Determining the economic value of offshore wind power plants in the changing energy system

Christoph Richts, Malte Jansen
Fraunhofer Institute for Wind Energy and Energy System Technology

EERA DeepWind'2015, Trondheim, 05.01.2015

Fraunhofer IWES

Agenda

- ✓ **Motivation**

Content:

- ✓ Benefits of offshore wind power from a system perspective
- ✓ Forecasting Accuracy and Control Reserve Provision

Fraunhofer IWES

Fraunhofer Institute for wind energy and energy system technology in Kassel and Bremerhaven

Division Energy Economics and Grid Operatio

Research Groups:

Energy Economics and System Analysis
Virtual Energy Supply Systems
Forecasting

Fraunhofer
IWES

Division activity

- Simulation of energy systems
- Modeling Renewable Energies and Conventional Unit Commitment
- Research in Reserve Control Provision from Renewable Energies
- Energy Economics

Research for a …

2050

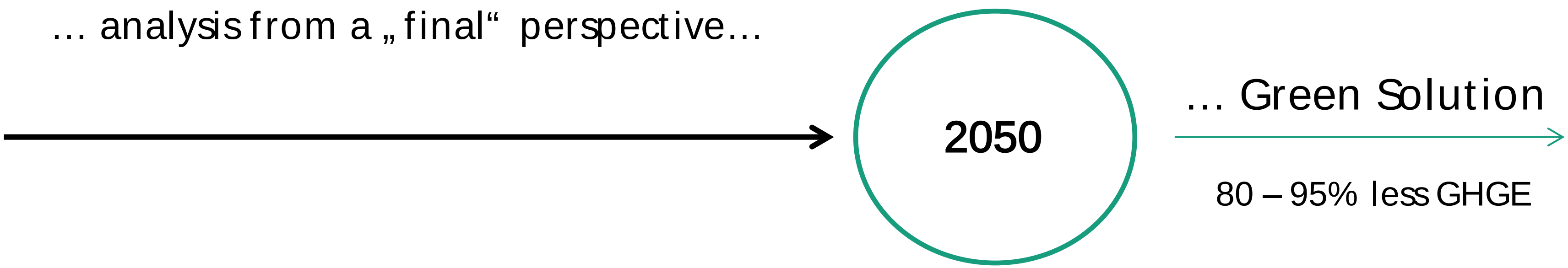
… Green Solution

80 – 95% less GHGE

Fraunhofer IWES

Approach

- Setting up an almost (80%) emission-free energy balance for 2050 (electricity, heat, mobility)
- Deriving new technologies and demand for Renewable Energies (RE)
- Defining paradigm changes: Sector coupling, efficient technologies, fast RE capacity addition
- … analysis from a „final“ perspective…



Agenda

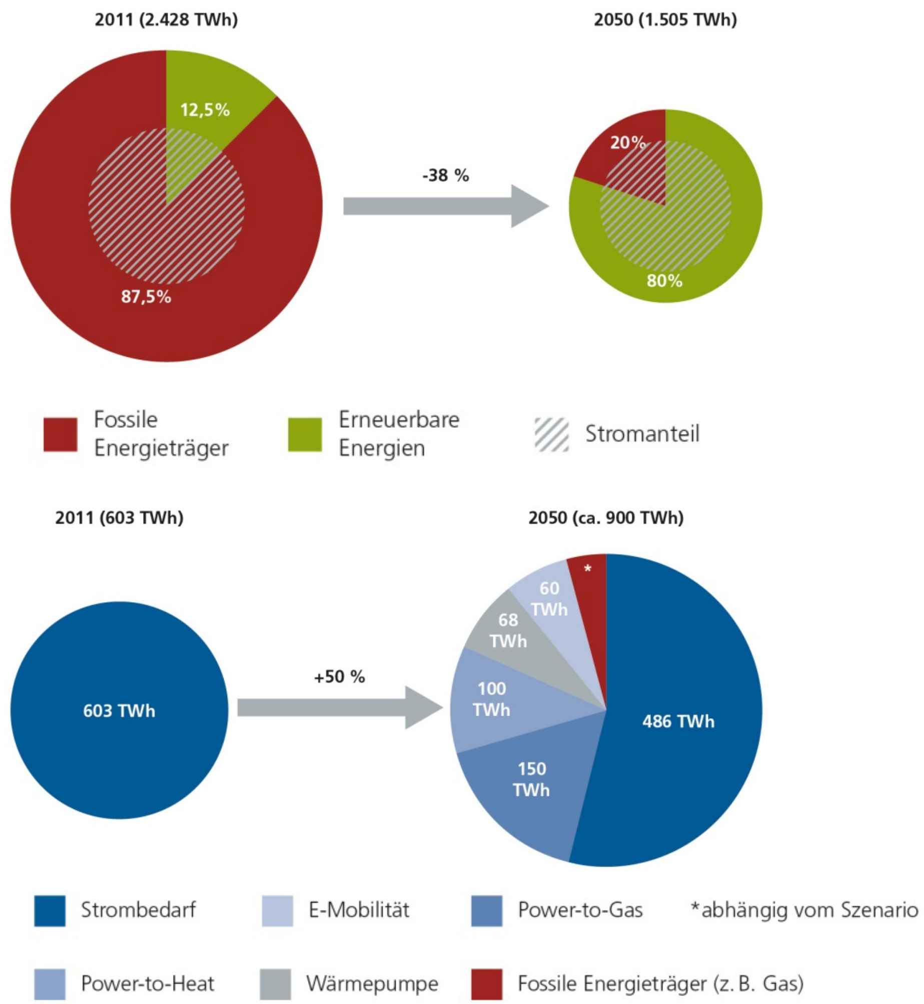
- ✓ Motivation

Content:

- ✓ **Benefits of offshore wind power from a system perspective**
- ✓ Forecasting Accuracy and Control Reserve Provision

Fraunhofer IWES

How do we get to an emission-free energy balance?



Energy Efficiency

- Primary energy (all sectors): - 38%
- Electricity (conventional): - 25%

Electrification & Sector coupling

- Heat pumps, e-mobility, Power-to-Heat (PtH), Power-to-Gas (PtG)

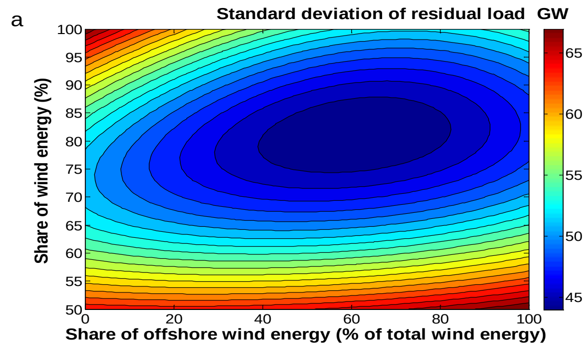
Electricity demand

- 900 TWh of which 800 TWh are from RE

Fraunhofer IWES

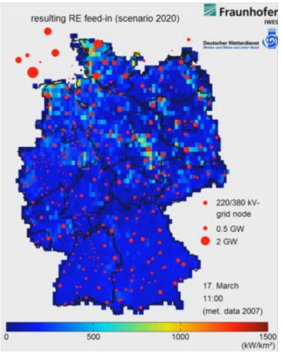
Finding an optimal mix of RE for 2050
Approach

Hypothesis:
Minimizing standard deviation (SD) of residual load is optimal from a system perspective

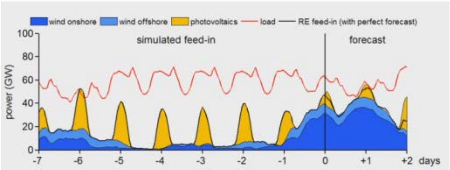


Physical RE simulation (high spatial & hourly resolution)
(800 TWh = 50% On, 30% Off, 20% PV)

Analysis of SD

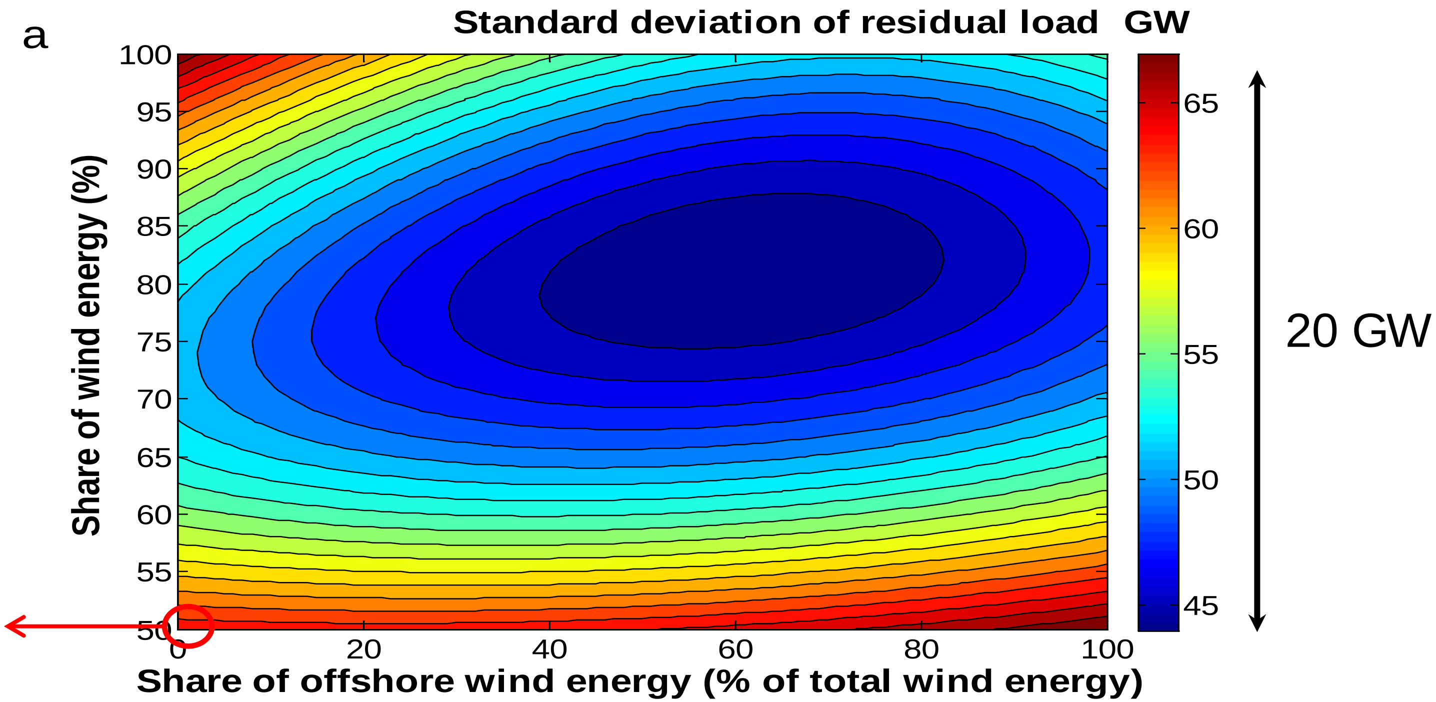


Scaling of RE-timeseries for all possibles RE-mixes



Fraunhofer IWES

Results in detail



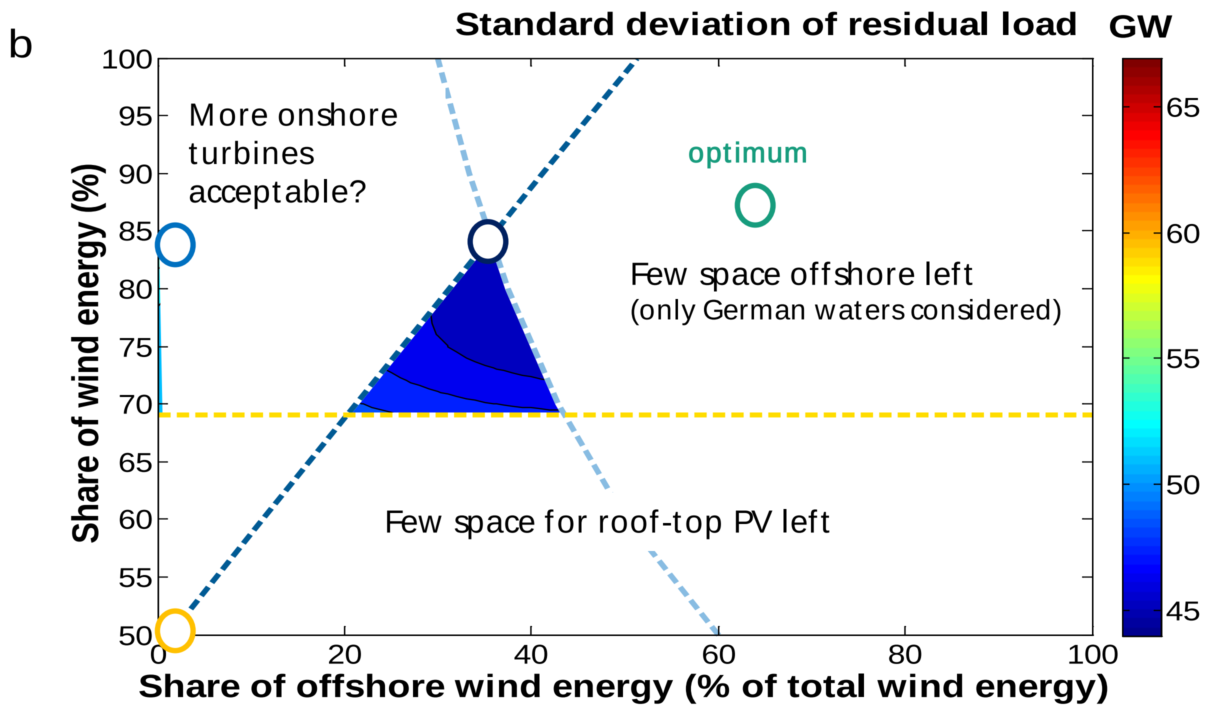
On: 50% (400 TWh)
PV: 50% (400 TWh)
Off: 0%

Fraunhofer
IWES

Taking into account potential estimations

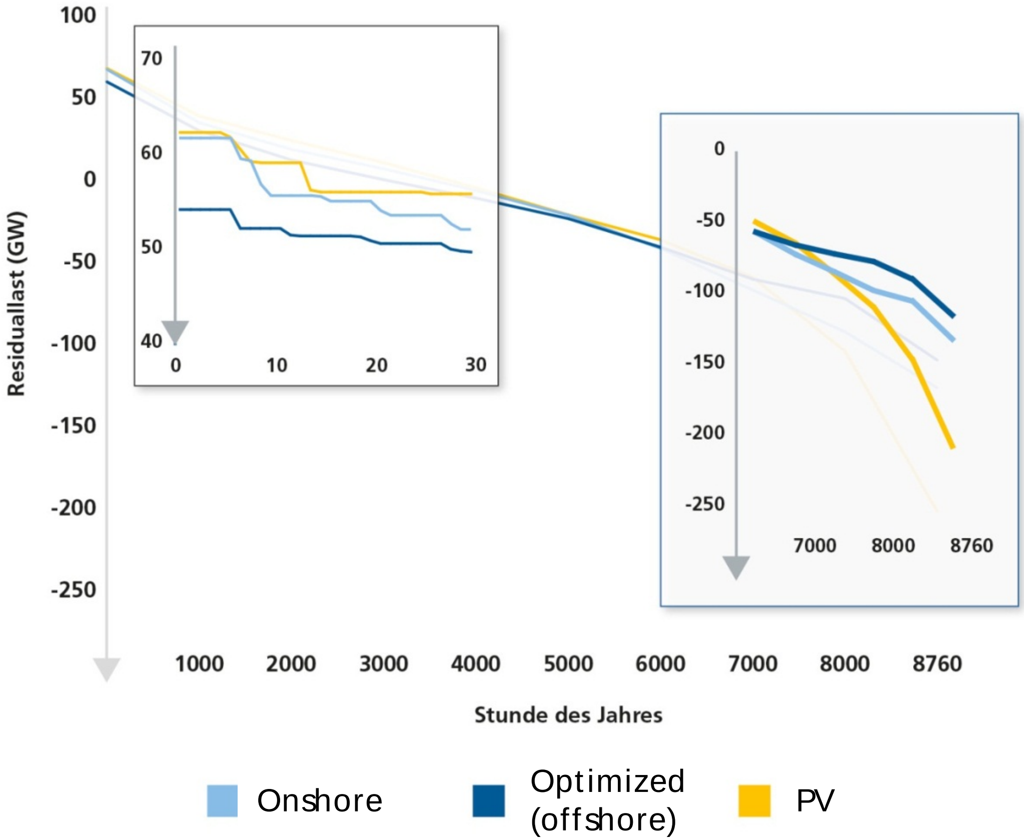
Three scenarios selected for analysis

- „Optimized“ (offshore)
- onshore
- PV



Fraunhofer IWES

Offshore wind enegy impact on residual load



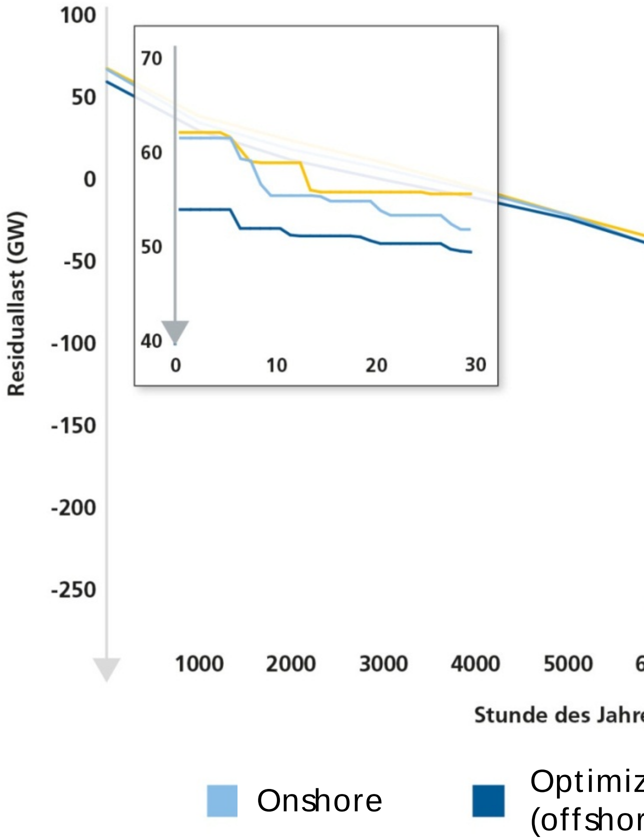
Optimized scenario

(> 50 GW offshore wind)

1. Reduces peak load (back-up-capacity needed)
2. Reduces total positive residual load
3. Reduces average power/energy ratio of excess power (storage capacity needed)
4. Reduces non-usable excess power

Fraunhofer IWES

Cost Estimate I: Back-up and residual power demand

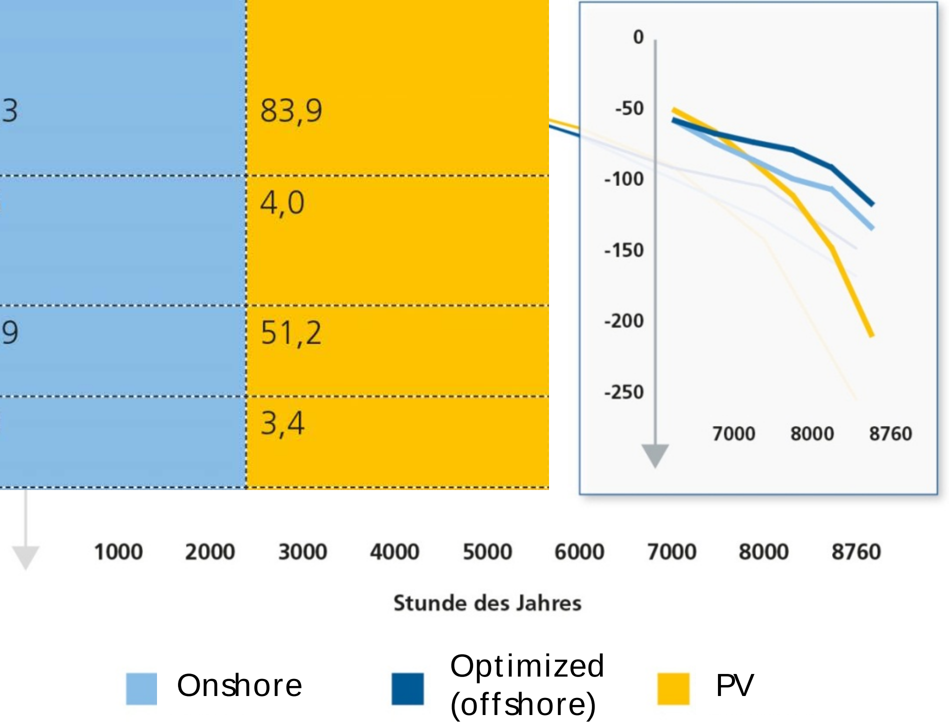


	Optimized growth scenario	Onshore growth scenario	Photovoltaics growth scenario
Back-up capacity (GW)	54,4	62,0	62,6
Investment costs – annuity basis (billions of euros)	1,8	2,0	2,0
Residual power demand (TWh)	53,4	68,9	81,8
Fuel costs for residual power demand (billions of euros)	4,8	6,2	7,4

Fraunhofer
IWES

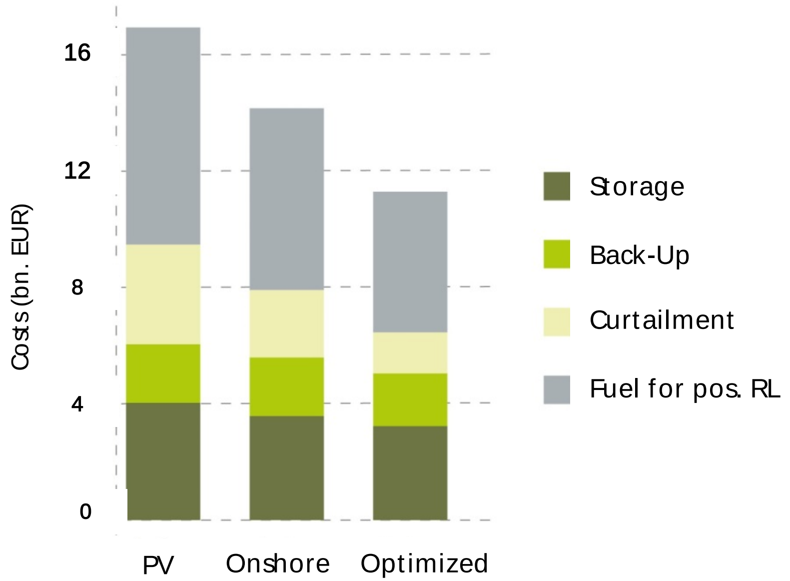
Cost Estimate II: Storage capacity and Excess production

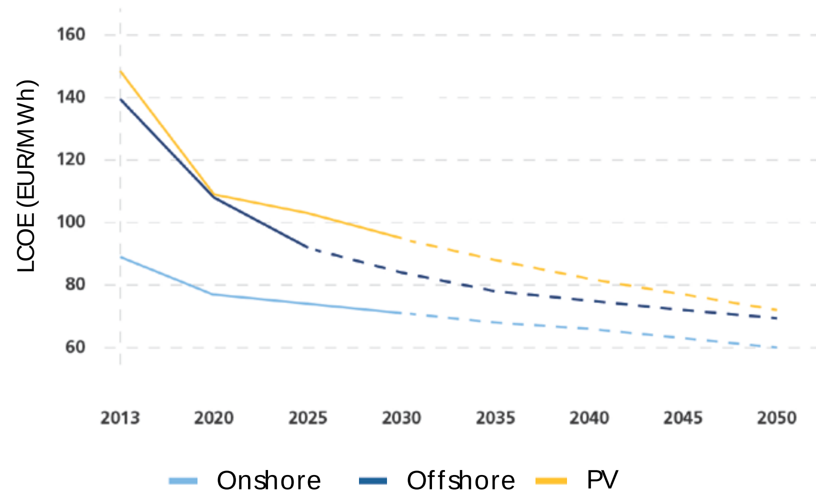
	Optimized growth scenario	Onshore growth scenario	Photovoltaics growth scenario
Storage capacity (GW)	67,9	74,3	83,9
Investment costs – annuity basis (billions of euros)	3,2	3,6	4,0
Excess production (TWh)	20,3	35,9	51,2
Curtailment costs (billions of euros)	1,3	2,3	3,4



Fraunhofer IWES

Flexibility costs are reduced
Overall system costs strongly depend on RE-price development





Cumulative flexibility costs (billions of euros)	11,1	14,0 (+26%)	16,8 (+50%)

+

Cumulative levelised costs of electricity (billions of euros)	52,4	50,4	52,9

=

Total costs for flexibility and power production (billions of euros)	63,5	64,5	69,7

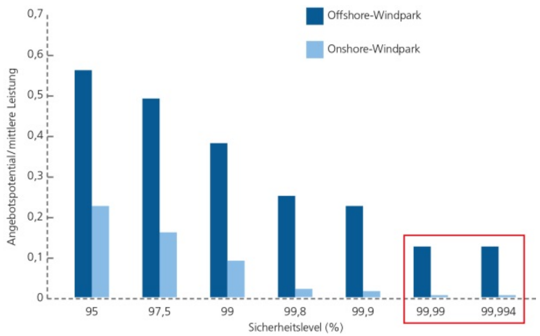
Agenda

- ✓ Motivation

Content:

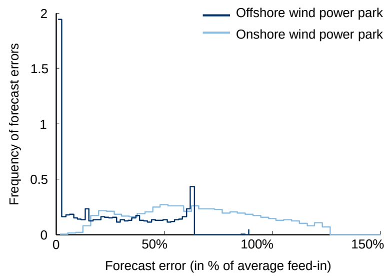
- ✓ Benefits of offshore wind power from a system perspective
- ✓ **Forecasting Accuracy and Control Reserve Provision**

Determination of control reserve power
Approach



Analysis of forecasting accuracy

Comparison of onshore and offshore capabilities



Calculation of potential to offer control reserve by wind power

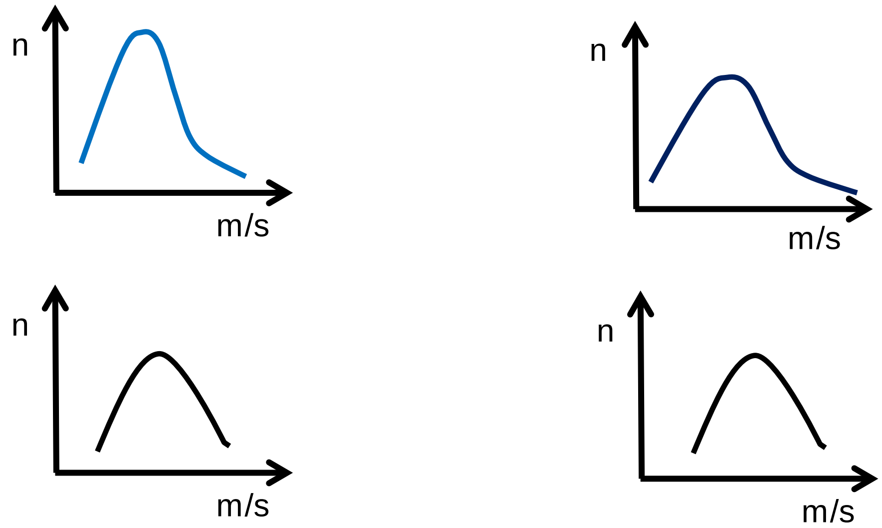
Fraunhofer IWES

Getting the power forecasting error in form of a frequency distribution

Onshore | Offshore

Weibull-Distribution wind speed

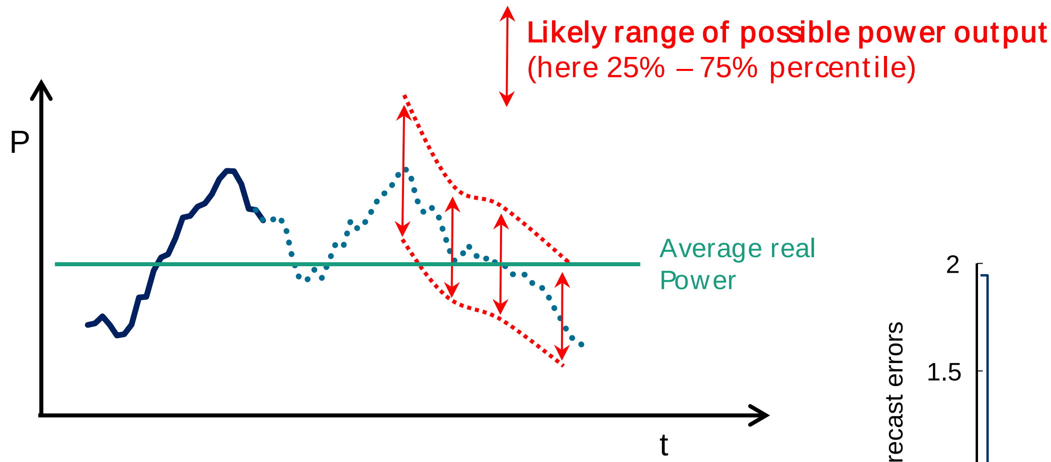
Error of wind forecast

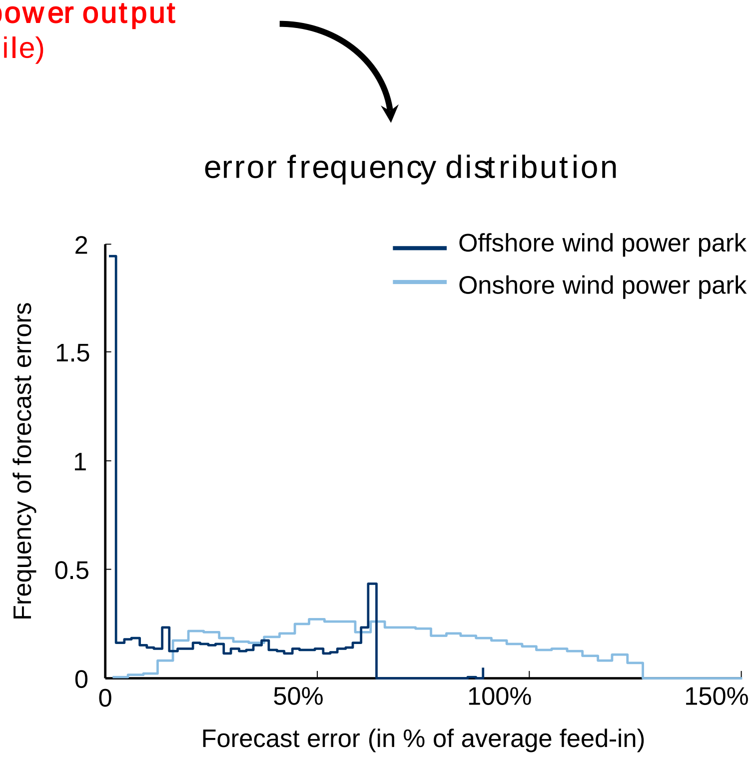


Calculating the real power and forecasted power with a phyiscal wind power model

Fraunhofer IWES

Probabilistic forecast and error frequency distribution



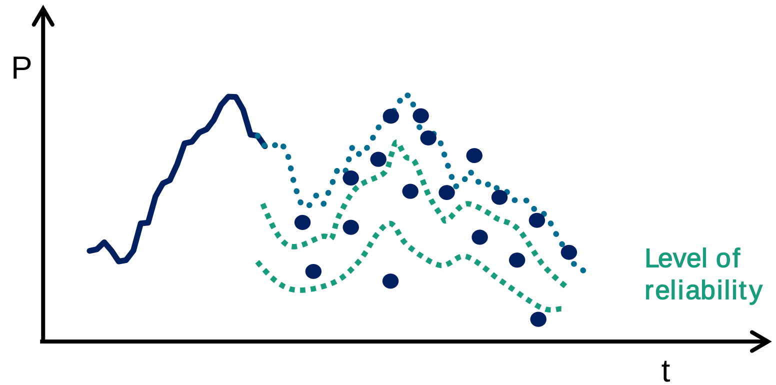


Average forecast error (in% of average feed-in): **Onshore = 60%**

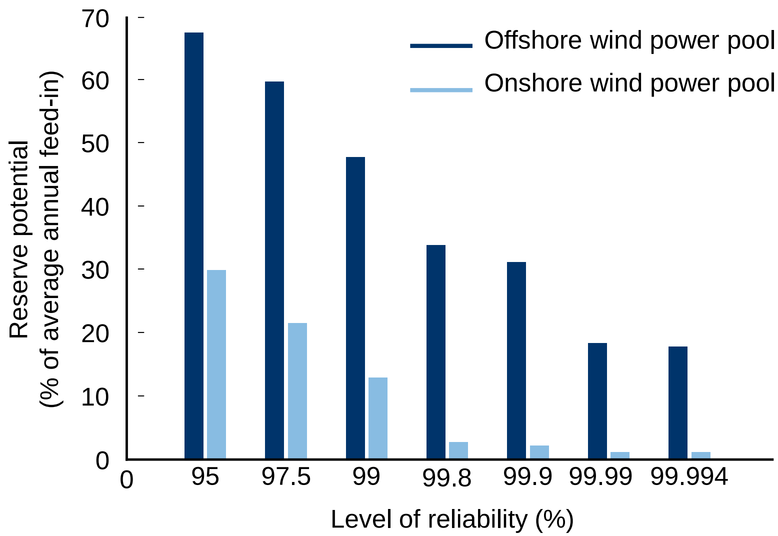
Offshore = 25%

Fraunhofer IWES

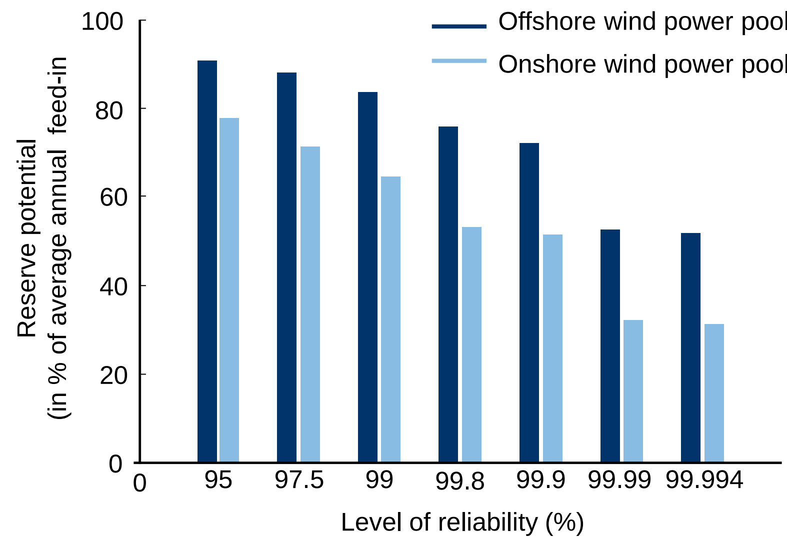
Potential to offer control reserve and reliability



day-ahead



hour-ahead



Conclusion

- offshore wind power **decreases overall systems costs if generation costs become more competetive**, basically …
  - due to better load coverage and thus, lower costs for fuel to cover RL
  - due to less curtailment of renewable energy

- offshore wind power is able to offer **a large share of its production as control reserve** (negative and positive)
  - for reliability as conventional plants offer potential is

	day-ahead	hour-ahead
Offshore:	~18%	~50%
Onshore:	~ 2%	~25%

… of annual power production!

Thank you for your attention!

Fraunhofer Institute for wind energy and energy system technology
in Kassel and Bremerhaven

Advancing wind energy and energy system technology

<u>Contact:</u>

Christoph Richts

Fraunhofer-Institut für Windenergie und
Energiesystemtechnik

+49(0)561 7294-463

christoph.richts@iwes.fraunhofer.de

www.iwes.fraunhofer.de

Fraunhofer IWES