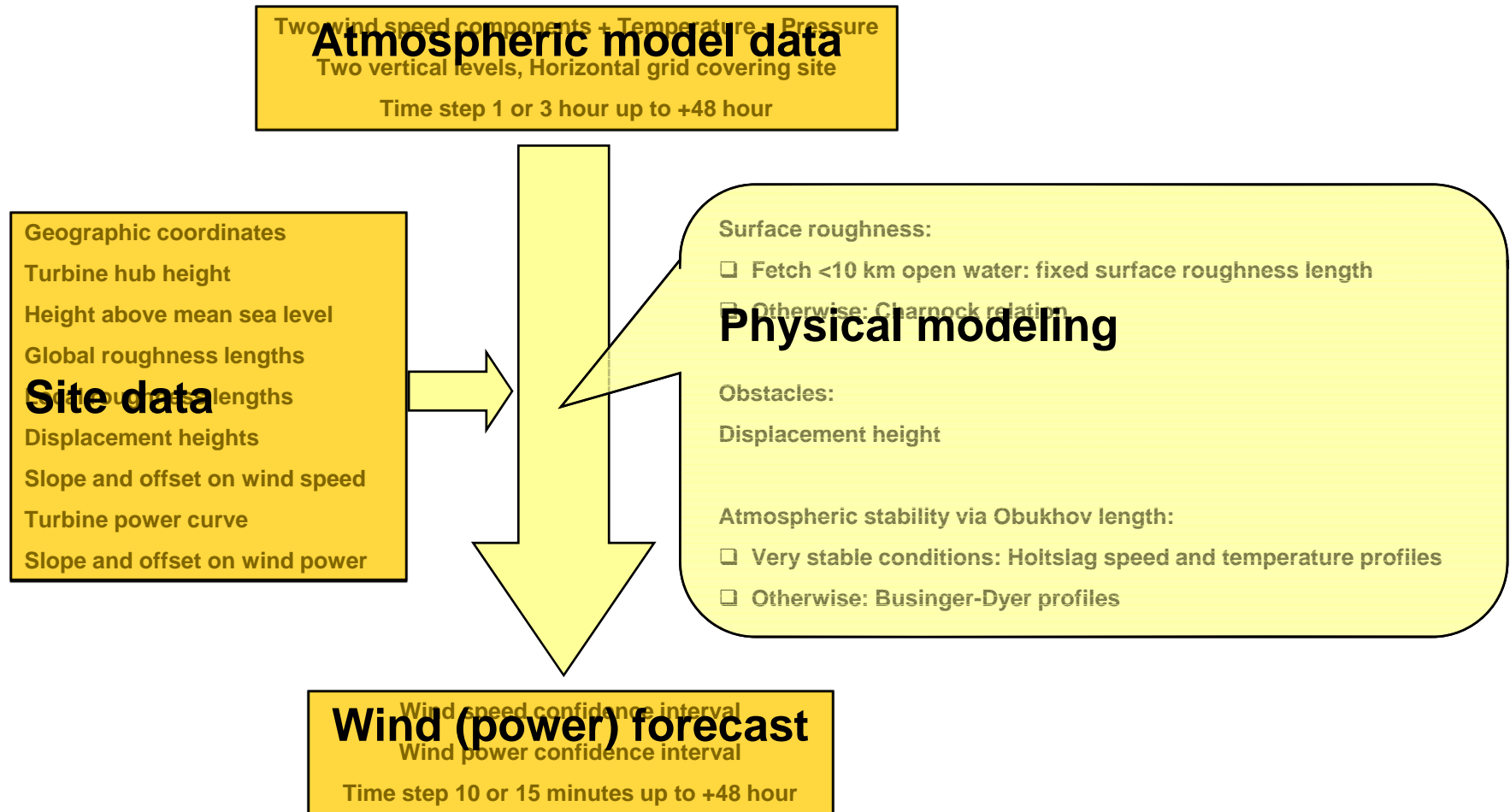
- Methodology
 - * Forecasting method
 - * Offshore Windfarm Egmond aan Zee
 - * Imbalance system

- Experience
 - * Forecast optimization
 - * Economic value of forecasting
 - * Predictability of exceedances and extremes

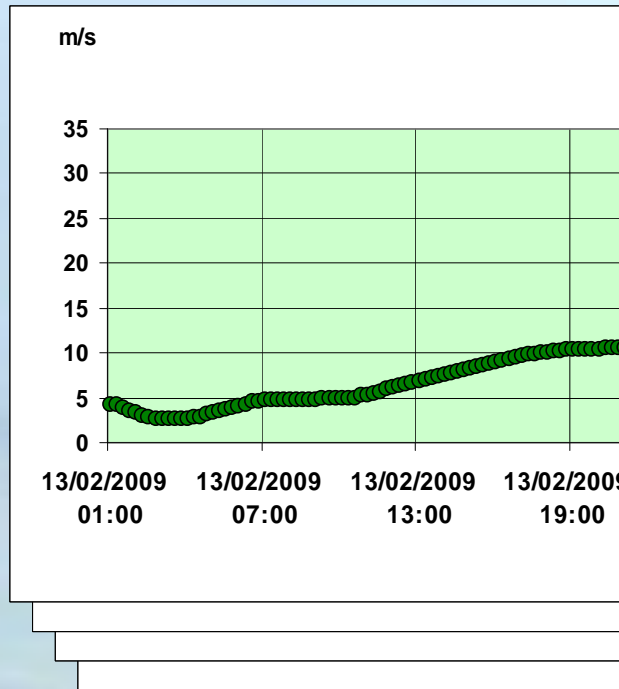
Forecasting method AVDE



Forecasting method AVDE



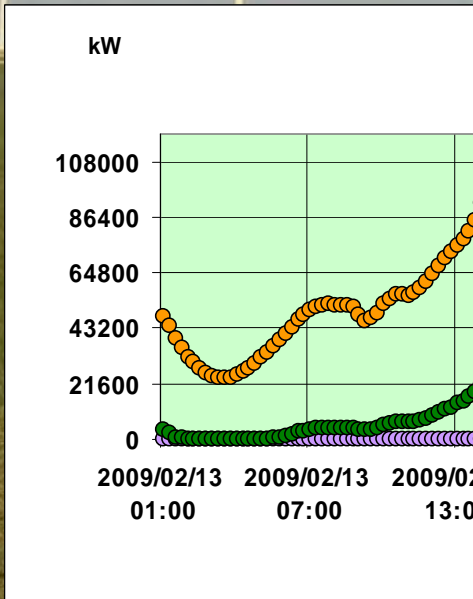
Wind speed forecasting mode of AVDE



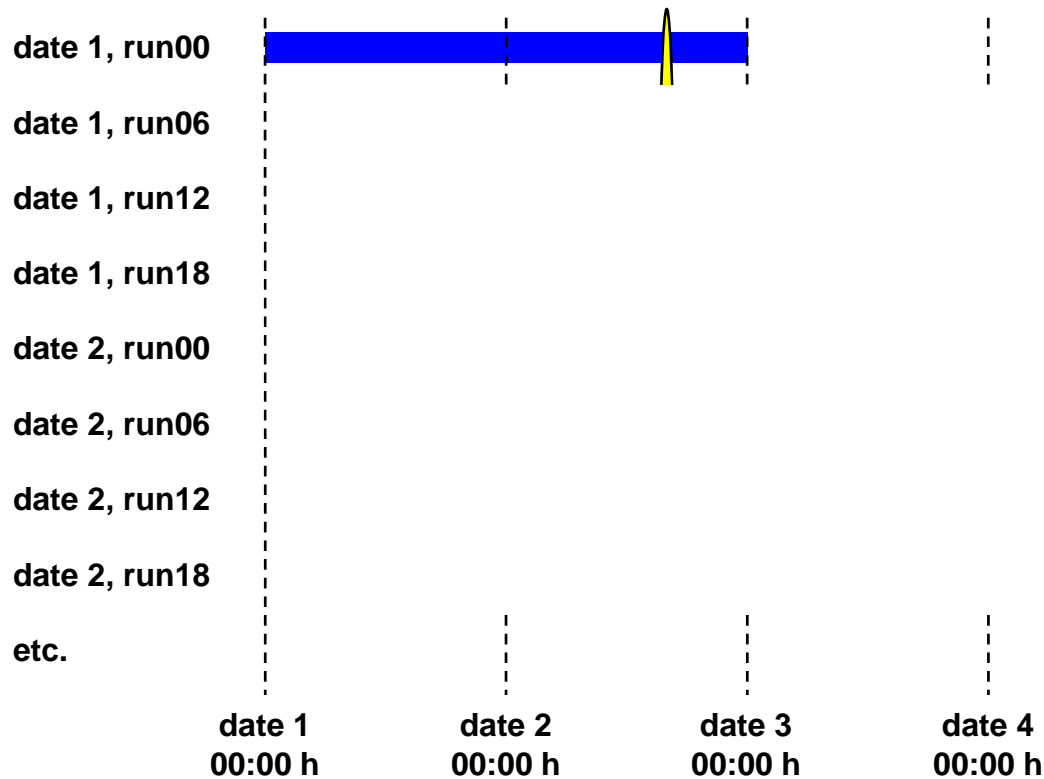
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# wN1	52.606362	4.389639	70					
#								
#	date	period	temp	press	ws	wd	mol	turbint
#[dy/mn/yr]	[hr:mn]	[degC]	[hPa]	[m/s]	[deg]	[hm]	[-]	
#								
13/02/2009	01:00-01:15	3.6	1011.7	4.3	312.4	3.04	0.028	
13/02/2009	01:15-01:30	3.6	1011.5	4.2	310.2	0.75	0.021	
...								
14/02/2009	00:00-00:15	4.0	1013.9	8.2	25.6	0.39	0.019	
14/02/2009	00:15-00:30	4.0	1014.0	8.0	26.1	0.36	0.018	
14/02/2009	00:30-00:45	3.9	1014.1	7.9	26.6	0.34	0.017	
14/02/2009	00:45-01:00	3.9	1014.1	7.7	27.1	0.31	0.017	
14/02/2009	01:00-01:15	3.9	1014.2	7.6	27.6	0.29	0.016	
14/02/2009	01:15-01:30	3.9	1014.2	7.5	28.0	0.27	0.016	
...								
14/02/2009	22:30-22:45	4.9	1017.8	7.4	240.7	0.27	0.015	
14/02/2009	22:45-23:00	5.0	1017.7	7.7	240.3	0.29	0.015	
14/02/2009	23:00-23:15	5.0	1017.6	7.9	239.9	0.32	0.016	
14/02/2009	23:15-23:30	5.1	1017.5	8.1	239.5	0.35	0.016	
14/02/2009	23:30-23:45	5.1	1017.4	8.4	239.1	0.39	0.017	
14/02/2009	23:45-00:00	5.2	1017.3	8.6	238.7	0.43	0.017	
...								
...								
15/02/2009	01:00-01:15	5.5	1016.7	9.9	236.5	0.84	0.021	

Wind power forecasting mode of AVDE

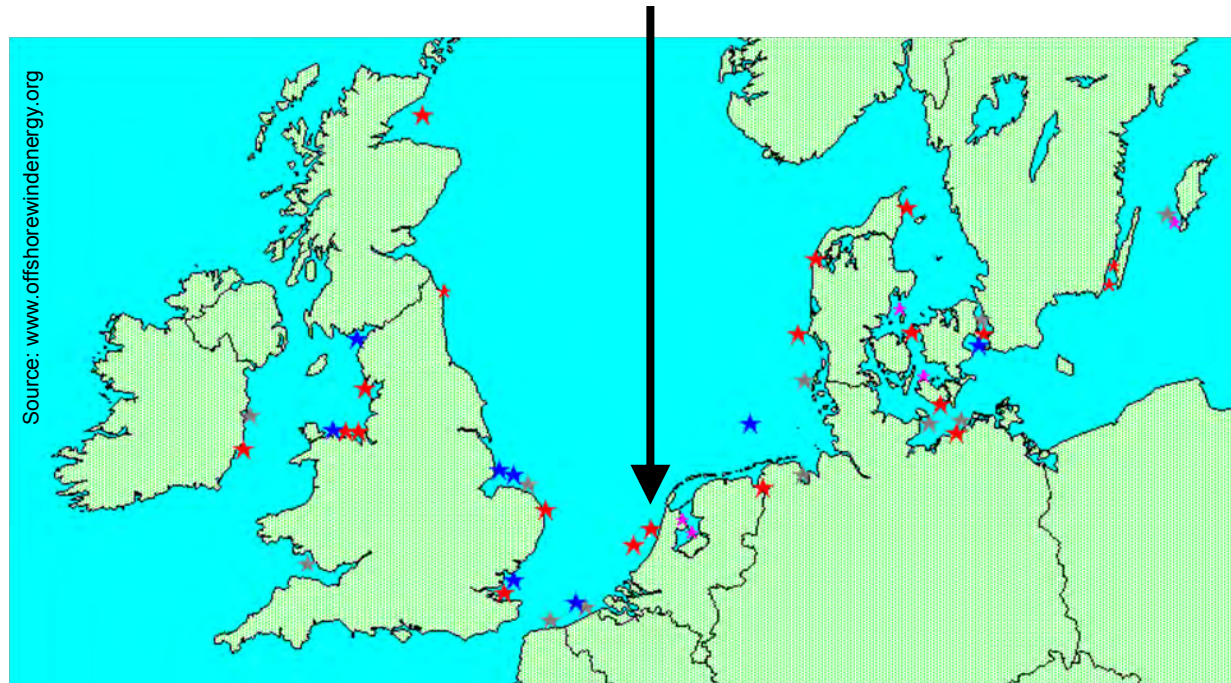
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#											
#	Date	Period	PTU	PowNO	PowExp	PowLCL	PowHCL	PowVarInt	WsExp	Wd	Rho
#	[yr/mn/dy]	[hr:mn]	[-]	[kW]	[kW]	[kW]	[kW]	[-]	[m/s]	[deg]	[kg/m ³]
#											
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	2009/02/13	01:15-01:30	6	4766.4	3399.7	0.0	46435.4	0.194	4.3	310.2	1.272
	...										
	...										
	2009/02/14	00:00-00:15	1	33040.6	28058.0	72.1	101652.3	0.055	7.7	25.3	1.274
	2009/02/14	00:15-00:30	2	31381.4	26434.5	14.6	100428.2	0.058	7.6	25.7	1.274
	2009/02/14	00:30-00:45	3	29355.3	24667.6	3.4	98864.7	0.053	7.4	26.2	1.274
	2009/02/14	00:45-01:00	4	27791.6	23497.8	2.9	97277.3	0.053	7.3	26.6	1.274
	2009/02/14	01:00-01:15	5	25968.9	22127.0	2.3	95221.7	0.048	7.1	27.1	1.275
	2009/02/14	01:15-01:30	6	24769.0	21096.1	1.8	93674.9	0.049	7.0	27.4	1.275
	...										
	...										
	2009/02/14	22:30-22:45	91	24731.9	21064.6	2.0	93253.9	0.043	7.1	240.3	1.274
	2009/02/14	22:45-23:00	92	26933.9	22758.2	2.7	95937.3	0.041	7.3	239.9	1.274
	2009/02/14	23:00-23:15	93	29833.2	25054.5	11.5	98729.7	0.046	7.5	239.5	1.274
	2009/02/14	23:15-23:30	94	32203.4	27366.4	77.6	100640.7	0.043	7.7	239.1	1.273
	2009/02/14	23:30-23:45	95	35253.1	30331.8	204.4	103084.4	0.048	8.0	238.6	1.273
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	...										
	...										
	2009/02/15	00:45-00:00	4	53126.6	46431.3	2800.7	110339.2	0.051	9.2	236.3	1.271



Hierarchy of forecasts



Offshore Wind Farm Egmond aan Zee



Offshore Wind Farm Egmond aan Zee



Image © 2007 Aerodata International Surveys

Image NASA
© 2007 Tele Atlas

elev 0 m Streaming 100%

Eye alt 29.76 km



Imbalance system

□ Programme imbalance

□ Imbalance energy: $E_{imb} = \Delta E = E_{mea} - E_{frc} = c (P_{mea} - P_{frc}) = c \Delta P$

□ Surplus energy: $E_{sur} = E_{imb}$ if $E_{imb} > 0 \Leftrightarrow \Delta P > 0$

□ Shortage energy: $E_{sho} = -E_{imb}$ if $E_{imb} < 0 \Leftrightarrow \Delta P < 0$

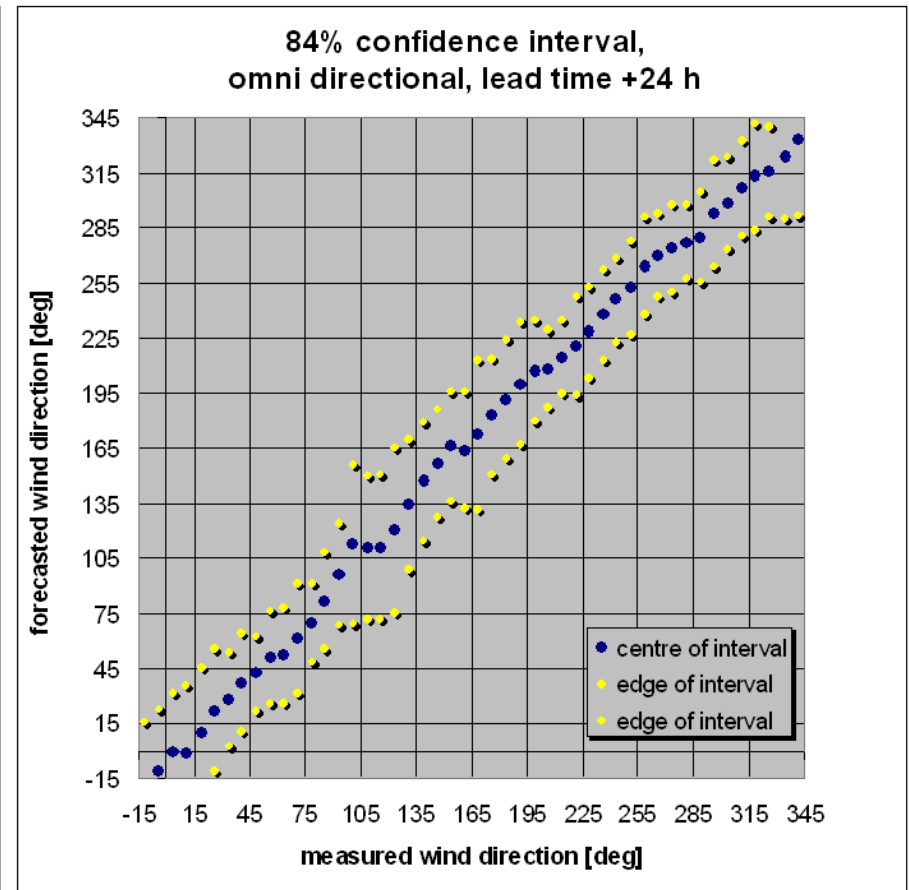
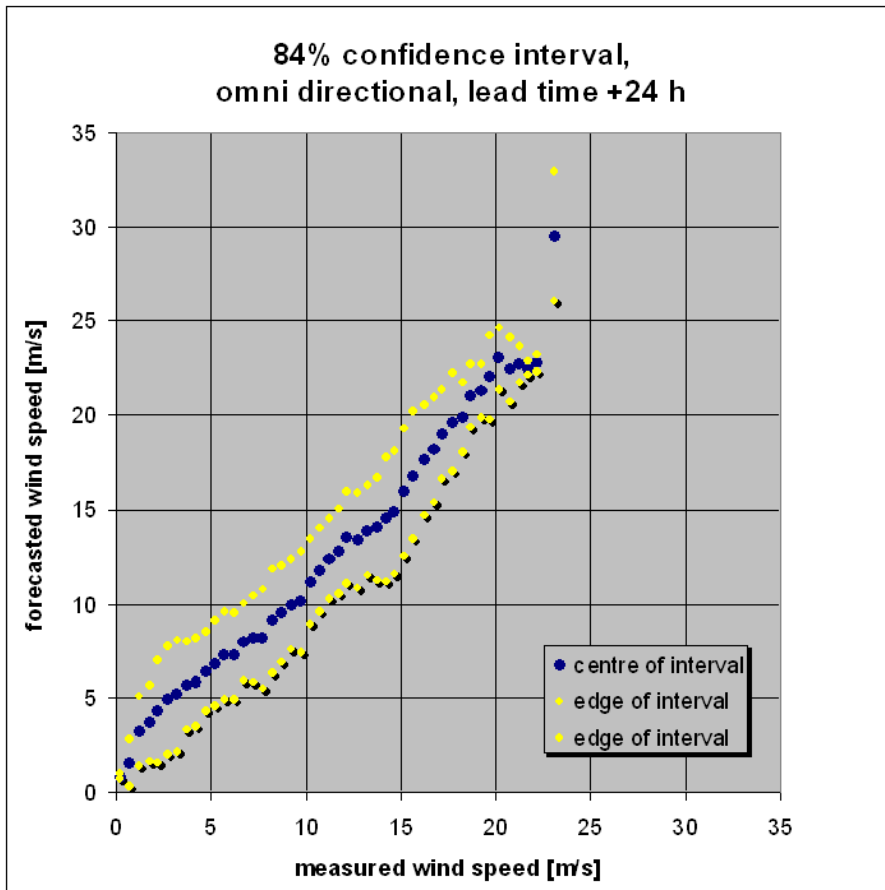
Forecast optimization

- Systematic forecasts errors
- Optimized wind speed forecast

$$* \quad W_{\text{frc,opt}} = a_w W_{\text{frc,AVDE}} + b_w \quad \text{if} \quad 4 \leq W_{\text{frc,AVDE}} \leq 20 \quad \text{m/s}$$

$$* \quad W_{\text{frc,opt}} = (a_w + 0.25b_w) W_{\text{frc,AVDE}} \quad \text{if} \quad 0 \leq W_{\text{frc,AVDE}} \leq 4 \quad \text{m/s}$$

Forecast optimization



Economic value of forecasting

- Imbalance fee = $0.11 p_{APX} E_{mea}$
- Imbalance payment = $p_{ext} E_{sho} - p_{fin} E_{sur}$

Economic value of forecasting

- ❑ Imbalance fee
- ❑ Imbalance payment

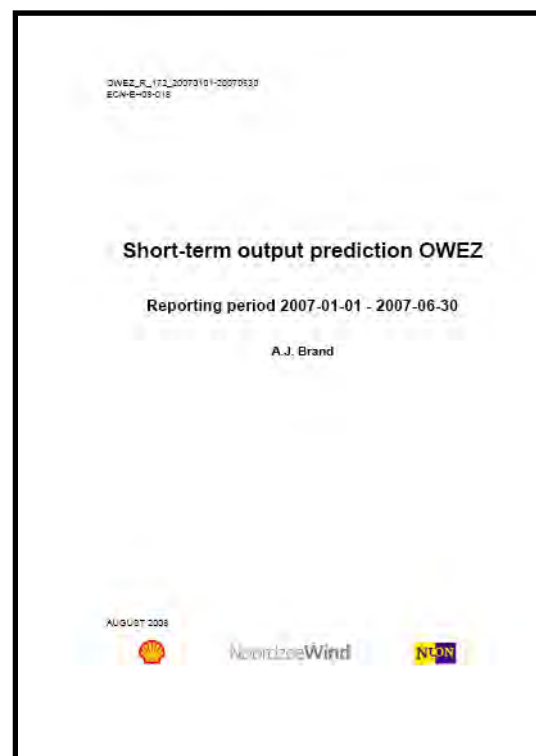
Predictability of exceedances and extremes

- Exceedances
 - * $24.5 \text{ m/s} < \text{wind speed} \leq 28.5 \text{ m/s}$
 - * $28.5 \text{ m/s} < \text{wind speed} \leq 32.6 \text{ m/s}$
 - * $\text{wind speed} > 32.6 \text{ m/s}$

- Extremes
 - * Smallest resp. largest value
 - * Largest downward resp. upward change

Predictability of exceedances and extremes

- ❑ Predictability of exceedances: Low
- ❑ Predictability of extremes: Poor
- ❑ Early-warning ability: Some evidence



Public reports available from NoordzeeWind

Summary

- OWEZ is better of with imbalance payments
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