

Grid reinforcement/extension costs caused by large-scale RES-E (wind) integration

Case studies derived from different European countries

Marian Klobasa

Fraunhofer Institute for Systems and Innovation Research (FhG-ISI), Karlsruhe, DE

Carlo Obersteiner, Wolfgang Prügler

Energy Economics Group (EEG)
Vienna University of Technology, AT

The sole responsibility for the content of this ppt-presentation lies with the authors. It does not represent the opinion of the European Communities. The European Commission is not responsible for any use that may be made of the information contained therein.

Overview

1. Factors determinant for RES-E grid integration
2. Overview on European case studies on grid reinforcement/extension measures and costs
3. Case studies: Germany, Netherlands
4. Methodology for calculation of grid reinforcement/extension costs
5. Overview of empirical results derived from the European case studies
6. Implementation of results into the **GreenNet-EU27** model
7. Conclusions and Discussion

Factors determinant for RES-E grid integration

- **Geographical distribution und interconnections**
 - Dispersal of individual generators (conventional and wind)
 - Location of main demand areas
 - Internal grid status and connection to foreign networks
- **Variation and predictability**
 - Variation of generated electricity with time
 - Extent of the variation (availability)
 - Predictability of that variation
- **Technical properties of generators**
 - Controllability of power output
 - Rated power of each generator
 - Reliability of power plant
 - Experience of use by operators

10 European studies on grid reinforcement/extension measures and costs caused by wind integration

Country	Year	Study	Comment
Germany	2005	Integration of wind energy into the energy system up to the year 2020	Finished
Netherlands	2003	Survey of integration of 6000 MW offshore wind power in the Netherlands electricity grid in 2020	Finished
UK	2002	Quantifying the system costs of additional renewables in 2020	Finished
Belgium	2003	Impact of offshore wind generation on the Belgian high voltage Grid	Finished
Austria	2003	Auswirkungen des Windkraftausbaus in Österreich	Finished
France	2003	Growth and Grids – Panel discussion on issues of grid extension, supply predictability and power quality	Finished
Poland	2003	Study of Integration Possibilities of Wind Energy with the Polish Power Grid	Finished
Spain/Portugal	2004 2006	GreenNet WP2 Report: Costs and Technical Constraints of RES-E Grid Integration, Conference Papers EWEC 2006	Update
Ireland	2003 2006	The Impacts of Increased Levels of Wind Penetration on the Electricity Systems of Ireland, Conference Papers EWEC 2006	Update
Nordic Countries and others	2005 2006	Concerted Action for Offshore Wind Energy deployment (COD), Conference Papers EWEC 2006, Athens	Update

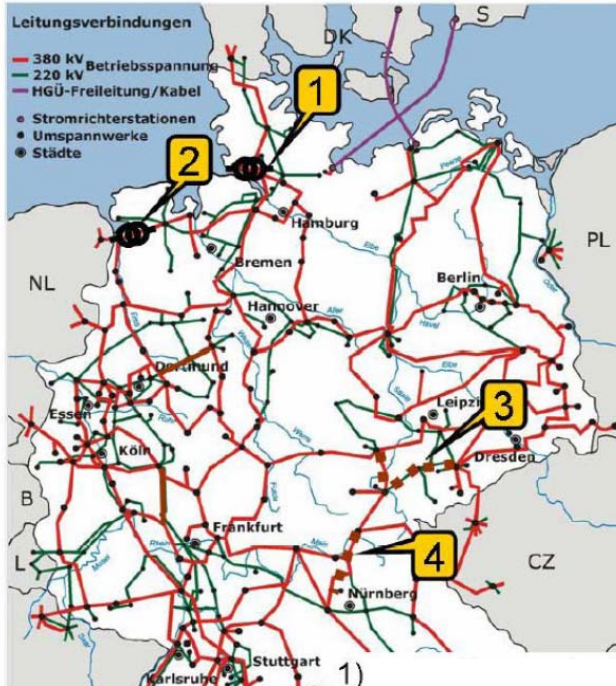
Case Study: Germany

Grid reinforcement/extension requirements for different wind penetrations

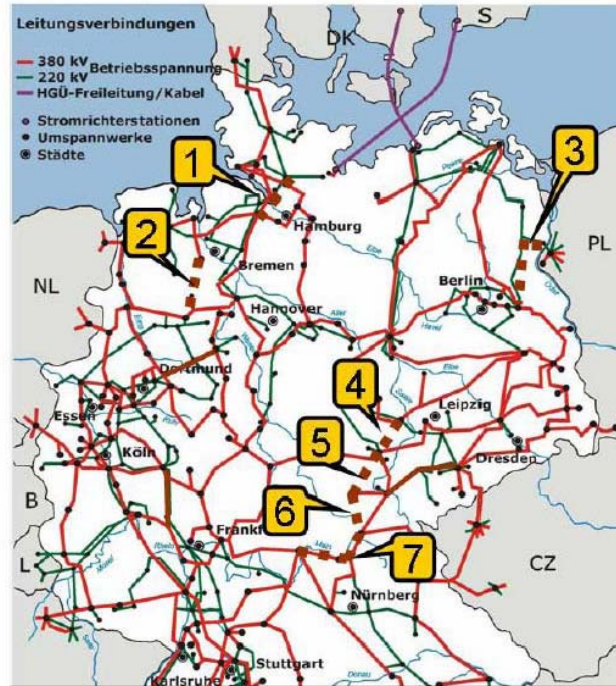
7 %

11 %

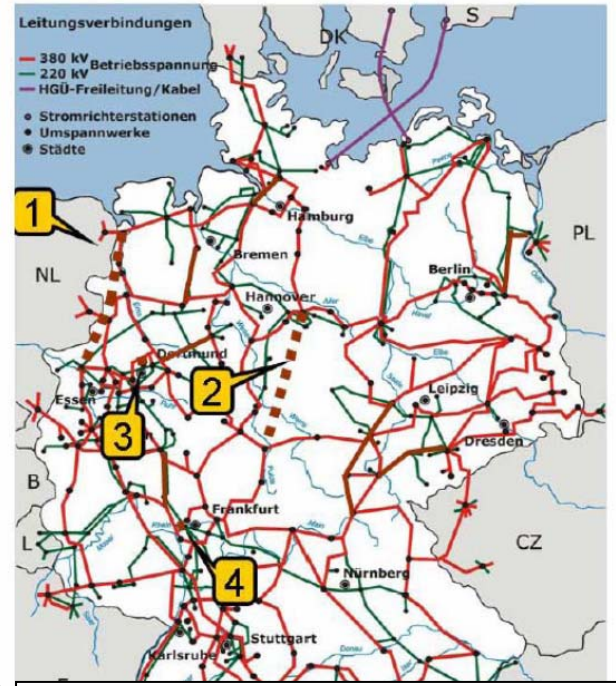
14 %



- 1) 1x Phase Shifter in Brunsbüttel
- 2) 2x Phase Shifter in Diele
- 3) Grid Reinforcement Thüringen
- 4) Grid Reinforcement Franken I



- 1) Hamburg/Nord – Dollern (45km)
- 2) Ganderkesee – Wehrendorf (80km)
- 3) Neuenhagen – Bertikow (110km)
- 4) Lauchstädt – Vieselbach (80km)
- 5) Vieselbach Altenfeld (80km)
- 6) Altenfeld – Redwitz (60km)
- 7) Grid Reinforcement Franken II



- 1) Diele – Niederrhein (200km)
- 2) Wahle – Mecklar (190km)
- 3) Bergkamen - Gersteinwerk
- 4) Kriftel – Pkt. Eschborn

Case Study: Germany

		Penetration 7 %	Penetration 11 %	Penetration 14 %
Total wind capacity	GW	22,4	29,8	36,0
Offshore wind capacity	GW	0	5,5	9,8
Grid network extension	Km	0	455	845
Grid extension costs	Mio. EURO	275	781	1136
Specific grid extension costs	Euro per MWh	0,51	0,88	0,96
Connection cost offshore	Mio. EURO	0	2600	4900

Source: Dena

Case Study: Netherlands

Grid reinforcement/extension requirements for 16% wind penetration

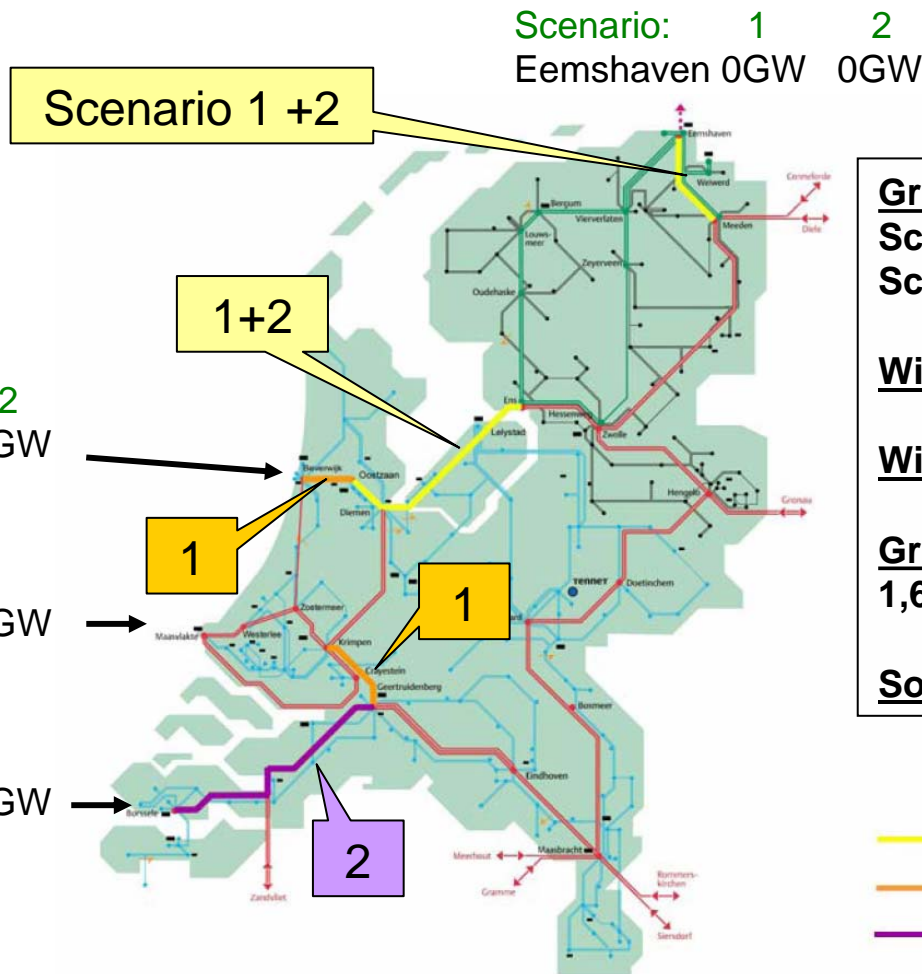
3 Situations:

- Import
- Export
- Zero

Scenario: 1 2
Beverwijk 3GW 2GW

Maasvlakte 3GW 2GW

Borssele 0GW 2GW



Grid Extension Costs:
Scenario 1: 370 - 403 Mio. €
Scenario 2: 344 - 413 Mio. €

Wind capacity: 6000 MW

Wind penetration: 16,6 %

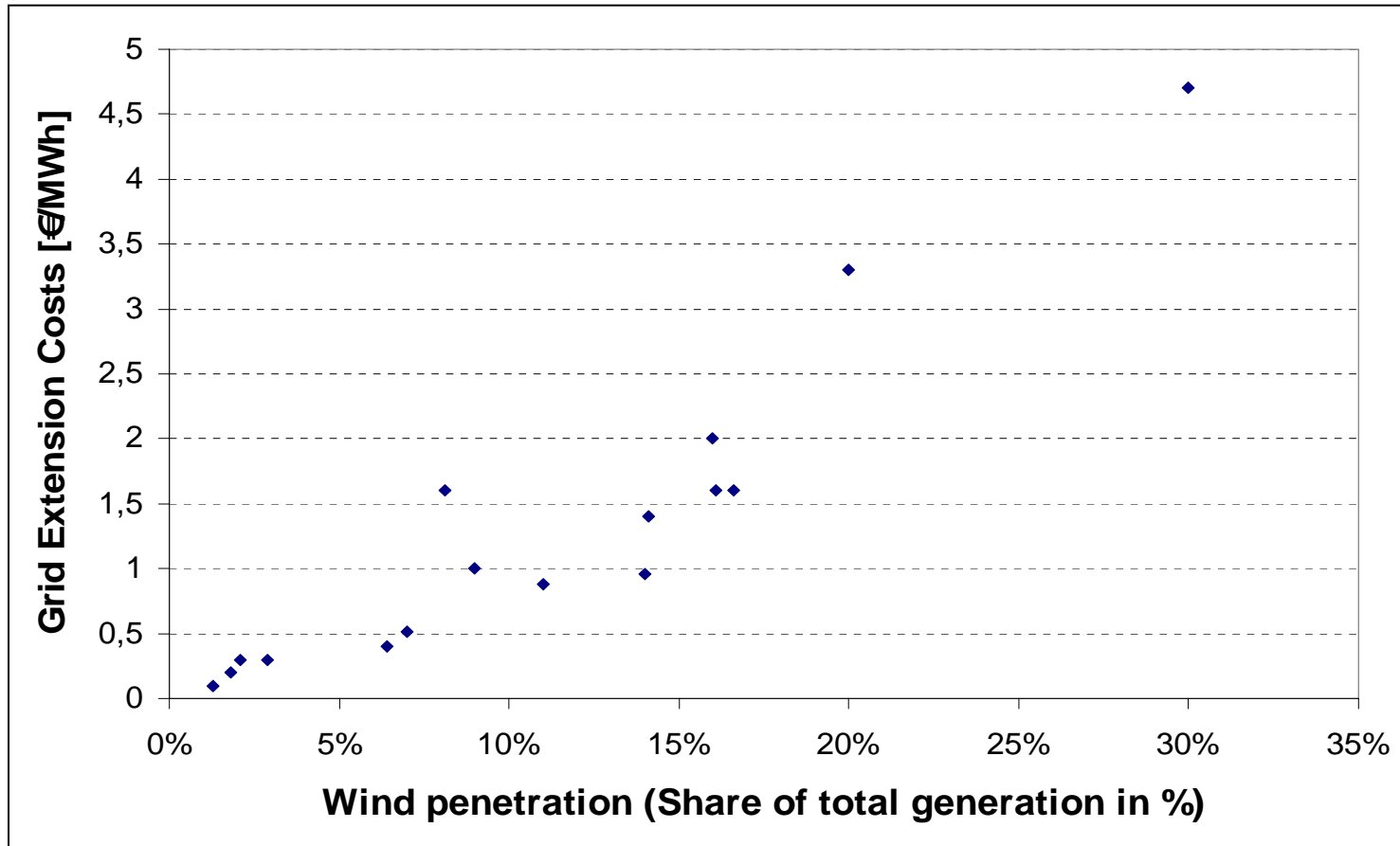
Grid extension costs:
1,6 € per MWh Wind Energy

Source: Novem

Methodology for calculation of grid reinforcement/extension costs

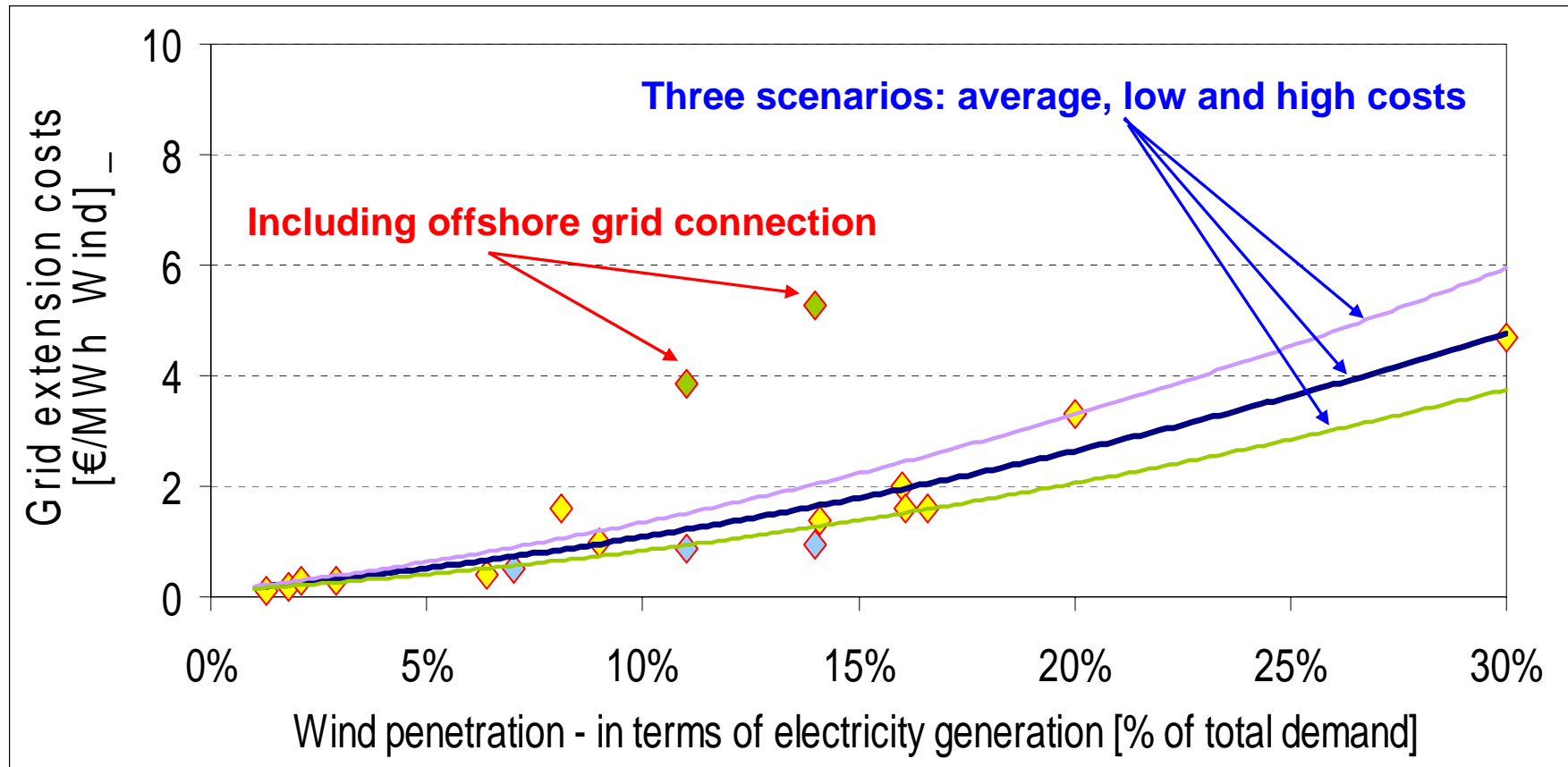
- **Total costs for grid reinforcement/extension**
- **Annualized over life time (technical or economical), 25 – 40 years.**
- **Typical interest rate: 5 %**
- **Calculation of wind energy generation over life time with total capacity.**
- **Calculation of specific costs per MWh wind energy generation.**

Specific grid reinforcement/extension costs



Implementation into the GreenNet-EU27 model

Interpolation of the results of different country-specific case studies



Conclusions and Discussion

Conclusions

- Wind penetration (offshore in particular) determines grid reinforcement/extension costs
- Maximum of additional costs at 5 € per MWh wind energy for high wind penetration
- Further details see in the corresponding deliverables D4a (Data Base) and D5a (Report) on the project website www.greennet-europe.org

Discussion

- Allocation of additional grid reinforcement/extension costs
 - To all wind generators versus only new wind generators versus all end-users
- Calculation method
 - Depreciation: Life time of grid investment, life time of wind park
 - Absolute level of interest rates
 - Share of grid reinforcement/extension costs due to wind or other generation