Grid integration of large scale wind
Challenges and R&D needs

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RWE Transportnetz Strom GmbH

Overview

- General Information
- The role of the TSOs in Germany / EEG
- Wind power fluctuations
- Grid Situation
- Wind power prediction

General Information

Subsidies EEG old/new

	EEG old [ct/kWh]	**EEG new** [ct/kWh]
Small Hydro	6,65 - 7,67 No Degression	3,70 - 9,67 Degression: 1 %/a
Waste	6,65 - 7,67 No Degression	6,65 - 9,67 Degression 1,5 %/a
Biomass	8,40 - 9,90 Degression: 1 %/a	3,90 - 19,50 (zzgl. 2 ct/kWh KWK) Degression: 1,5 %/a
Geothermal	7,16 - 9,00 No Degression	7,16 - 15,00 Degression: 1 %/a
Wind energy	5,90 - 8,80 Degression: 1,5 %/a	**5,50 - 9,10** Degression: 2 %/a
Photo voltaic	43,40 *) Degression: 5 %/a	45,70 - 62,40 Degression: 5 bzw. 6,5 %/a

higher Subsidies and higher Degression

General Information

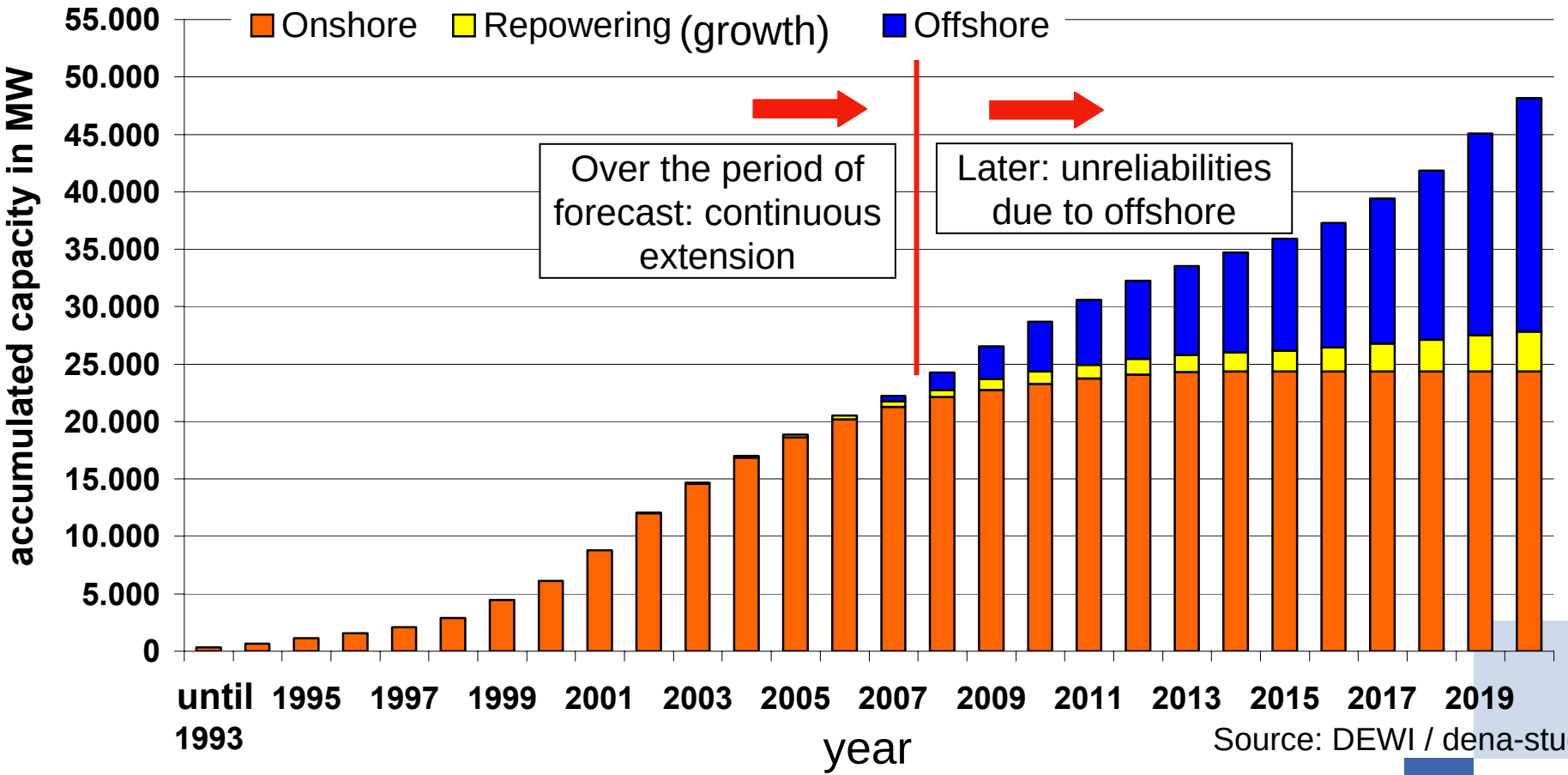
Installed Capacity and Number of Turbines

Control Area	Capacity [MW]	Number	Share
E.ON Netz AG	8006	8068	40 %
Vattenfall Europe Transmission	8021	6451	40 %
RWE Transportnetz Strom	3595	3349	18 %
EnBW	323	306	2 %
Total	**19946**	**18178**	**100 %**

November 2006

General Information

forecast of developement until 2020



Source: DEWI / dena-study

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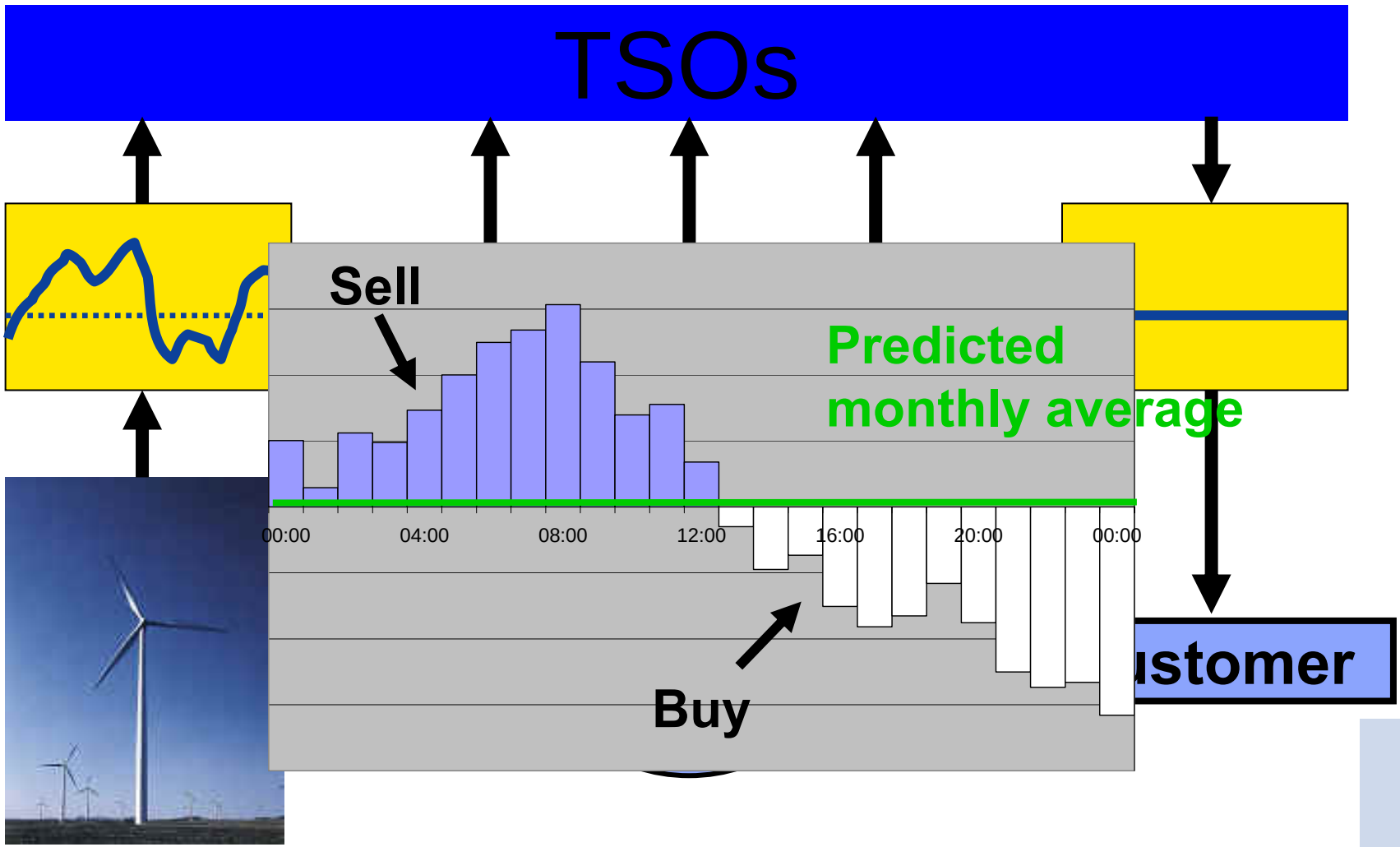
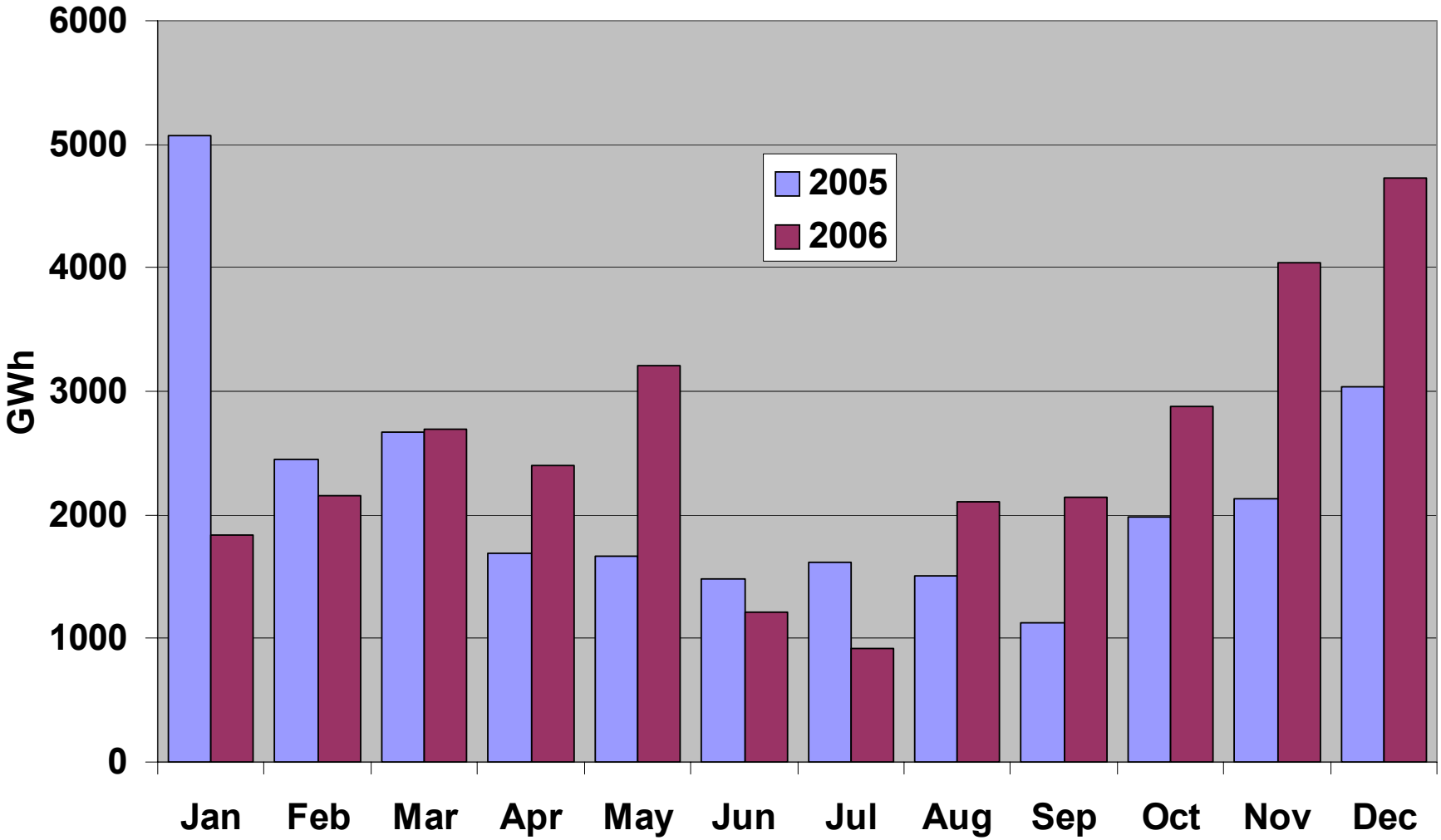
The role of the TSOs in Germany

Balancing



Monthly production

2005 & 2006



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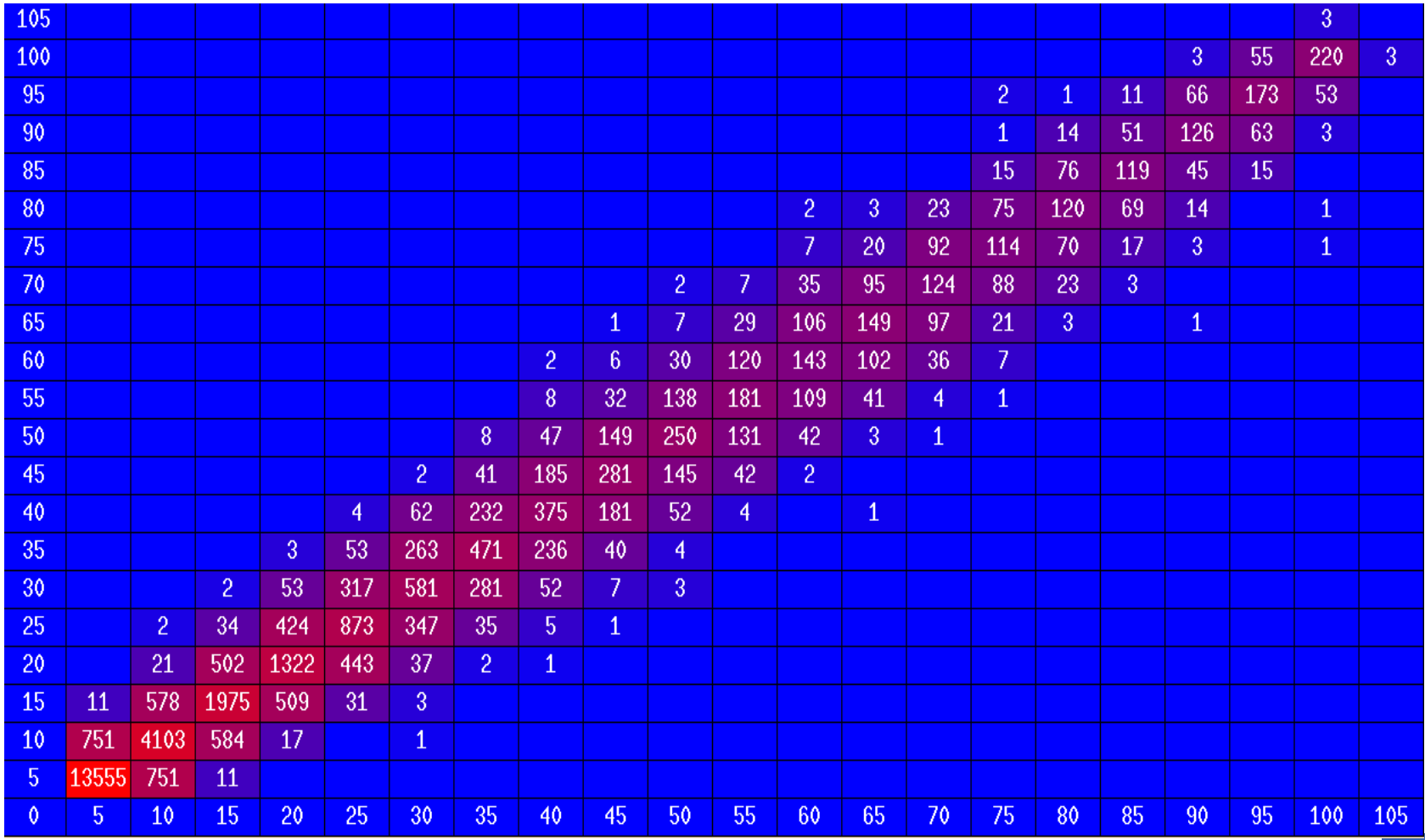
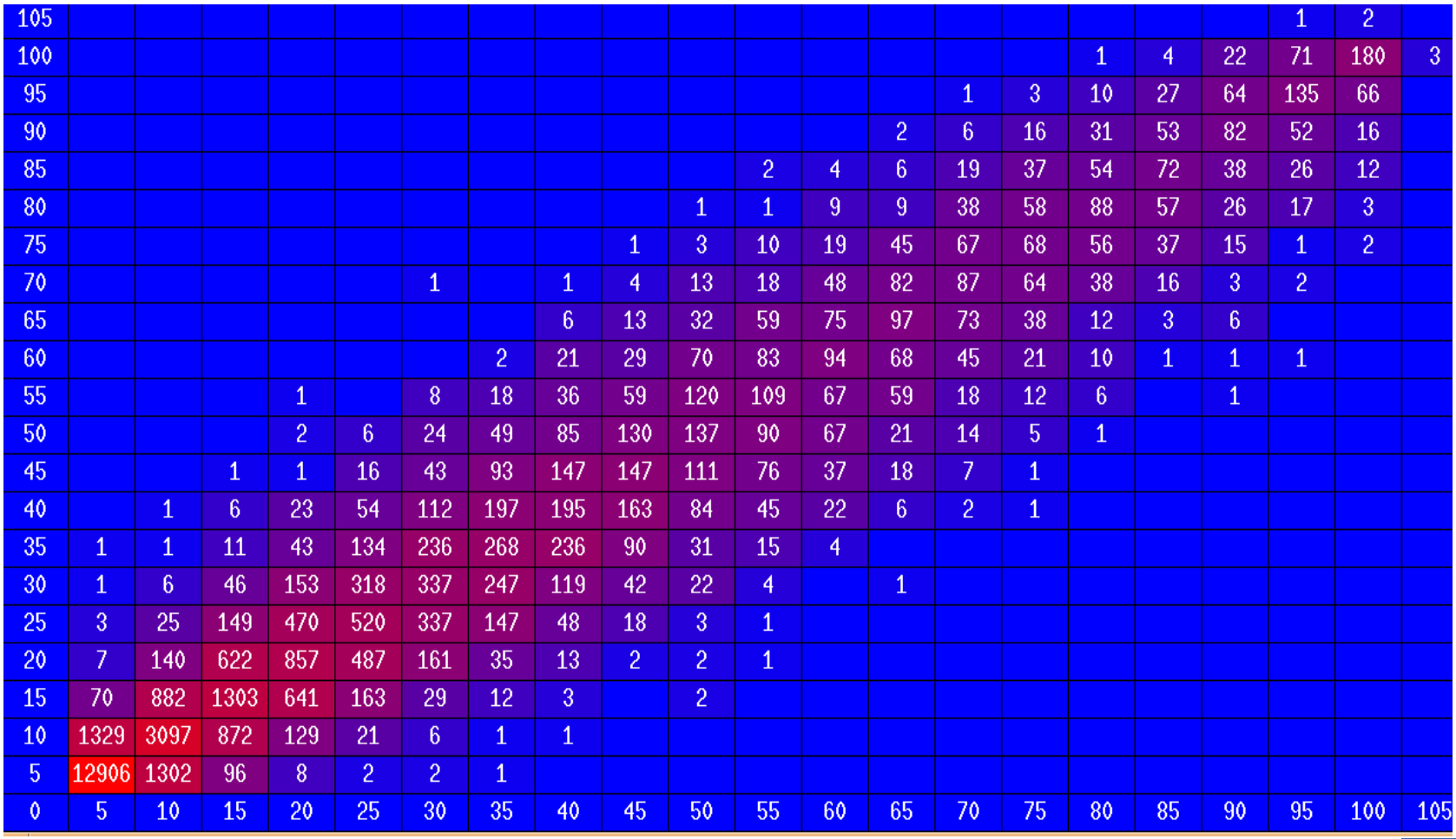
Change in Wind Power within 15 Minutes
RWE control area
(one year)



Source: ISET

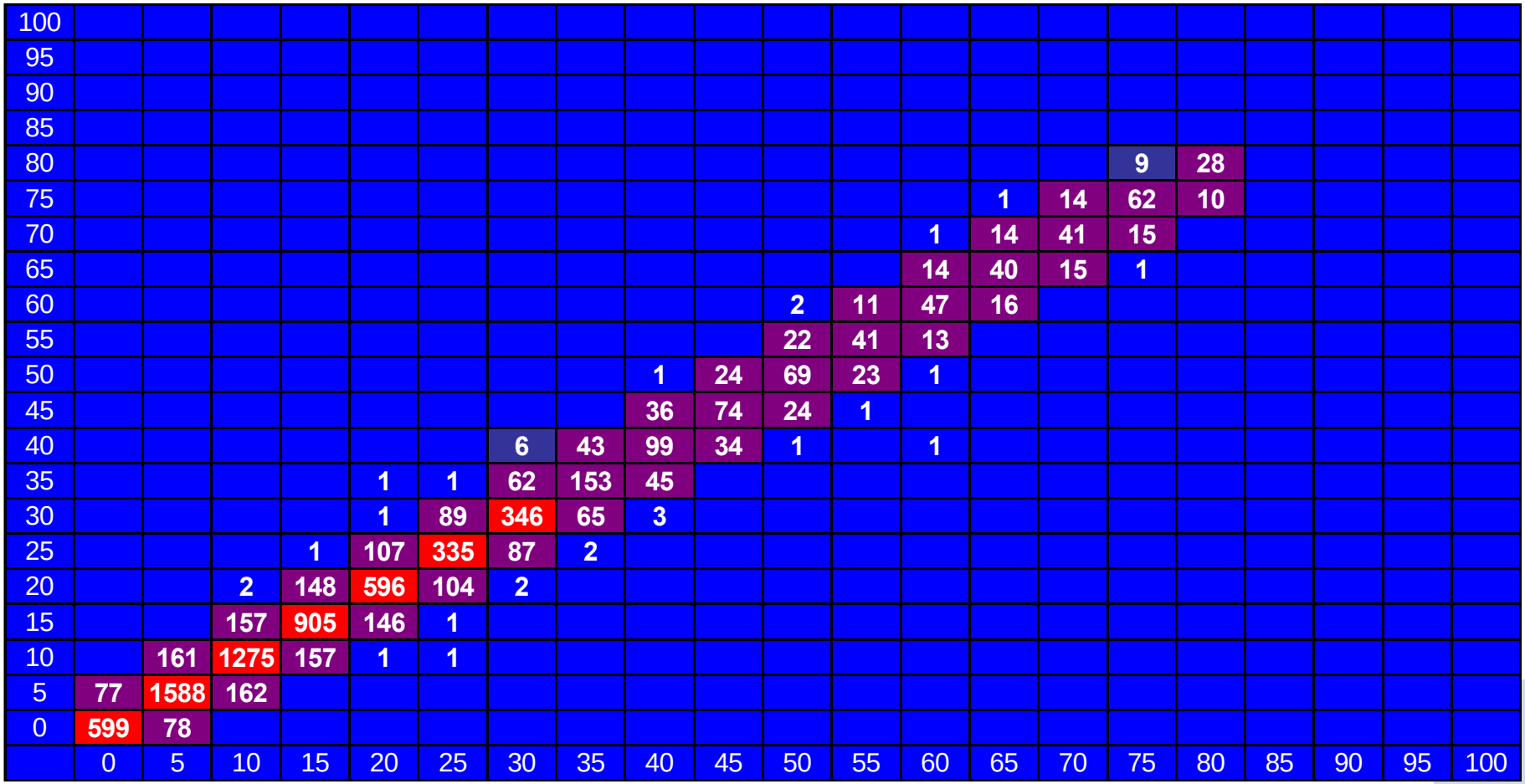
Change in Wind Power within one hour
RWE control area
(one year based on 15 Min data)



105																		1	2	
100															1	4	22	71	180	3
95													1	3	10	27	64	135	66	
90												2	6	16	31	53	82	52	16	
85										2	4	6	19	37	54	72	38	26	12	
80									1	1	9	9	38	58	88	57	26	17	3	
75								1	3	10	19	45	67	68	56	37	15	1	2	
70						1		1	4	13	18	48	82	87	64	38	16	3	2	
65								6	13	32	59	75	97	73	38	12	3	6		
60							2	21	29	70	83	94	68	45	21	10	1	1	1	
55				1		8	18	36	59	120	109	67	59	18	12	6		1		
50				2	6	24	49	85	130	137	90	67	21	14	5	1				
45			1	1	16	43	93	147	147	111	76	37	18	7	1					
40		1	6	23	54	112	197	195	163	84	45	22	6	2	1					
35	1	1	11	43	134	236	268	236	90	31	15	4								
30	1	6	46	153	318	337	247	119	42	22	4		1							
25	3	25	149	470	520	337	147	48	18	3	1									
20	7	140	622	857	487	161	35	13	2	2	1									
15	70	882	1303	641	163	29	12	3		2										
10	1329	3097	872	129	21	6	1	1												
5	12906	1302	96	8	2	2	1													
0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105

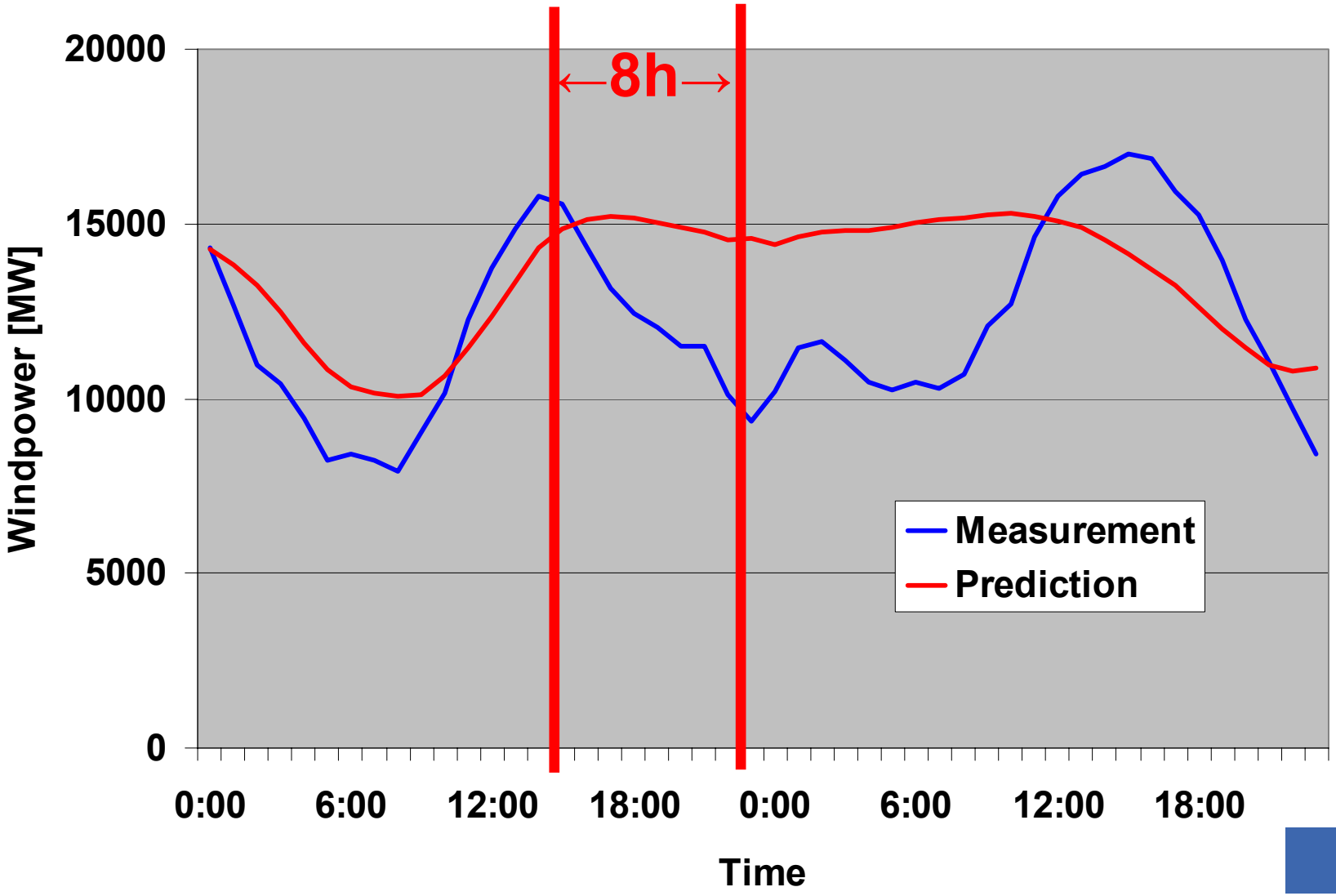
Source : ISET

Change in Wind Power within one hour Germany
(one year)



Source : ISET

Wind power during a storm front



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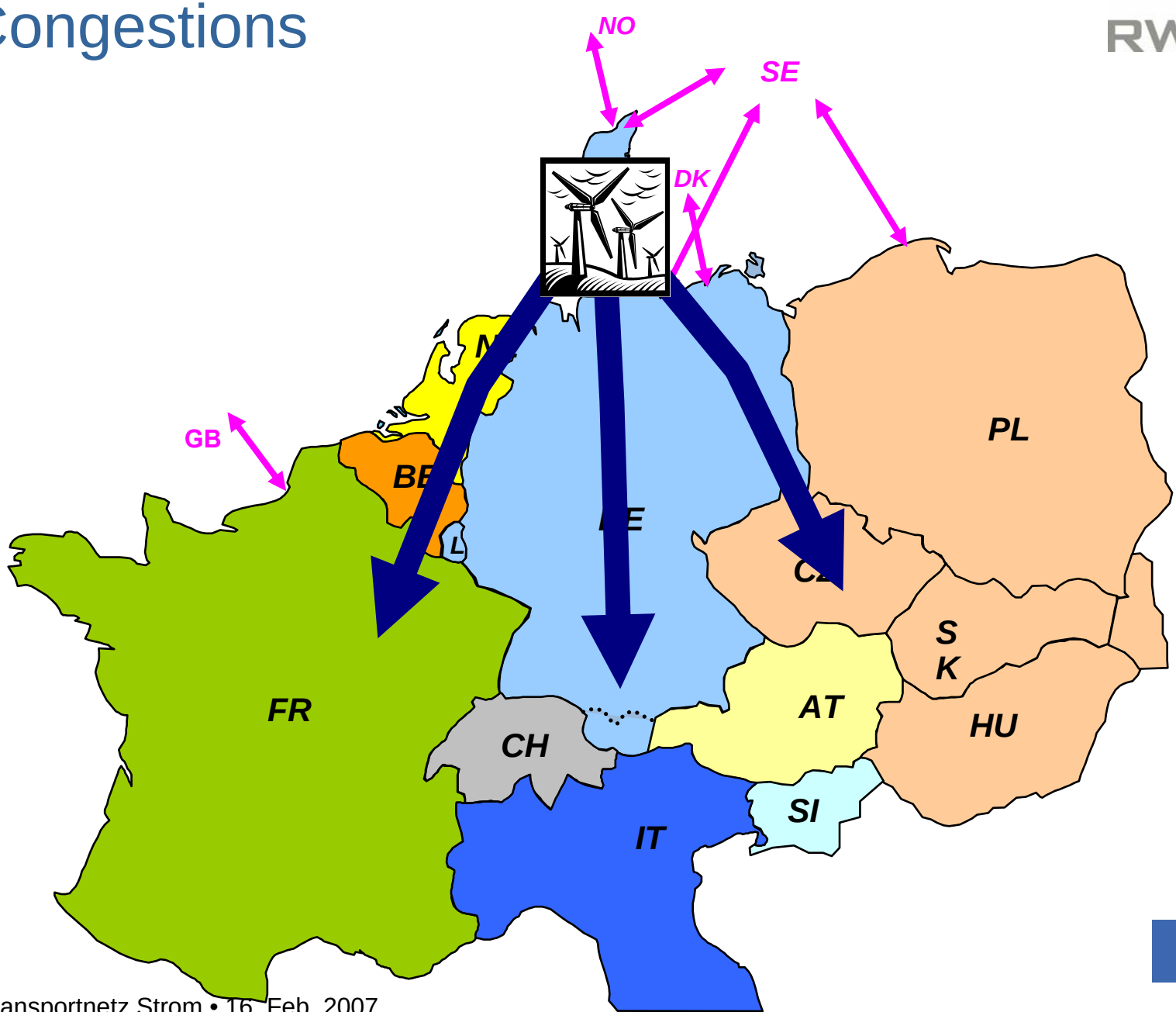
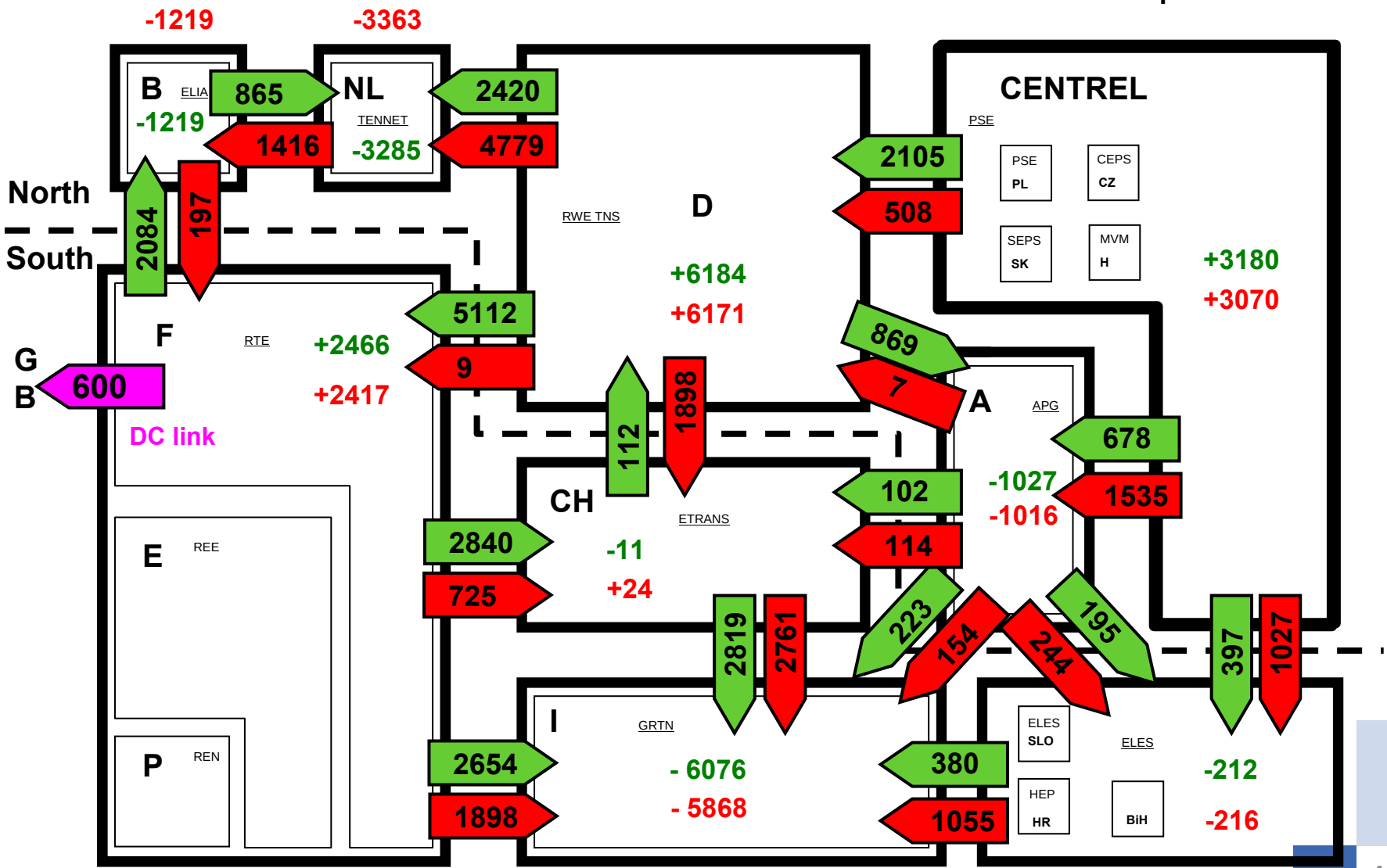
Congestions



Situation on 22.12.2004 at 17h30

scheduled power exchanges* vs. physical power flows*

+ Export
- Import



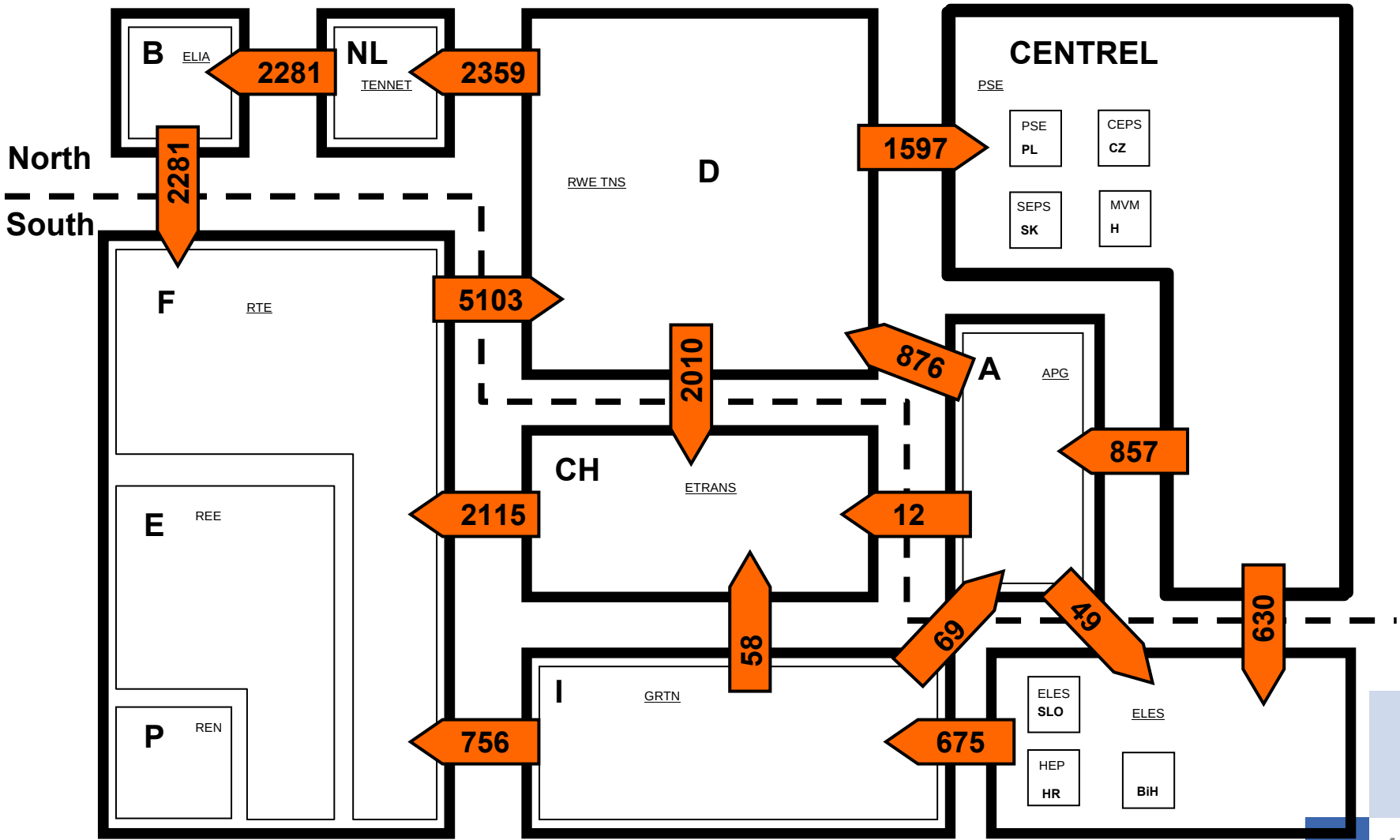
* realised values taken from VULCANUS

* simulation with adapted DACF data sets

Situation on 22.12.2004 at 17h30

resulting loop flows = physical flows - scheduled flows

+ Export
- Import



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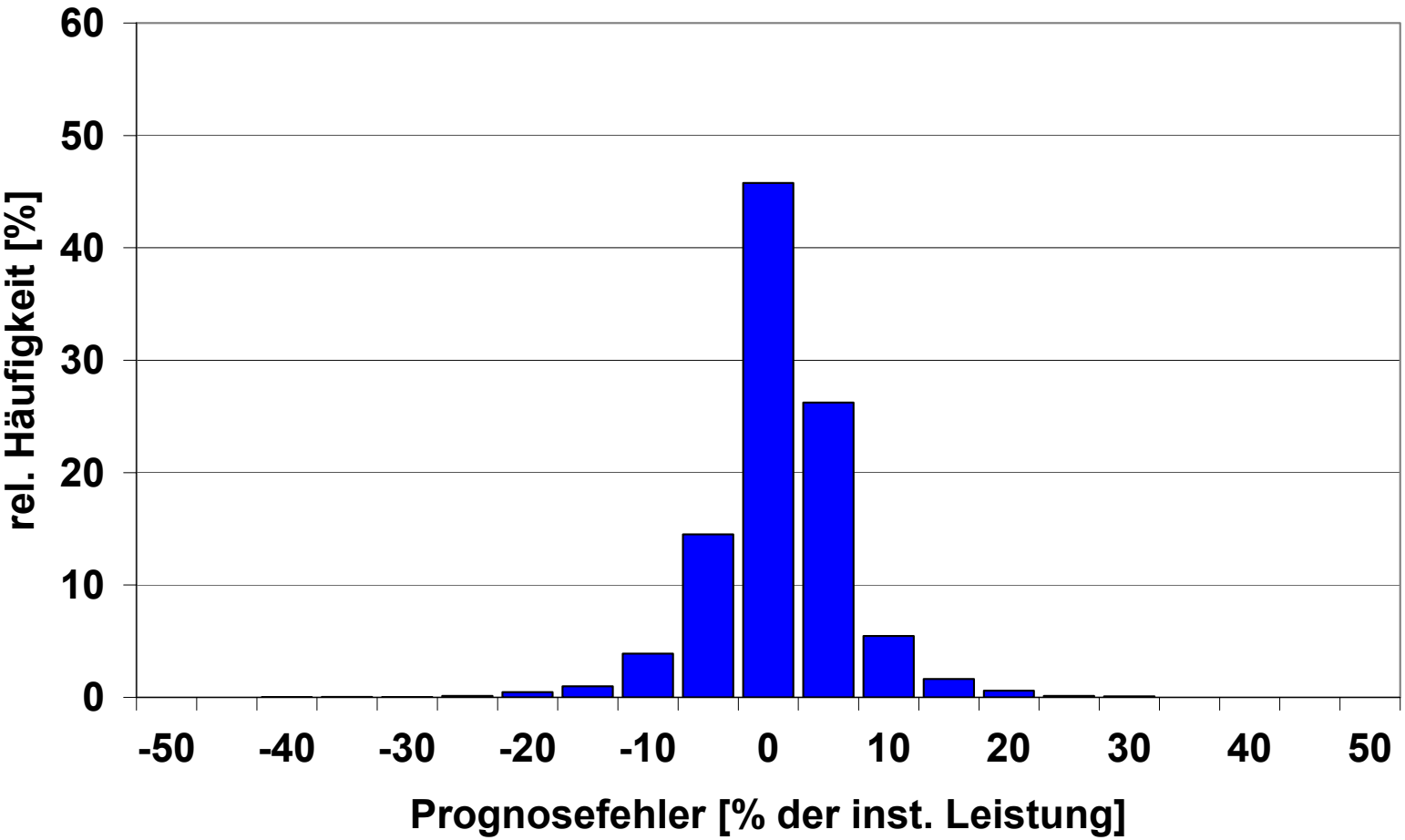
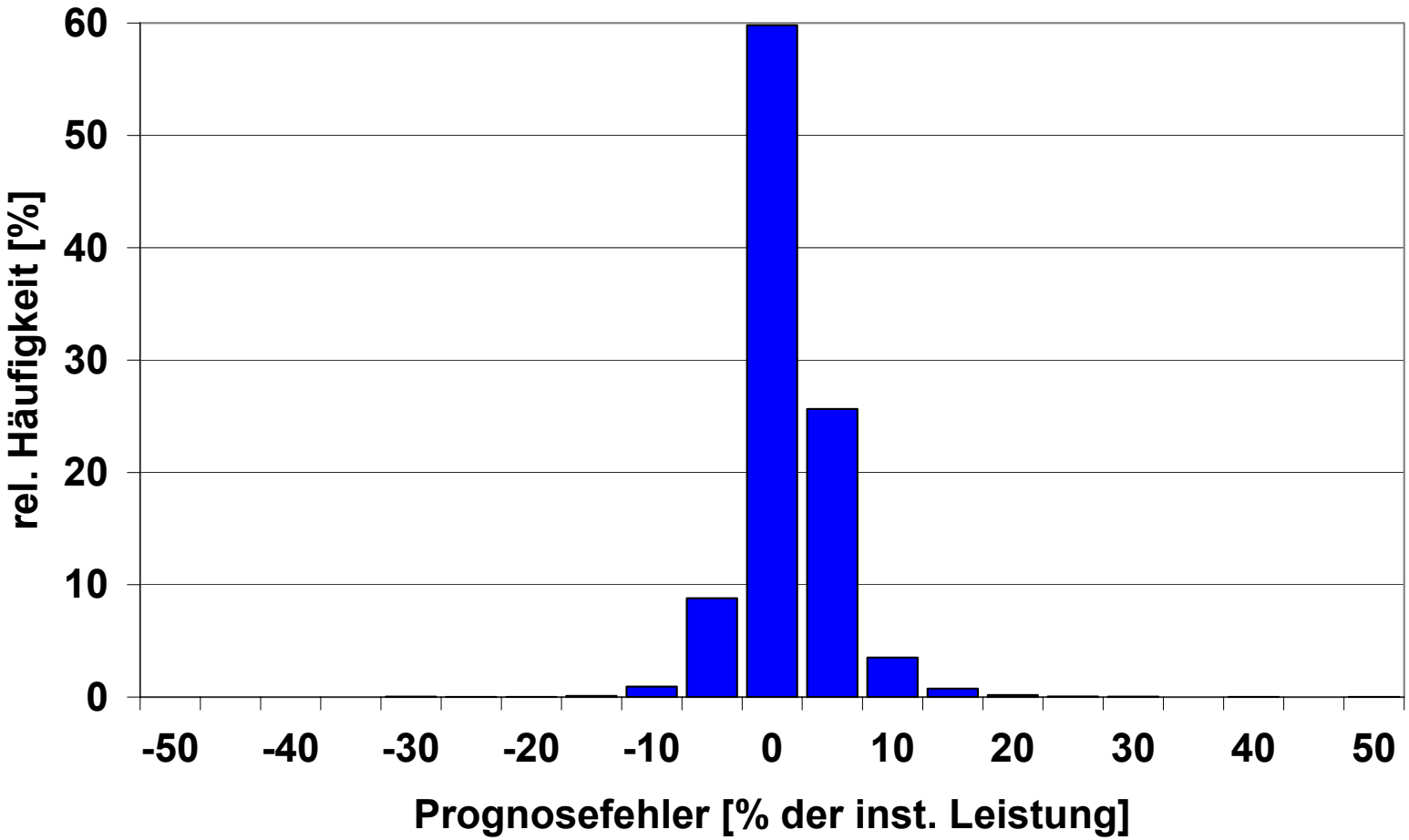
Day Ahead Forecast



Distribution of Errors of the Day Ahead Forecast (17 – 41 hours) for the German grid area
RMSE: 5.7 % of inst. Capacity; Correlation: 0.96

Source: ISET

Short Term Forecast (4h)



Distribution of Errors of the Short Term Forecast (4 hours) for the German grid area
RMSE: 3.3 % of inst. Capacity; Korrelation: 0.98

Source : ISET

Forecast Error

Comparison of day ahead and 4-hour forecast

Model	Error (RMSE)	Maximum Error	Correlation
Day ahead	5.8 %	-30 % 40 %	0.950
4h ahead	3.8 %	-28 % 36 %	0.977

- Further research for short term prediction is necessarily
- New project with ISET just started

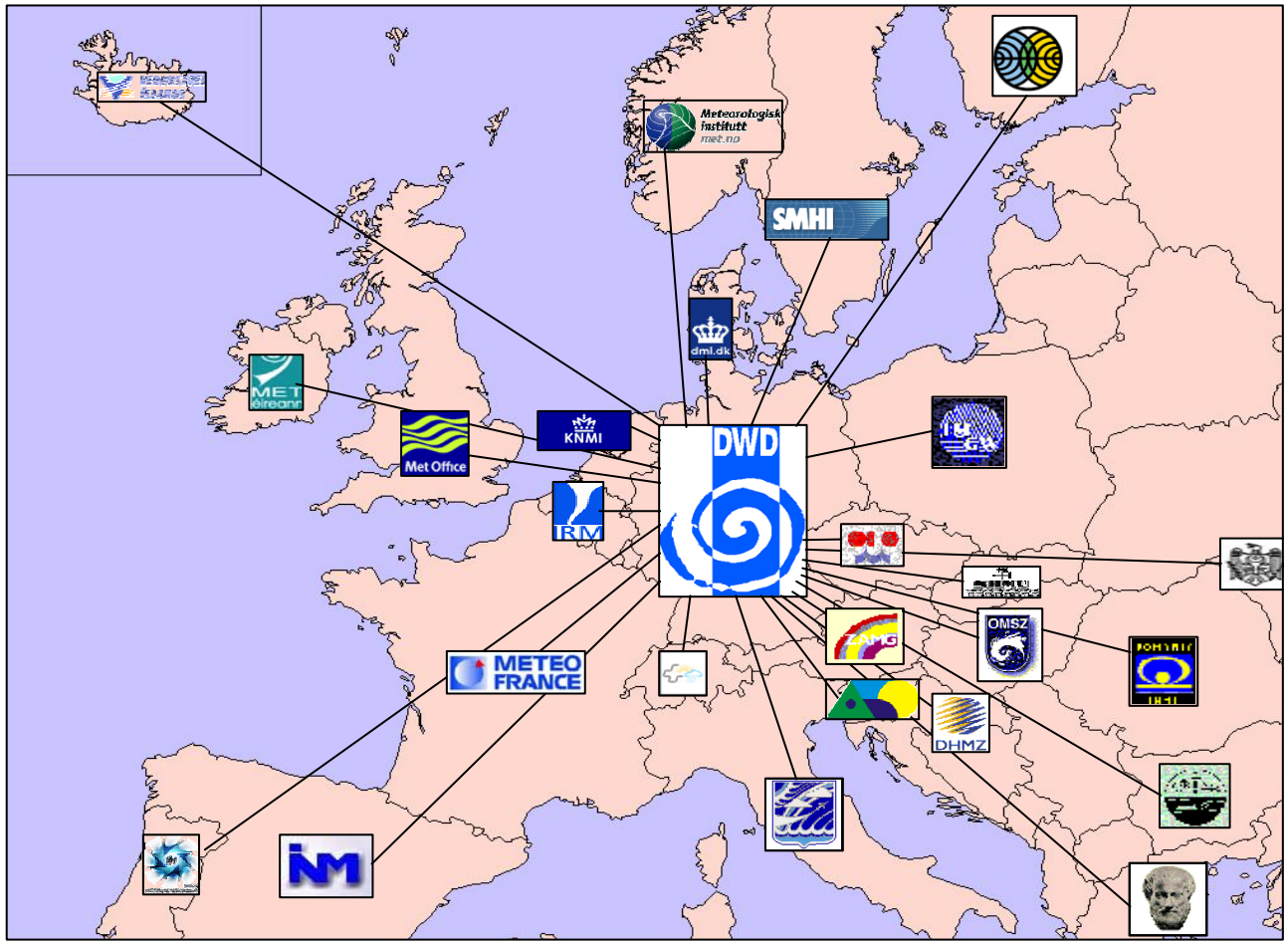
  Funded by the German Federal Environment Ministry

Day ahead prediction

Combining different weather models

- **Wind power prediction systems commonly use only one single numerical weather prediction model (NWP).**
- **But: The NWP models have strengths and weaknesses in different situations.**
  - e.g.: convection is over-estimated by one model, which leads to increase in the predicted wind speed.
- **Our approach: Combine different deterministic NWP to minimise the error of wind power forecasts with a focus on finding an optimal combination of weather models with regard to different weather situations.**

Combining Europe‘s best NWP for a better forecast



Project

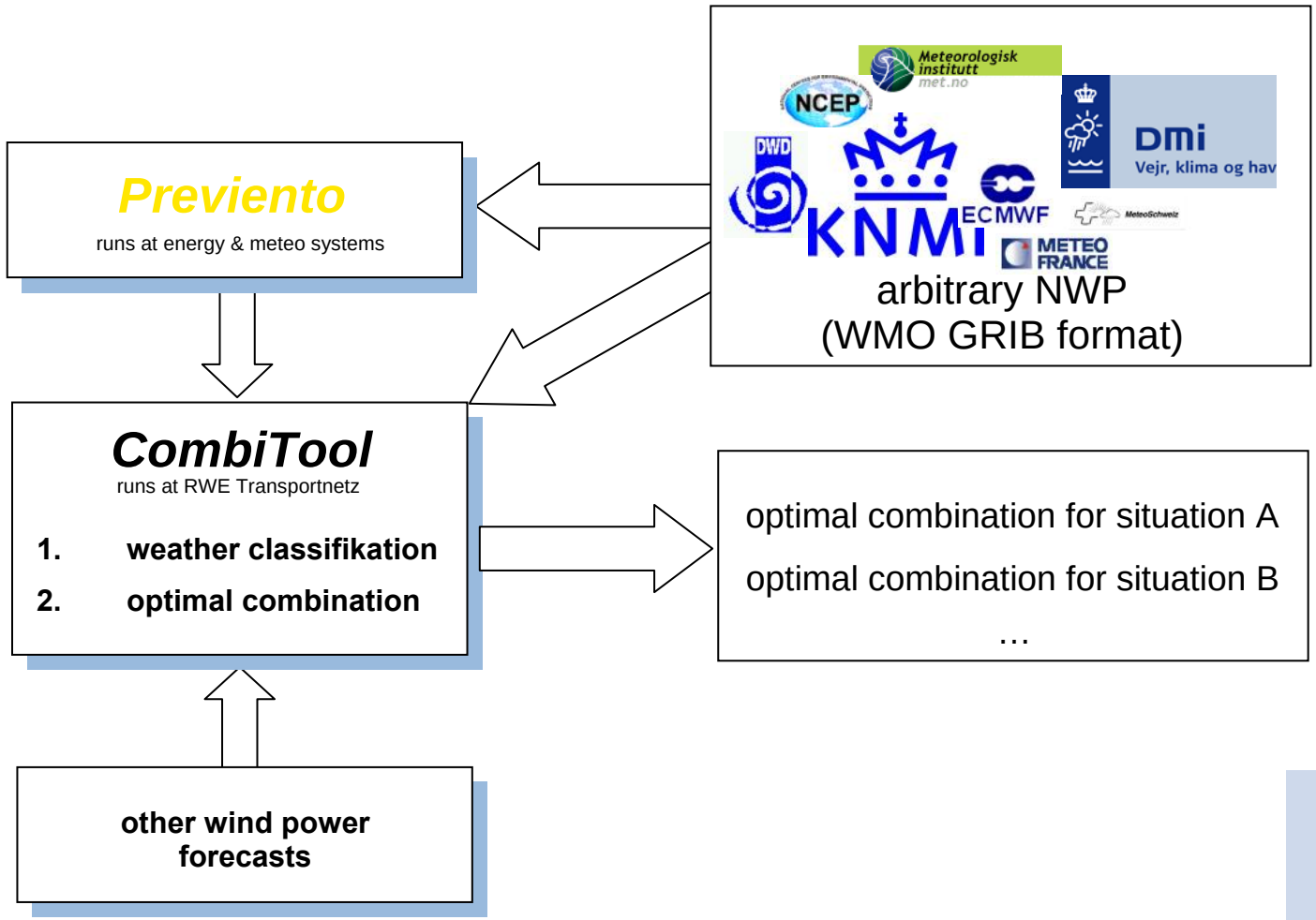
- **Coordinator/ Developer of „CombiTool“**
  - **energy & meteo systems GmbH**

- **Operational use:**
  - **RWE Transportnetz Strom GmbH**

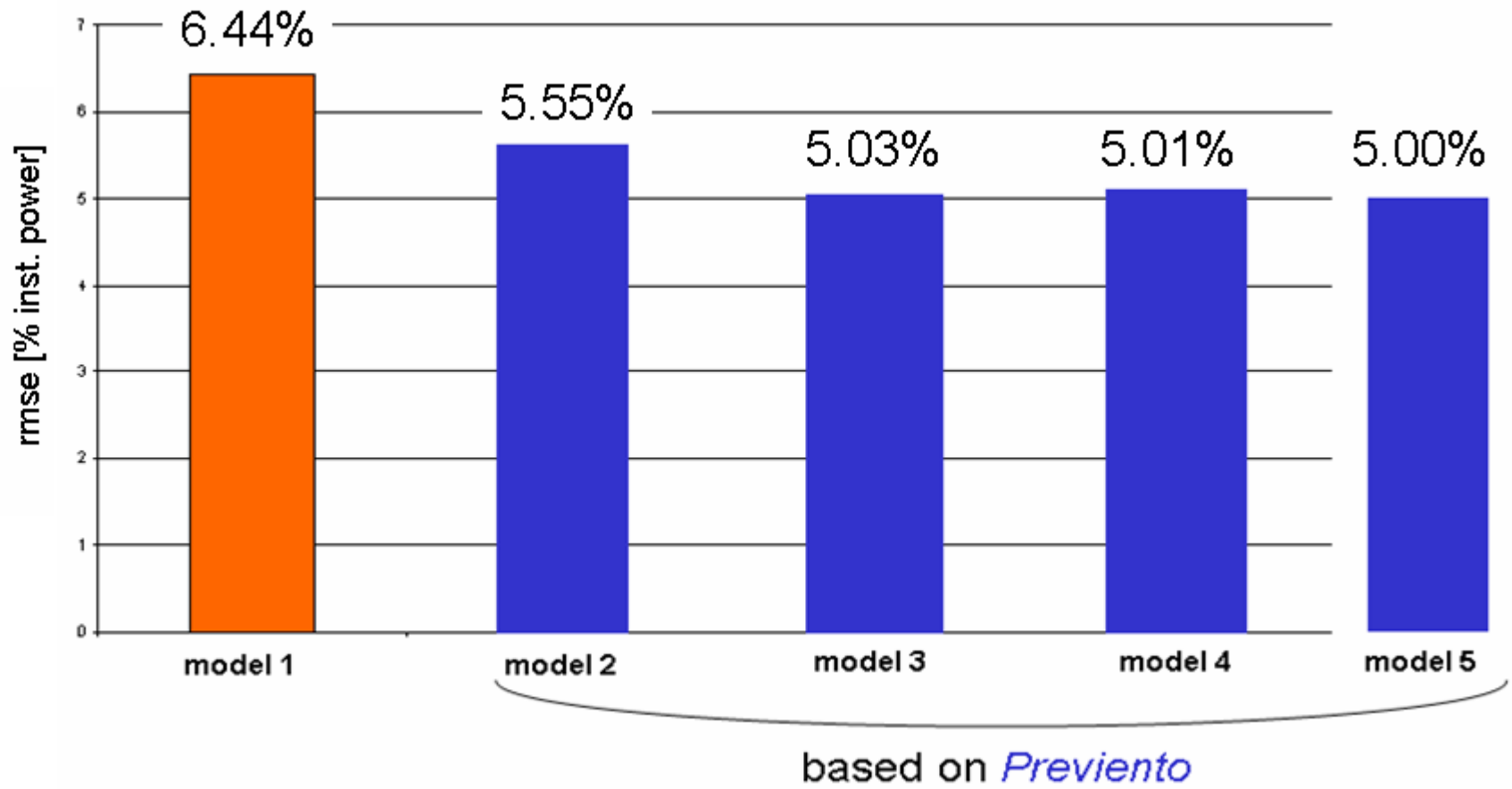
- **Project partner:**
  - **Deutscher Wetterdienst (DWD)**

The project is partly funded by the German Federal Environment Ministry.

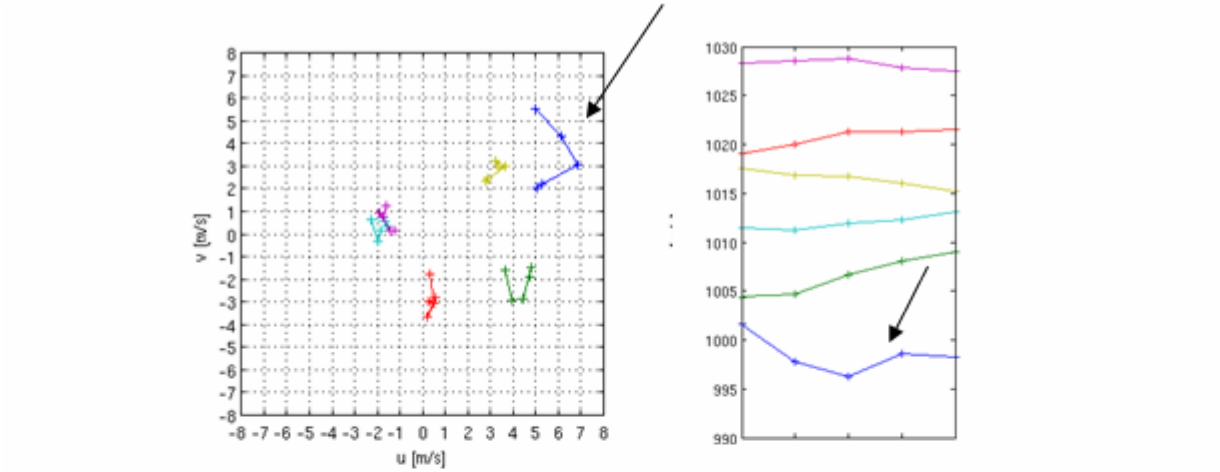
What the CombiTool does

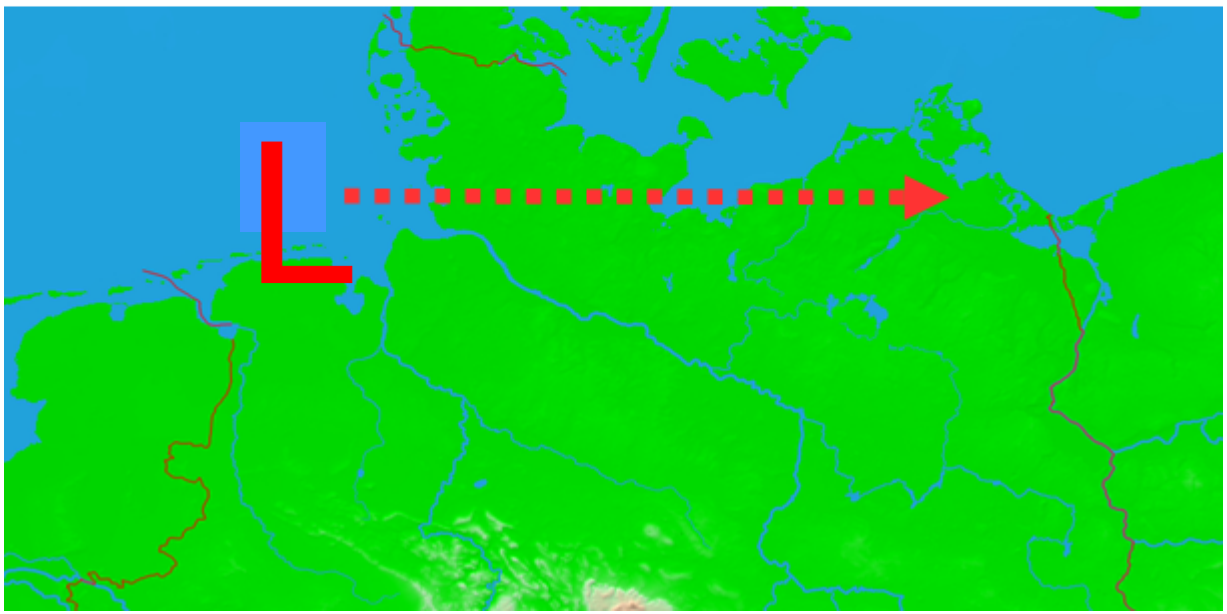


Root mean square error (rmse) dayahead-forecast January-October (all control Areas)

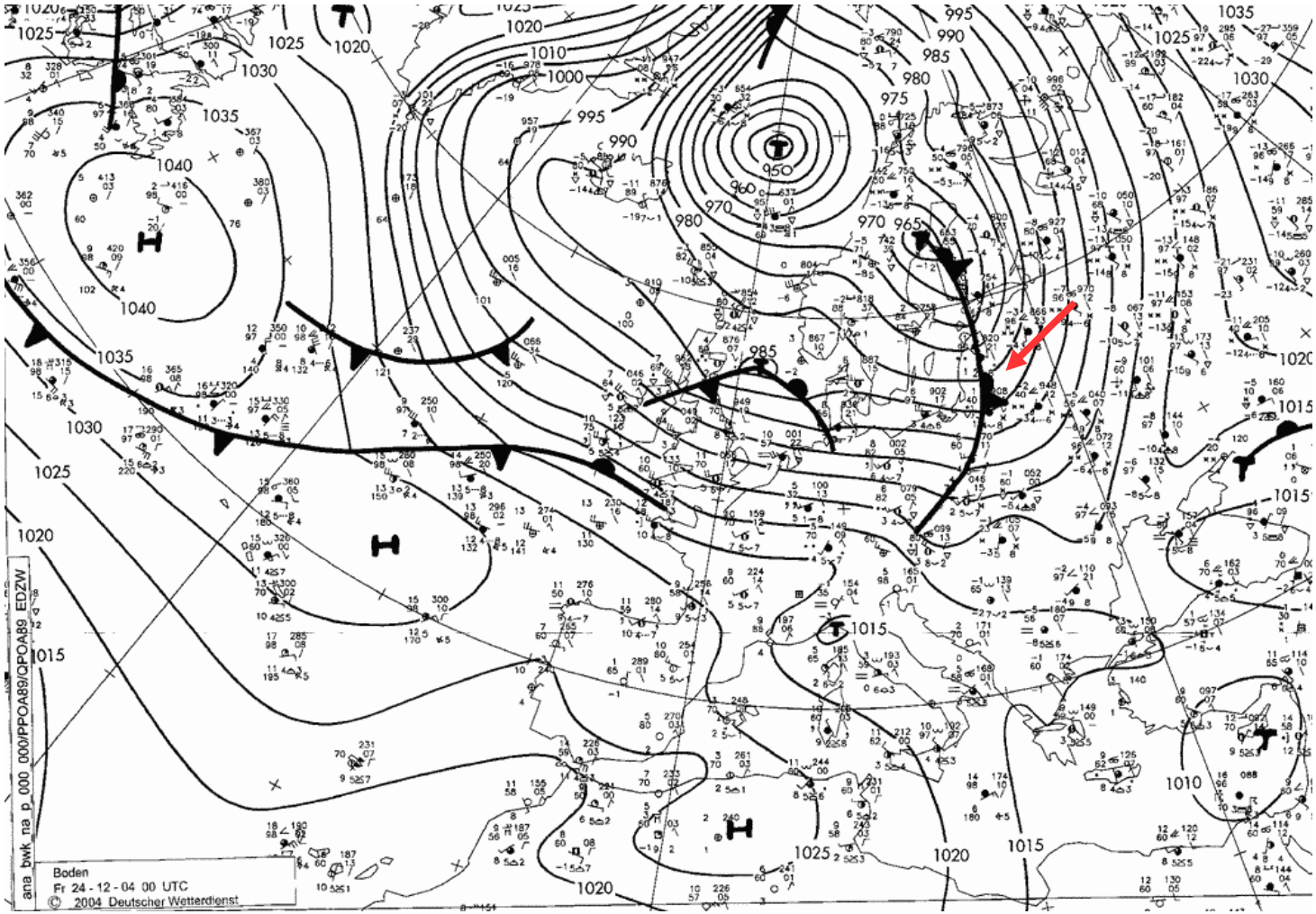


Example: Weather cluster „Cyclone passing – type A“

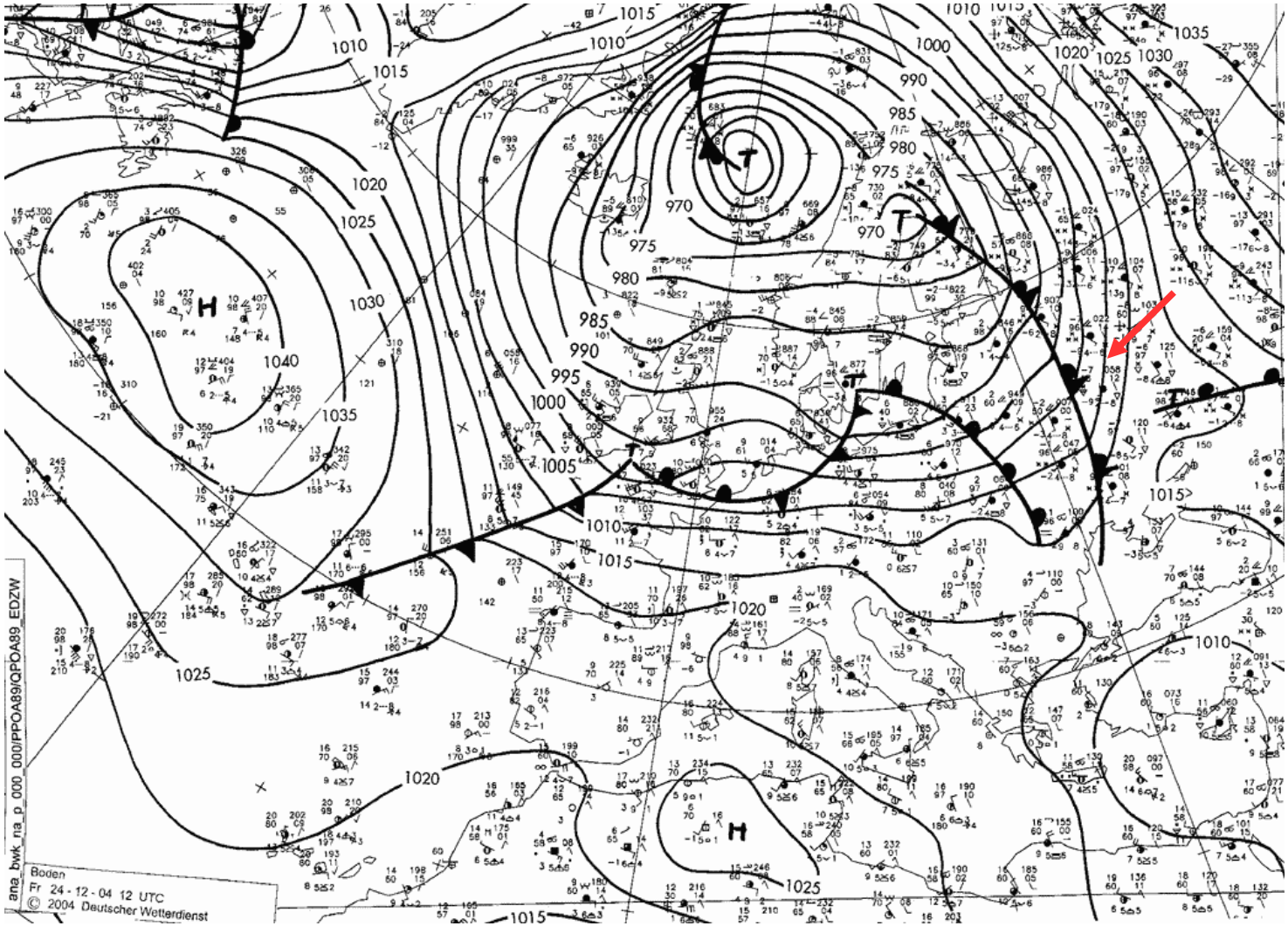




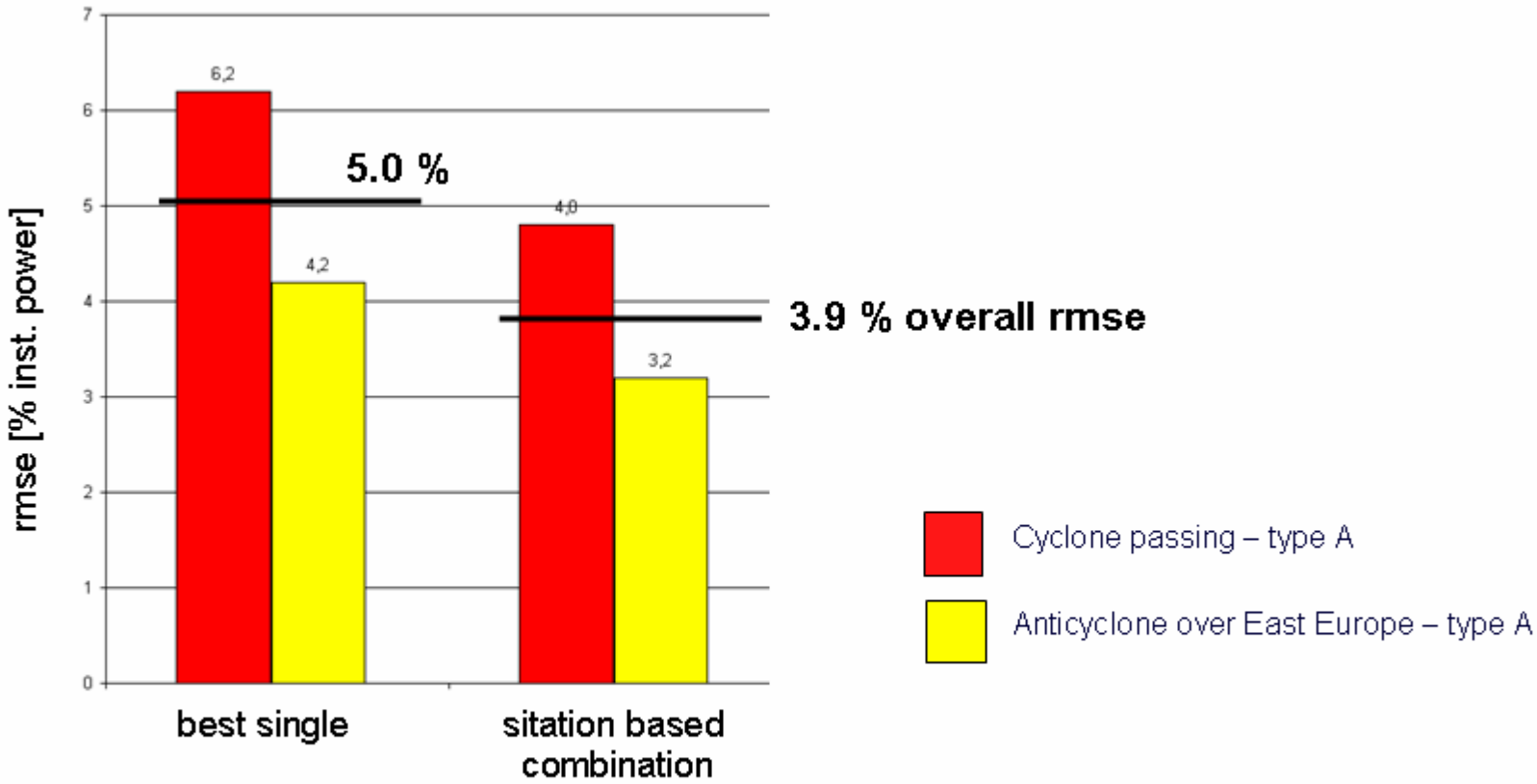
Weather cluster „Cyclone passing – type A“



Weather cluster „Cyclone passing – type A“



Accuracy in individual weather situations



- using optimal weights for each weather situation leads to considerable improvement

Summary of R&D Needs and Activities

- Improvement of short term predictions (1-8 hours).
- An automatic classification scheme, based on methods from synoptic climatology generates useful weather classes.
- Optimal combination of weighted NWP based on weather classification (day ahead prediction).
- Usage of ensemble prediction.
- Calculation of a confidential interval.
- Predicting network losses and congestions based on wind power forecast.

Thank you for your attention!