Germany's Energy Turnaround

Renewable energy, storage and transmission needs – close or far from the market

11-13 September 2012, Sand, Norway

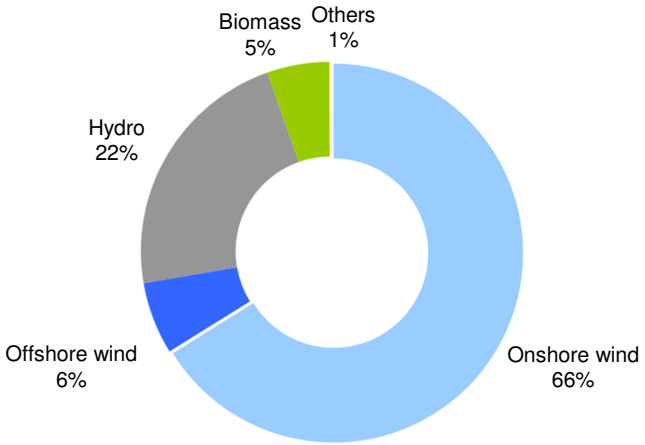
Jan Bruhn, RWE Innogy GmbH
Dr. Hans-Christoph Funke, RWE Innogy GmbH

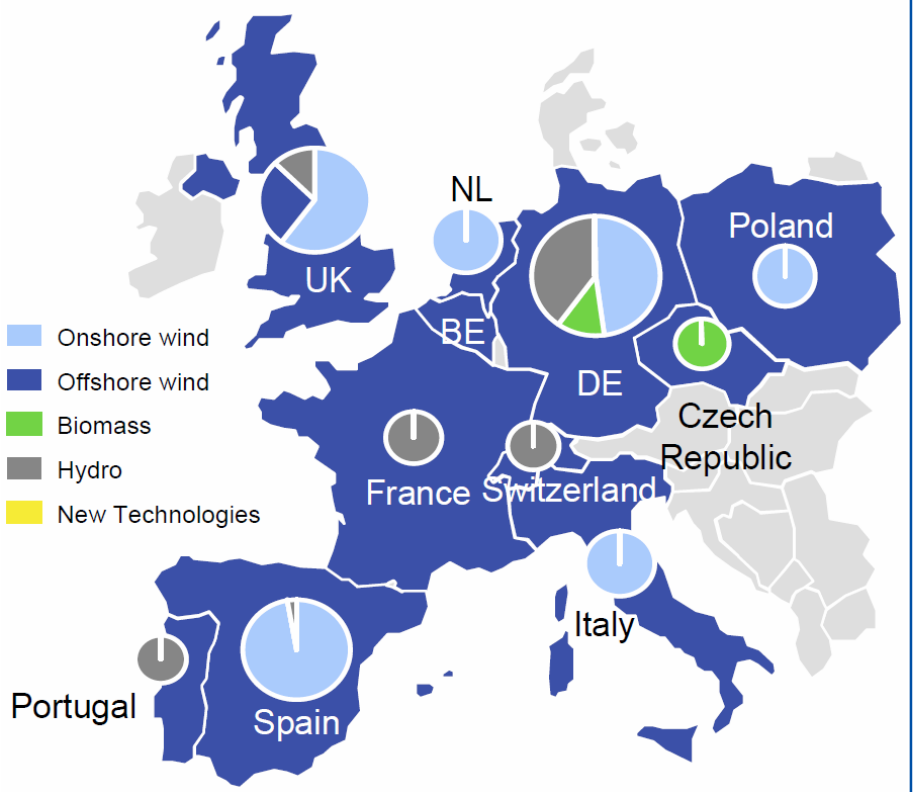
RWE
The energy to lead

RWE Innogy bundles the renewable activities and competencies across the RWE Group

RWE Innogy's Renewables Portfolio

- 2,430 MW in 10 European countries (without pumped-storage)





RWE Innogy (accounting view + PPA)

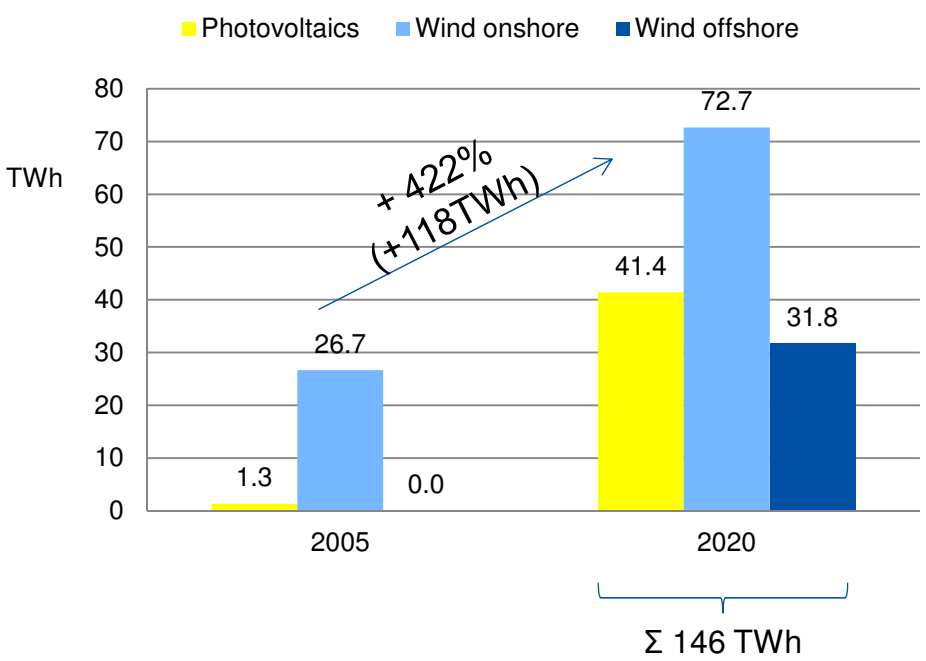
Source: Fact Book, RWE Innogy 31.03.2012, p.9

Germany's Energy Turnaround
Agenda

1. **Fluctuating generation**
2. Storage and transmission needs
3. Energy market discussion

Increasing fluctuation of generation will challenge the future power supply

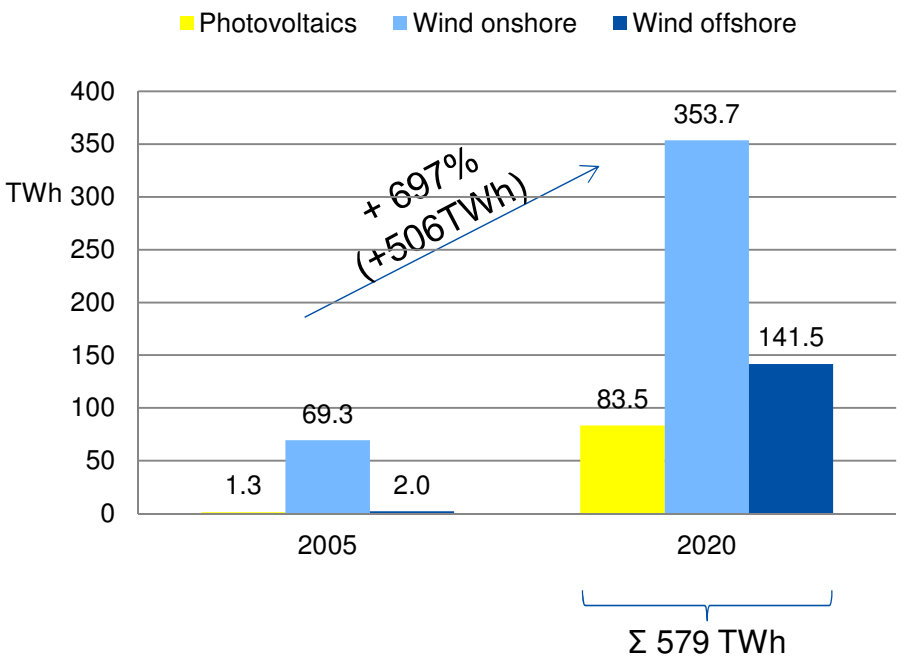
Germany's fluctuating generation



Total electricity consumption 562 TWh

Share in 2020: 26%

EU-27 fluctuating generation



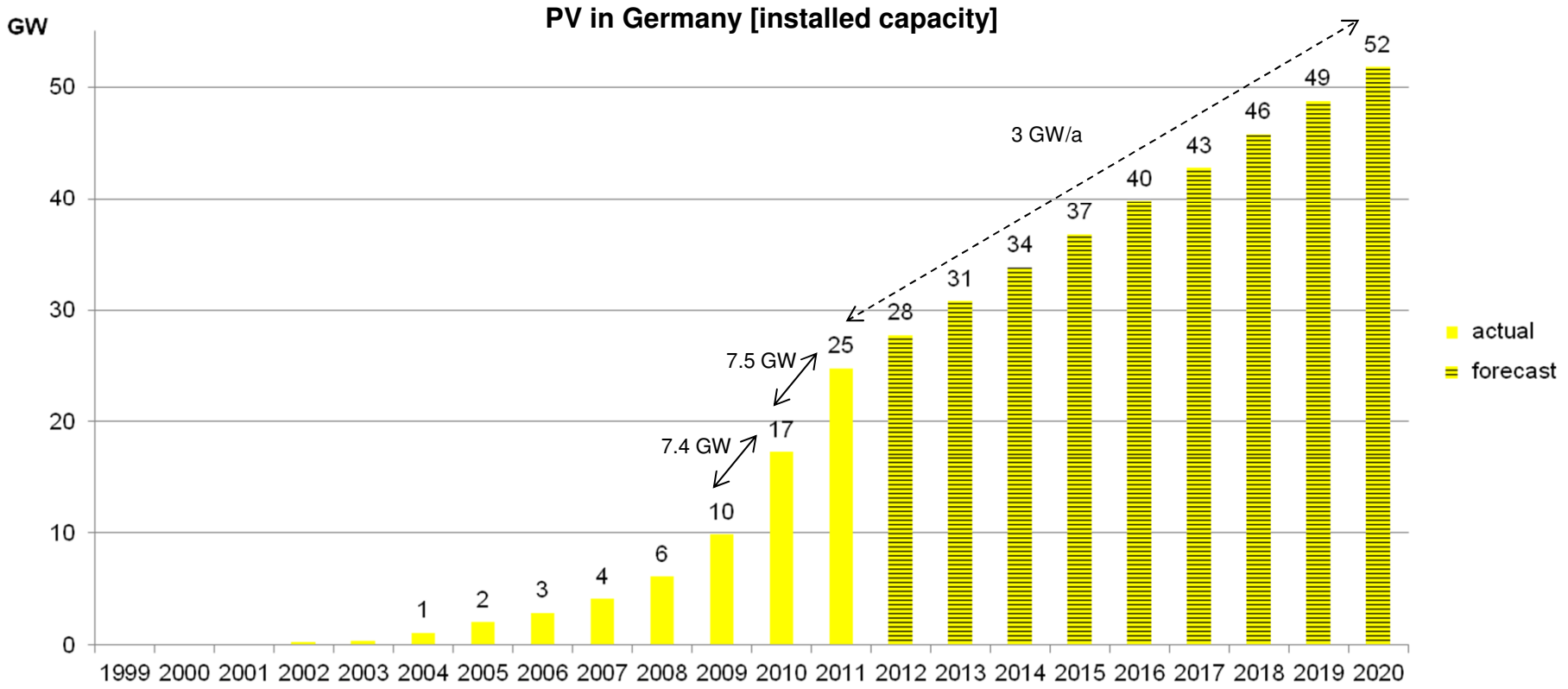
Total electricity consumption 3,537 TWh

Share in 2020: 16%

Source: EU-27 National Renewable Energy Action Plans
Wilkes, J. et al. (2011) - EU Energy Policy to 2050, EWEA, March 2011, pp.37-40

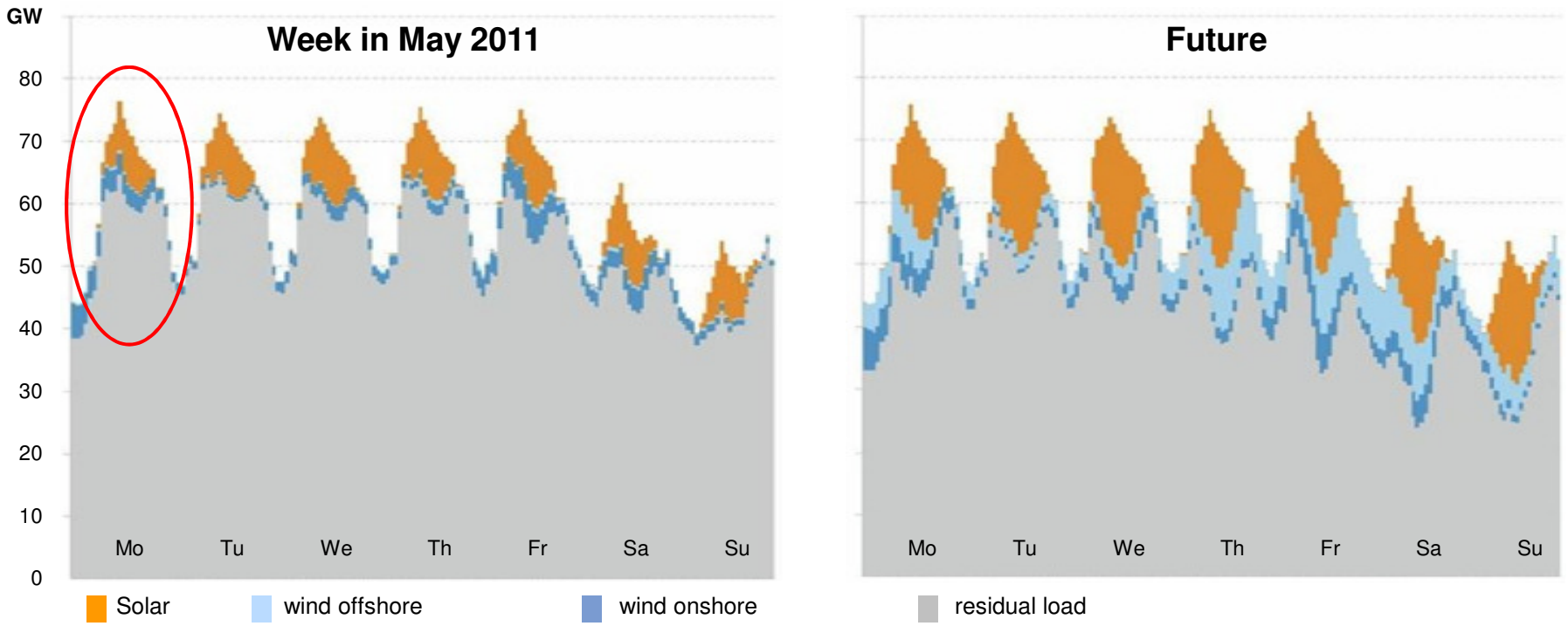
Germany focuses on strong growth of PV capacity

- Anticipated annual growth of PV before 2010: 1.7GW | after 2010: 3.5GW
- Actual PV growth in 2010 and 2011: 7.5GW / year
- 52GW in 2020 = 65% of Germany's peak load of 80 GW in 2020



Source: Brohm, R. (2010). - Marktentwicklung und Perspektiven der Photovoltaik in Deutschland, Bundesverband Solarwirtschaft e.V., 30.4.2010, p.10
Statistische Zahlen der deutschen Solarstrombranche, Bundesverband Solarwirtschaft e.V., Juni 2012, p.2

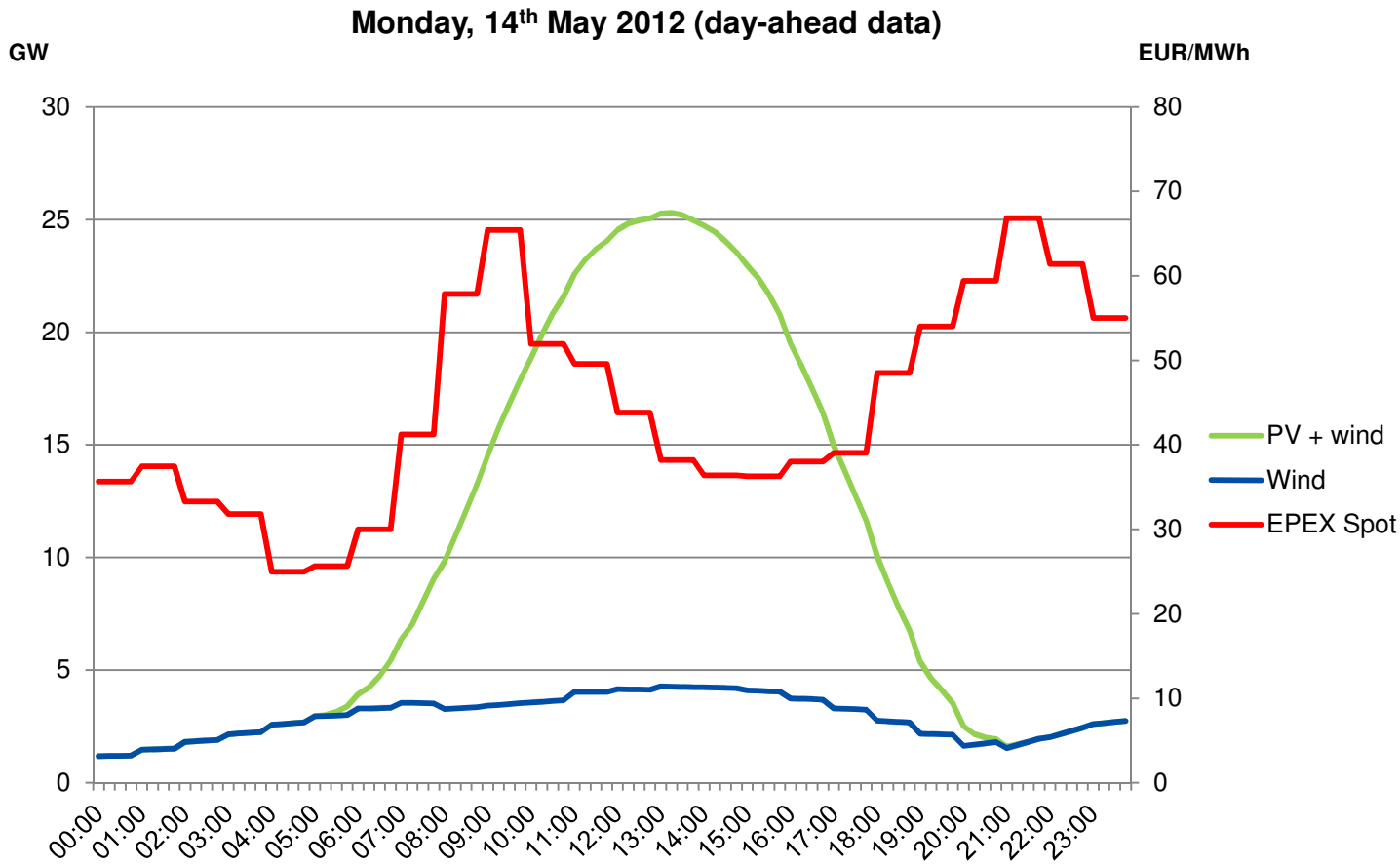
PV already influences the operation of power plants



- High PV generation→ residual load decreases → low electricity price
- Pumped-storage in the past: charging – discharging (1 cycles)
- Pumped-storage in the future: charging – discharging – charging – discharging (2 cycles)

Source: Gohsen, D. (2012). - Untersuchungen zu einem zukunftsfähigen Strommarktdesign , RWE Innogy, 24.7.2012, pp.9-11
Wirtschaftlichkeit von Pumpspeichern im Strommarkt, Workshop enervis , März 2012

High RE capacity significantly influences the electricity market price and operation of storage plants



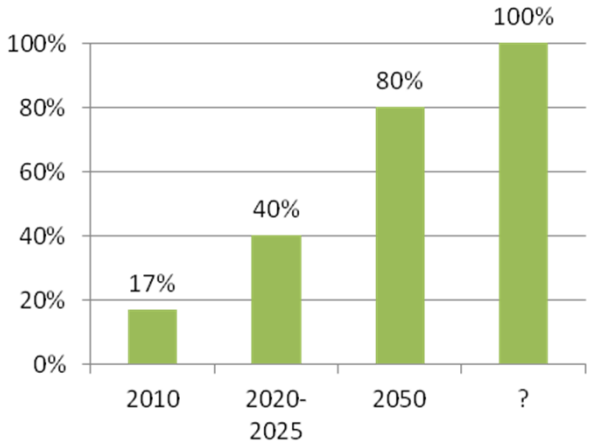
Source: European Energy Exchange AG, http://www.transparency.eex.com/de/

Germany's Energy Turnaround
Agenda

1. Fluctuating generation
2. **Storage and transmission needs**
3. Energy market discussion

A first approach – Germany's storage needs derived from the government's energy concept

Renewable energy percentage of gross electricity generation



- Up to 40% almost no storage needs for RE integration
- From 80 to 100% RE, storage needs triples (GW and GWh)

Comparison of different storage usage for the 80% scenario

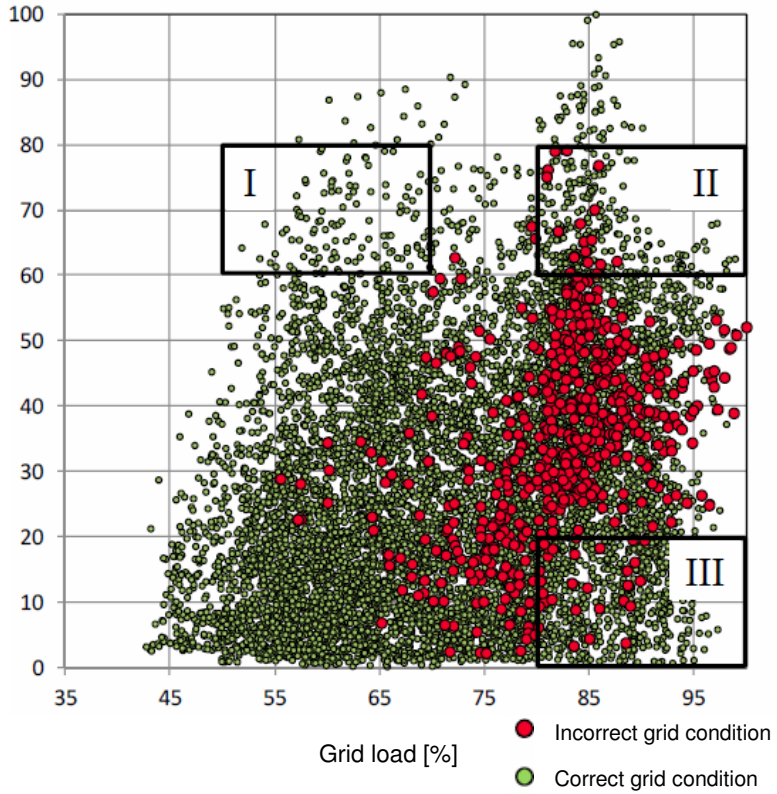
	full storage of RE [scenario D]			limited storage of RE [scenario E] (50% installed capacity)		
	charging power [GW]	discharging power [GW]	energy [GWh]	charging power [GW]	discharging power [GW]	energy [GWh]
short-term storage [hours]	28	26	140	14	14	70
long-term storage [days]	36	29	8,000	18	18	7,000
curtailed wind and PV	0 GWh/a			400 GWh/a		

- Based on weather data of year 2007, including both extremes: wind calm and storm periods
- Focus on Germany only: no imports, no exports
- Focus on 100% system availability
- No grid bottlenecks, grid is considered as a "copper plate"
- Energy [GWh] more important than installed capacity [GW]
- Mix of short-term and long-term storage is recommended

Source: Adamek, F. et al. (2012) - Energiespeicher für die Energiewende, VDE-Studie, VDE, June 2012, pp.5-37

No preference for storage locations close to load or origin

Grid conditions, 40% RE scenario, grid 2, D_{RE}



Incorrect grid conditions, 40% RE scenario, grid 2

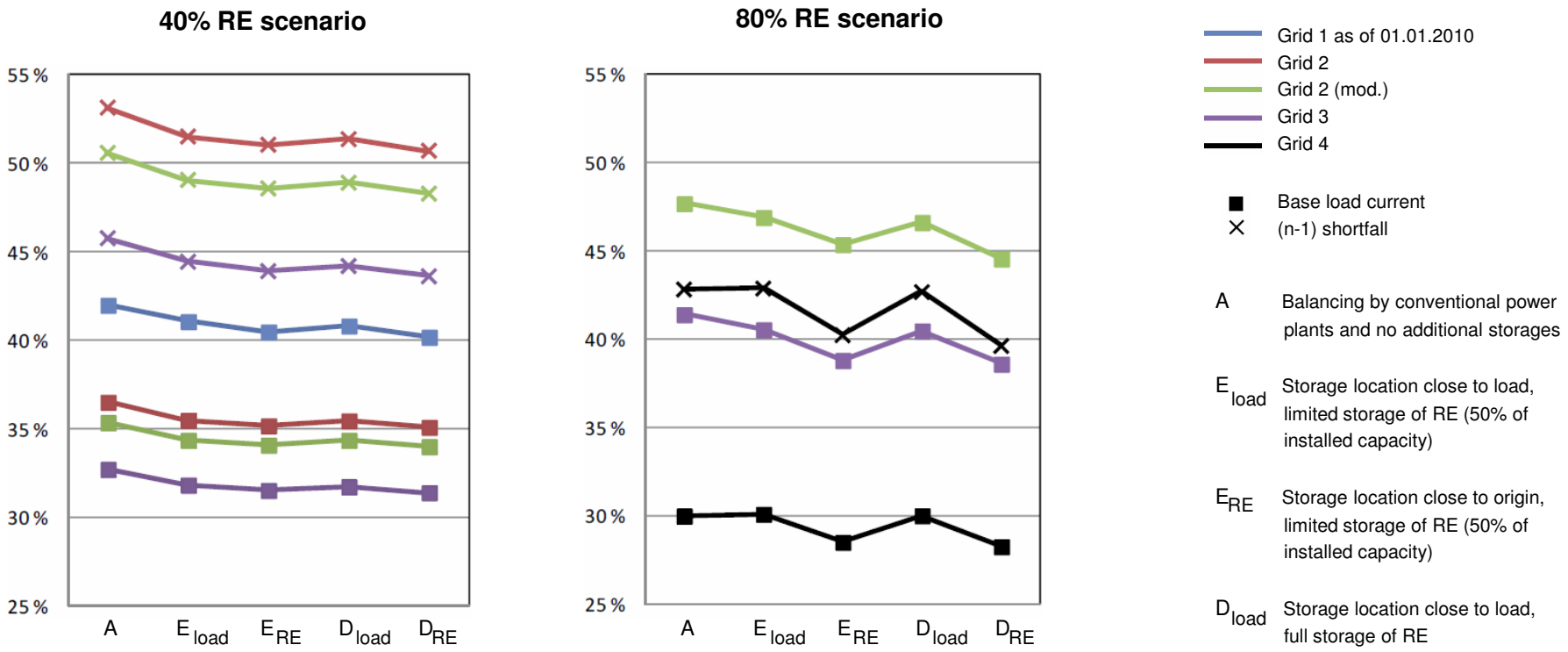
	Amount of incorrect grid conditions			
				total
	I	II	III	
A	15	9	57	594
E_{load}	8	29	26	572
E_{RE}	0	21	34	565
D_{load}	9	28	21	579
D_{RE}	0	18	29	558

Scenario reference: see next page

> Depending on the situation, sometimes a storage location close to the load is more beneficial than to the origin and vice versa

Grid expansion is the best option to reduce the grid load factor

Expected values of highest load factor

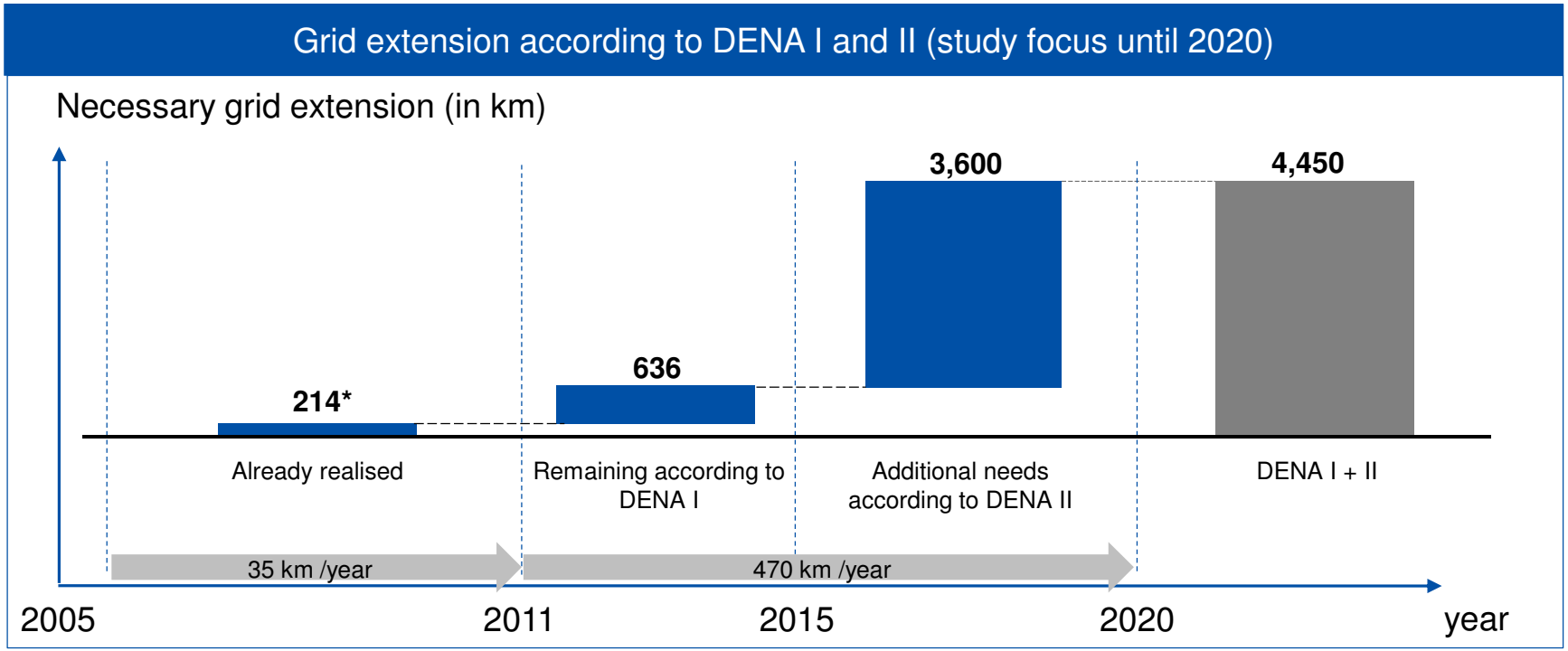


> Storages only marginally reducing the grid load factor

> Storages close to origin of generation show a slightly higher reduction of the grid load factor

Source: Adamek, F. et al. (2012) - Energiespeicher für die Energiewende, VDE-Studie, VDE, June 2012, pp.45-127

4,450 km of new grids are necessary to integrate the non-transmittable energy until 2020



- New storage facilities will have almost no impact on the necessary grid expansion
- Storage capacities will shift the generation characteristics of conventional power plants
- Existing electricity market gives no incentive for new energy storages

Source: Summary -Planning of the Grid Integration of Wind Energy in Germany Onshore and Offshore up to the Year 2020, dena Grid study, 15.3.2005
Summary - Integration of Renewable Energy Sources in the German Power Supply System from 2015 – 2020 with an Outlook to 2025, dena Grid Study II
*Monitoringbericht 2011, Bundesnetzagentur

Germany's Energy Turnaround
Agenda

1. Fluctuating generation
2. Storage and transmission needs
3. **Energy market discussion**

Does Germany's energy turnaround will lead to changes of the existing energy-only-market?

Current discussion in Germany:

Energy-only-market

- Operators of power plants are paid by the amount of generated energy
- Do the operators have enough incentives to provide a sufficient level of conventional capacities in future?

Future

Driver for a capacity market

- Almost no profit contribution of peak power plants (low full load hours)
- Tertiary control services are already a implicit capacity mechanism but prices significantly decreased for positive capacities (for negative capacities prices slightly decreased only)
- Lower electricity wholesale market price due to high amount of RE without any commodity costs
- Possible secured capacity shortage

Source: Gohsen, D. (2012). - Untersuchungen zu einem zukunftsfähigen Strommarktdesign , RWE Innogy, 24.7.2012, pp.15-18
Achner, S. et al. (2011). - Kapazitätsmarkt – Rahmenbedingungen, Notwendigkeit und Eckpunkte einer Ausgestaltung, Bet, 02.09.2011
Elberg, C. et al. (2012). - Untersuchungen zu einem zukunftsfähigen Strommarktdesign, ewi, April 2012

Capacity markets and their characteristics – a new market design for Germany's energy market?

Current discussion in Germany:

	Comprehensive CM	Selective CM	Strategic reserve CM
Advantages	> Good solution in order to reach a certain capacity as all power plants are participating	> Lower financial risks > No windfall profits when focusing on new-build only	> Usage during energy shortage only otherwise like energy-only-market > Financing through capacity payment only
Disadvantages	> Windfall profits for existing plants > New-build plants will be price setters	> Selection of nominated plants > Inefficient due to inaccurate capacity forecast (how much capacity is available in year x?)	> Inefficient dispatch of generation and demand (load shedding and high electricity price before using the strategic reserve) > Dimensioning of strategic reserve capacity

Source: Gohsen, D. (2012). - Untersuchungen zu einem zukunftsfähigen Strommarktdesign , RWE Innogy, 24.7.2012, pp.15-18
Achner, S. et al. (2011). - Kapazitätsmarkt – Rahmenbedingungen, Notwendigkeit und Eckpunkte einer Ausgestaltung, Bet, 02.09.2011
Elberg, C. et al. (2012). - Untersuchungen zu einem zukunftsfähigen Strommarktdesign, ewi, April 2012

Does Germany's energy-only-market persist if other options will be implemented?

Current discussion in Germany:

Conclusion

> There is need for research: evaluation of different market design approaches
> There is need for action: no time left to wait and see
> It is not a question whether or not but how and when

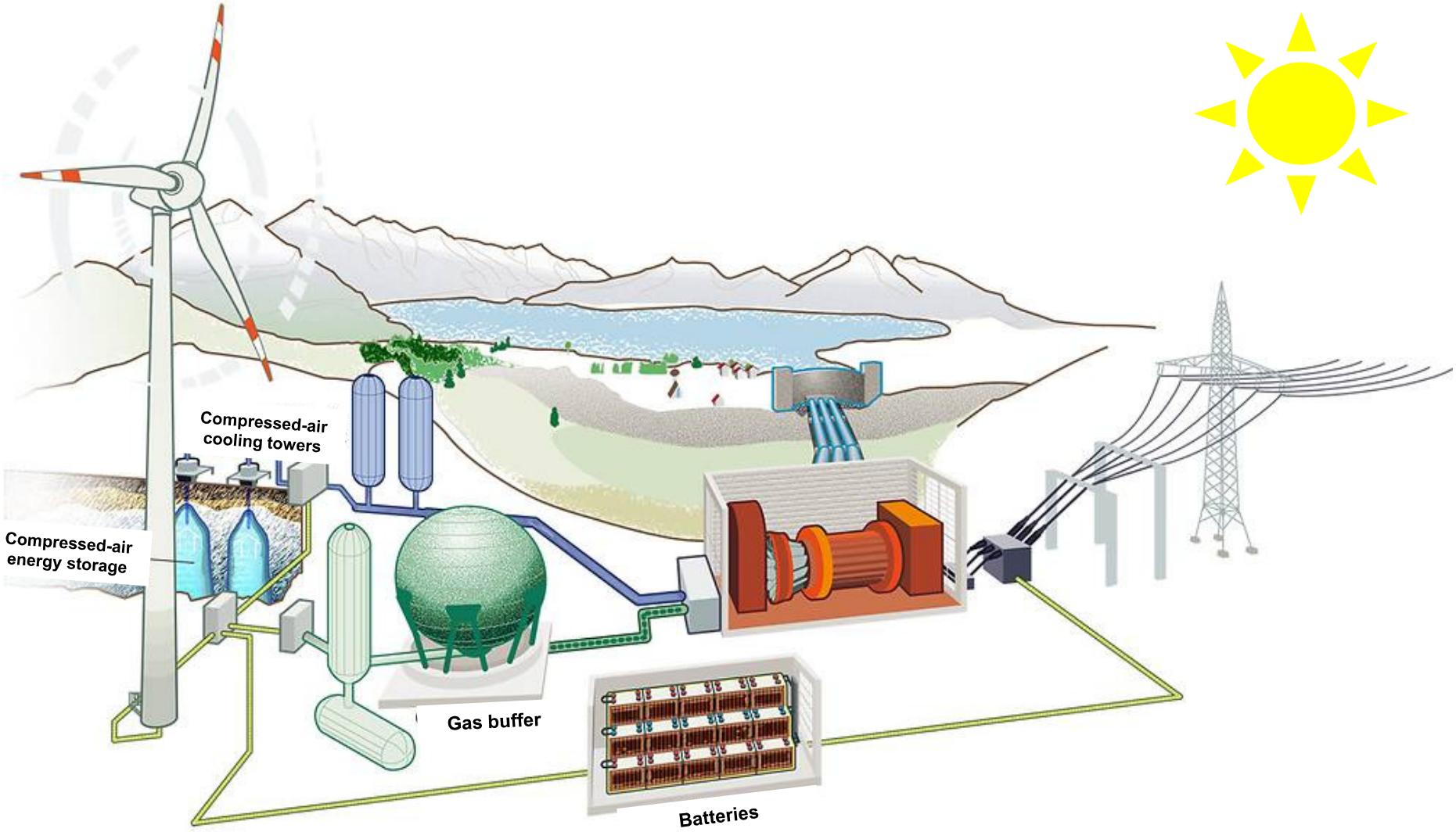
Future

But there are other options…

> Stronger market integration of RE (generation in line with the electricity price)
> Grid expansion to remove the regional bottlenecks
> Implementation of energy storages
> Increase the power price sensitivity of the customers
> Support of regional capacities if required due to grid bottlenecks
> Ensure investment security by political frameworks / directives

Source: Gohsen, D. (2012). - Untersuchungen zu einem zukunftsfähigen Strommarktdesign , RWE Innogy, 24.7.2012, pp.15-18
Achner, S. et al. (2011). - Kapazitätsmarkt – Rahmenbedingungen, Notwendigkeit und Eckpunkte einer Ausgestaltung, Bet, 02.09.2011
Elberg, C. et al. (2012). - Untersuchungen zu einem zukunftsfähigen Strommarktdesign, ewi, April 2012

How does the future look like?



Source: Schuster, J. & Kunz, M. (2010). - Aus Wind werde Gas, Focus Magazin no.11 (2010)