

Power system stress due to massive renewable installation

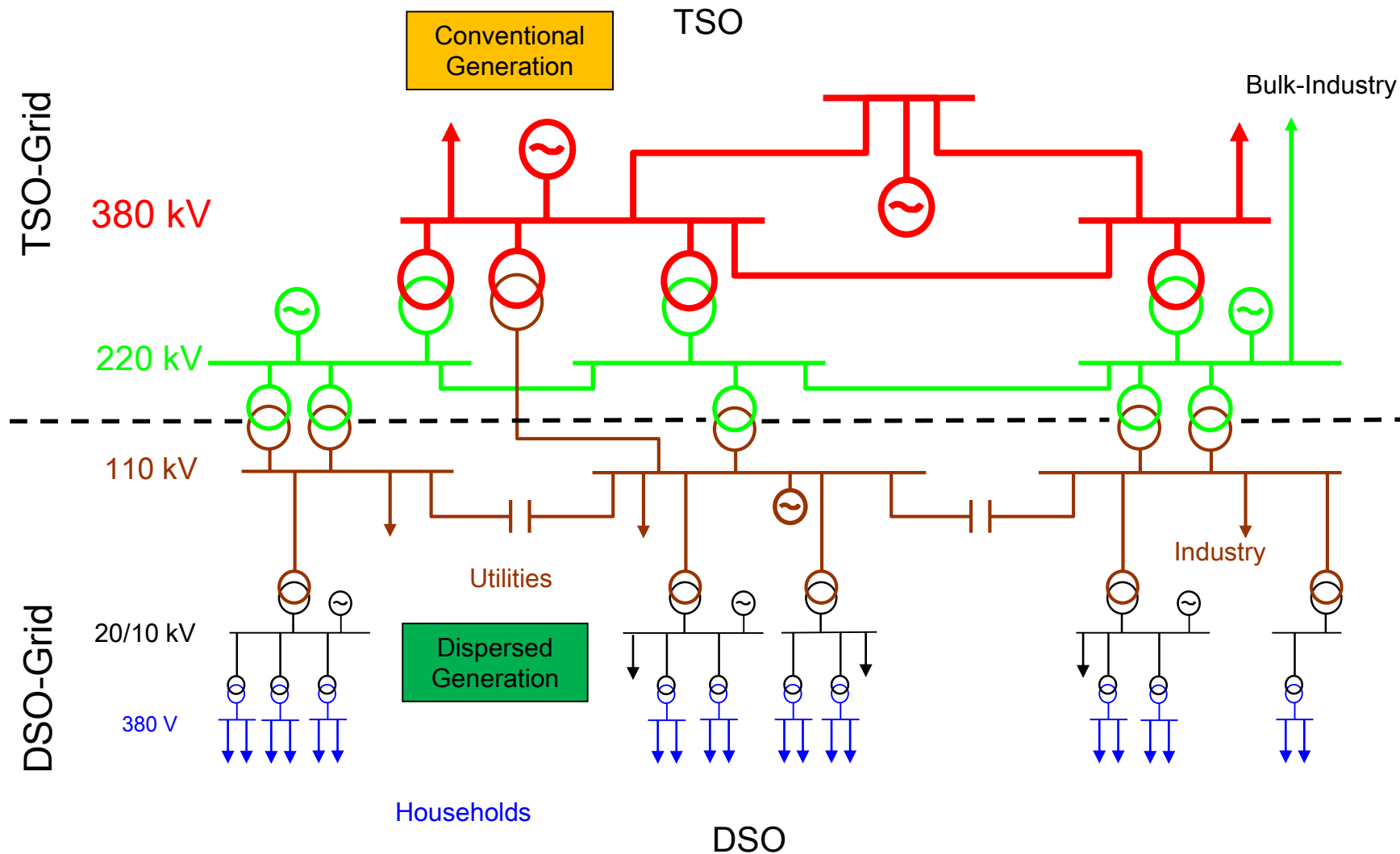
Klaus Kleinekorte
Amprion GmbH, Germany

PARIS, Monday August 25th, 2014

Content

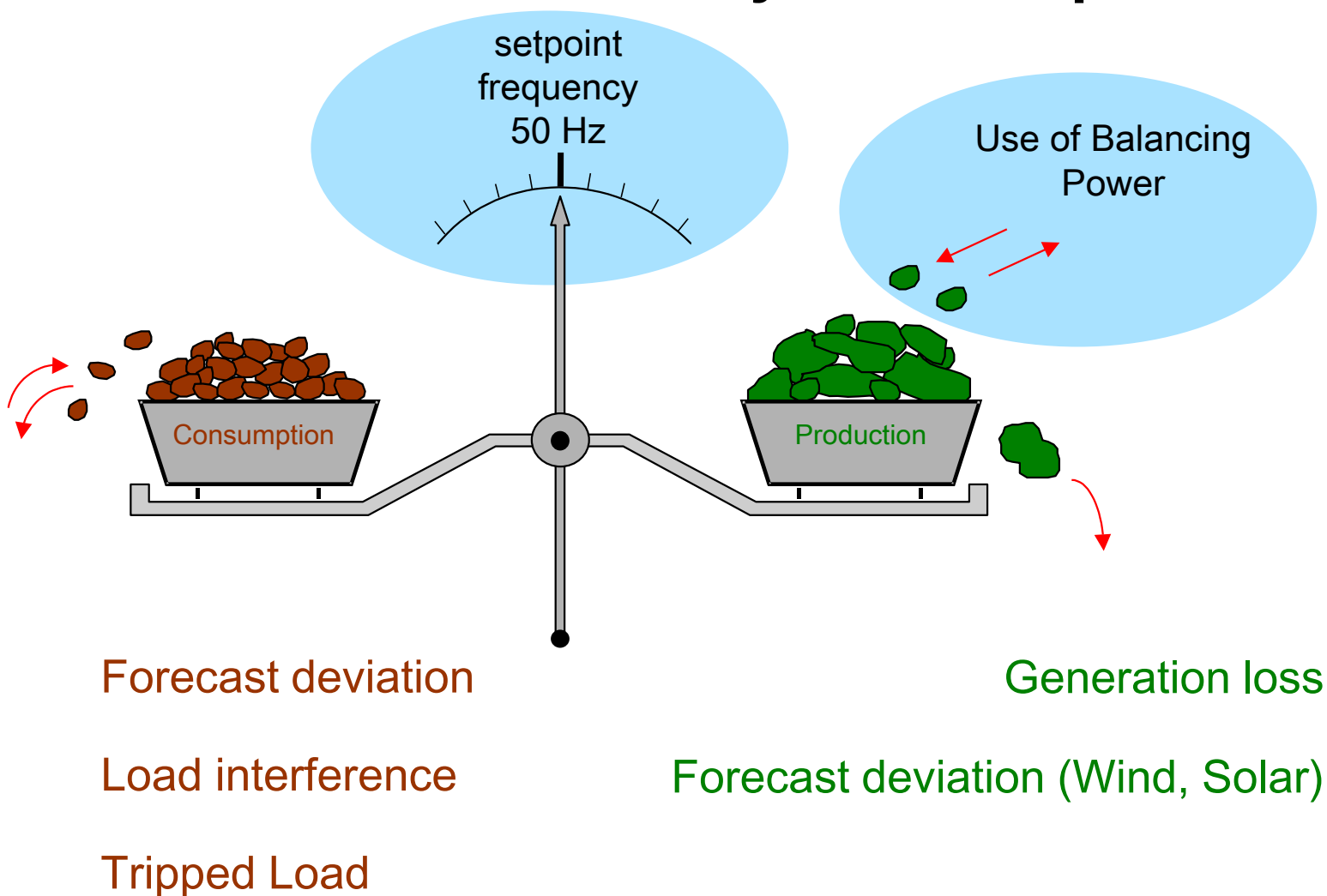
- Transmission System Operation – short reminder
- German targets on RES installation
- The TSO's perspective to RES
- The Market and Conventional Generation perspective to RES
- Summary

Grid responsibility TSO versus DSO according to voltage levels in Germany





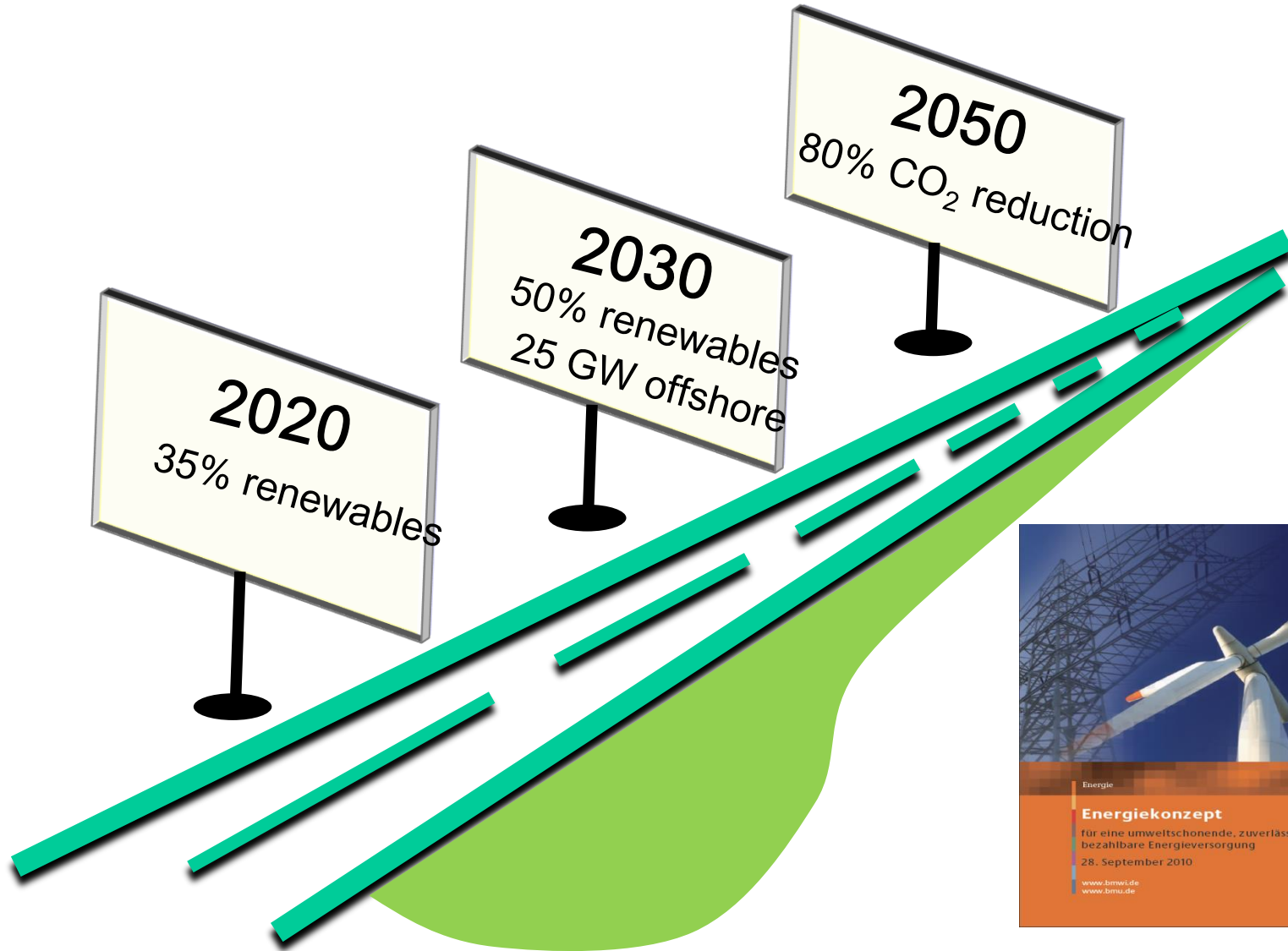
Load Frequency Control and Power Balance – System Responsibility



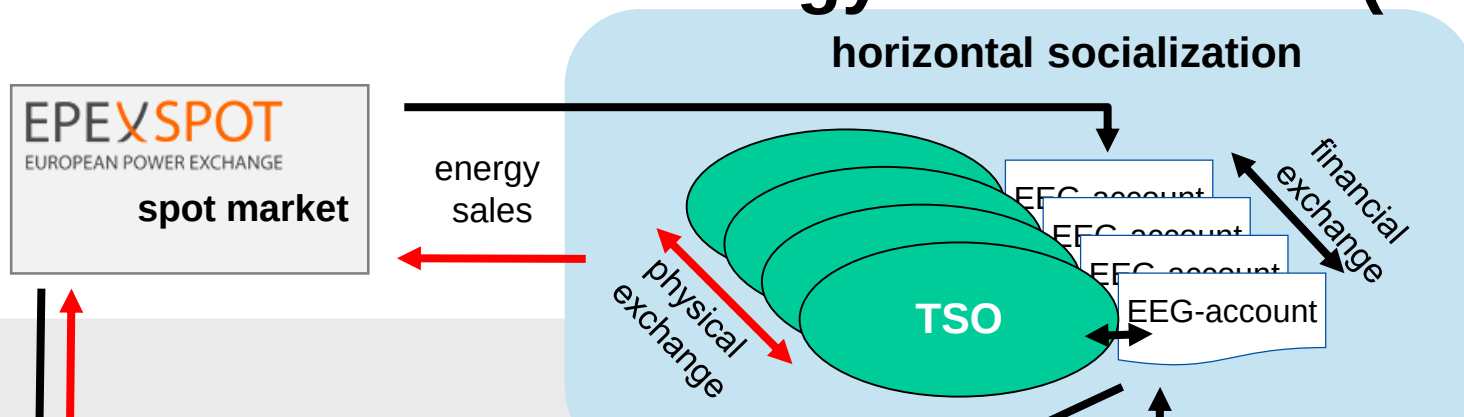
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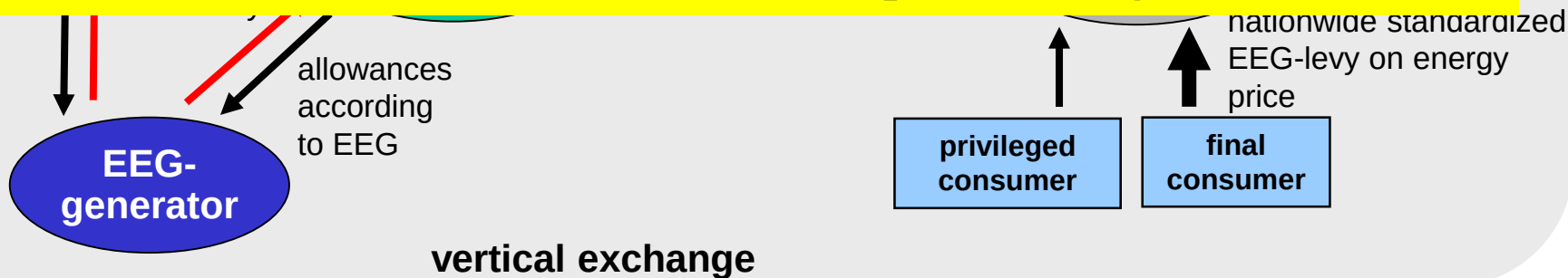
Germany, quo vadis? Road to “Green Revolution”



Allocation mechanism of the Renewable Energy Sources Act (EEG)



about 20 Billion €
subsidiaries per year

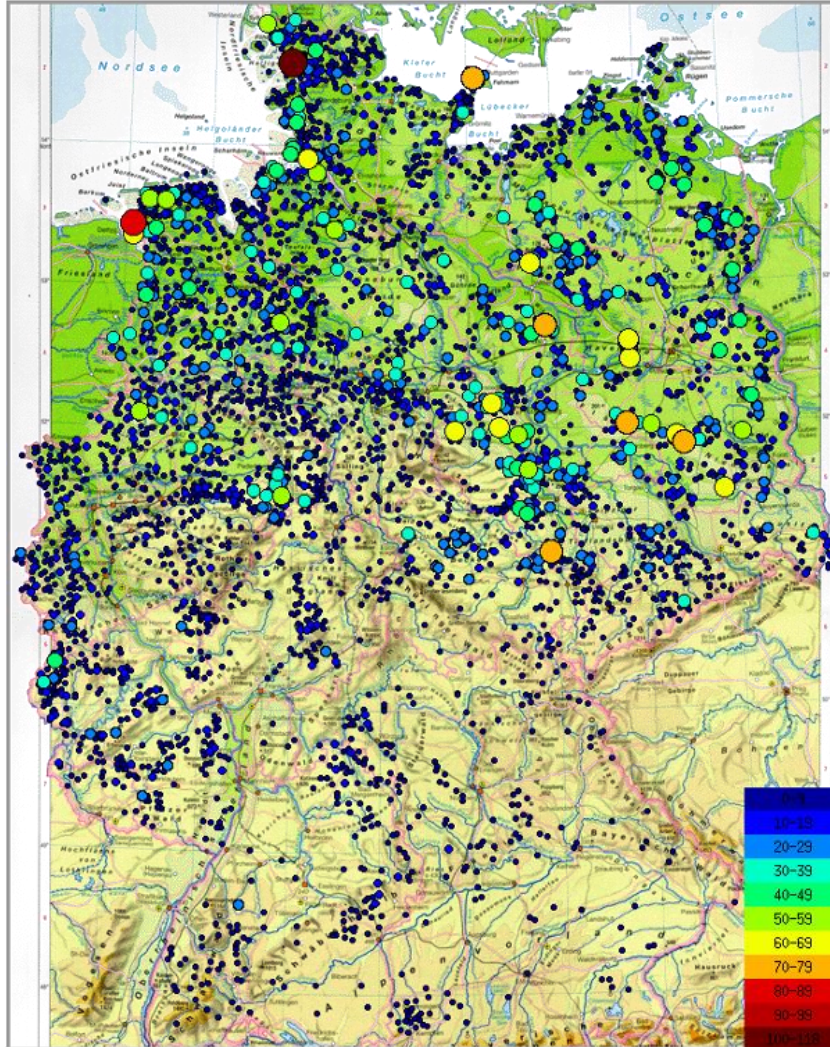


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Impact of Renewable Generation on Grid Security (1/2)

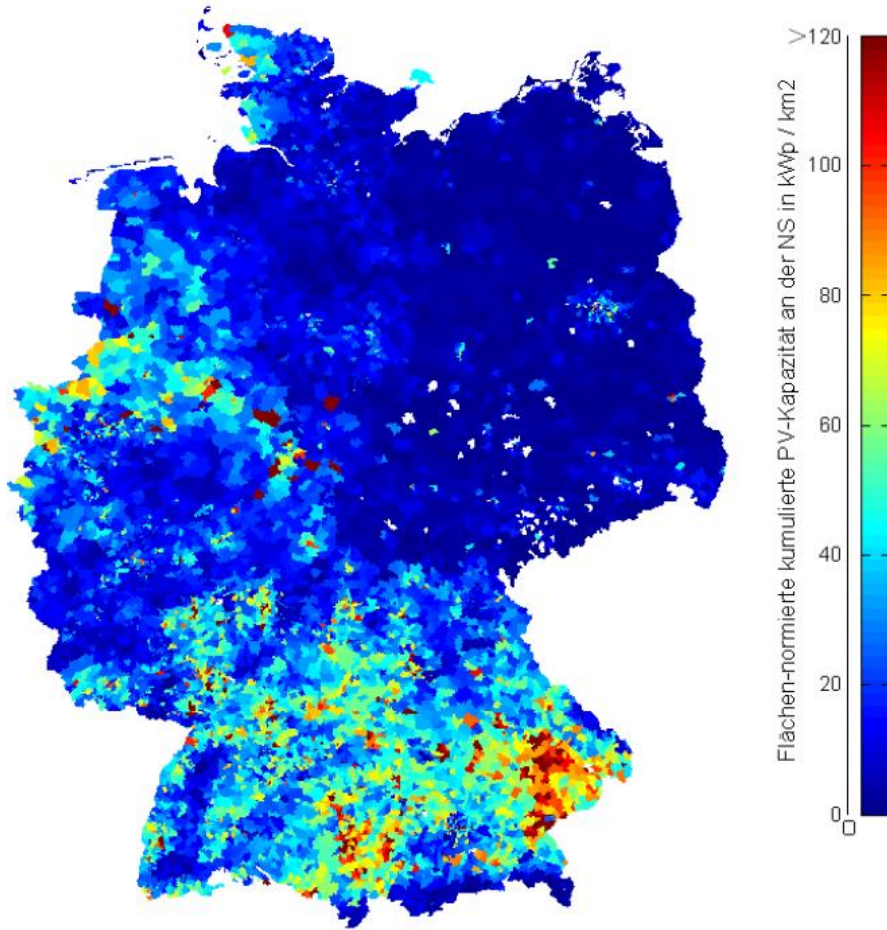


Due to the guaranteed infeed right Renewable Generation leads to a fluctuating and unusual power flow in the grid:

- In Germany Wind generation is installed in the northern and eastern part of the country
- High Wind power leads to bulk energy flows from North to South because most industry is concentrated in southern part of Germany



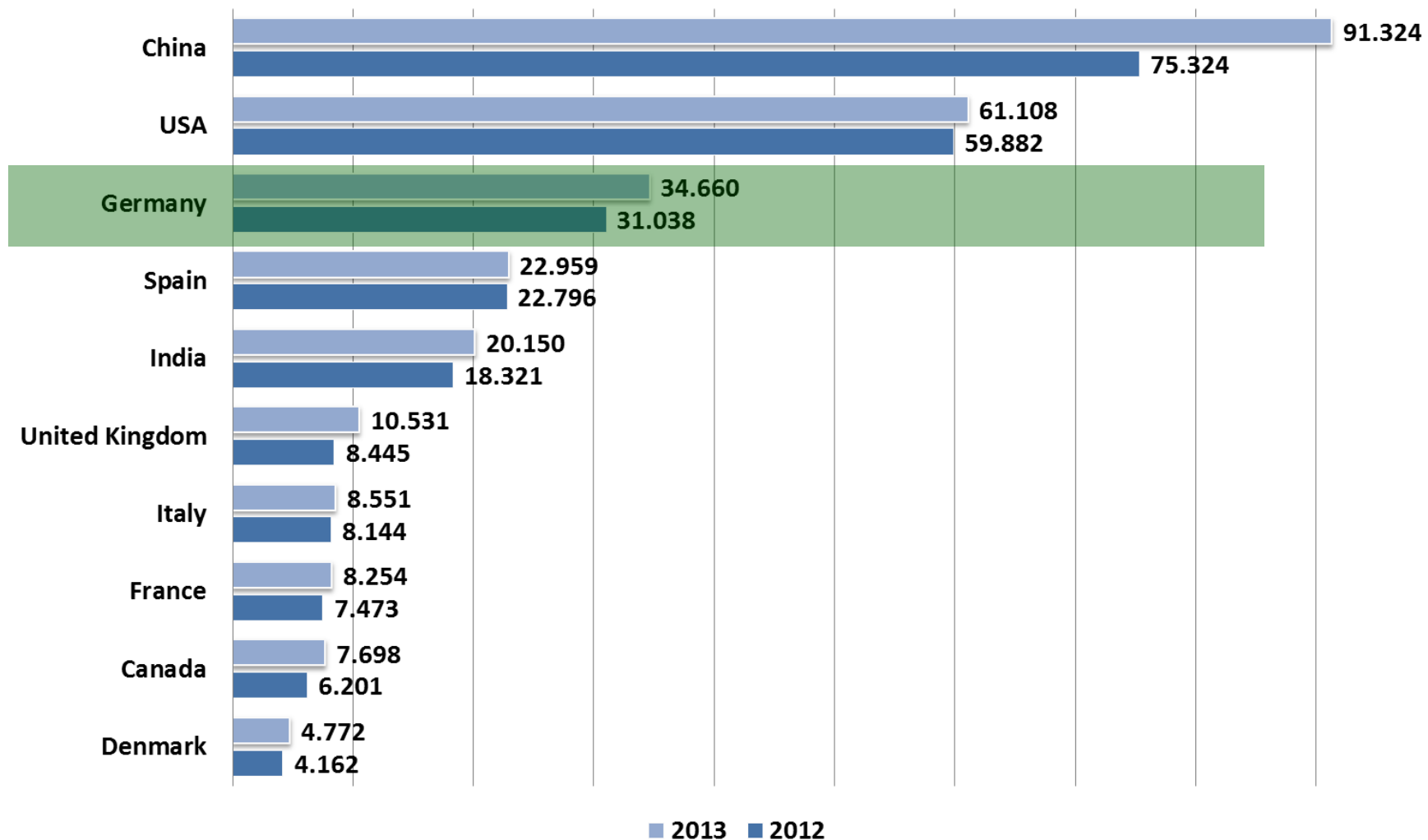
Impact of Renewable Generation on Grid Security (2/2)



Due to the guaranteed infeed right Renewable Generation leads to a fluctuating and unusual power flow in the grid:

- In Germany PV generation is installed in the southern part of the country mainly.
- High PV power leads to bulk energy flow into DSO grids and from DSO to TSO - reverse operation.

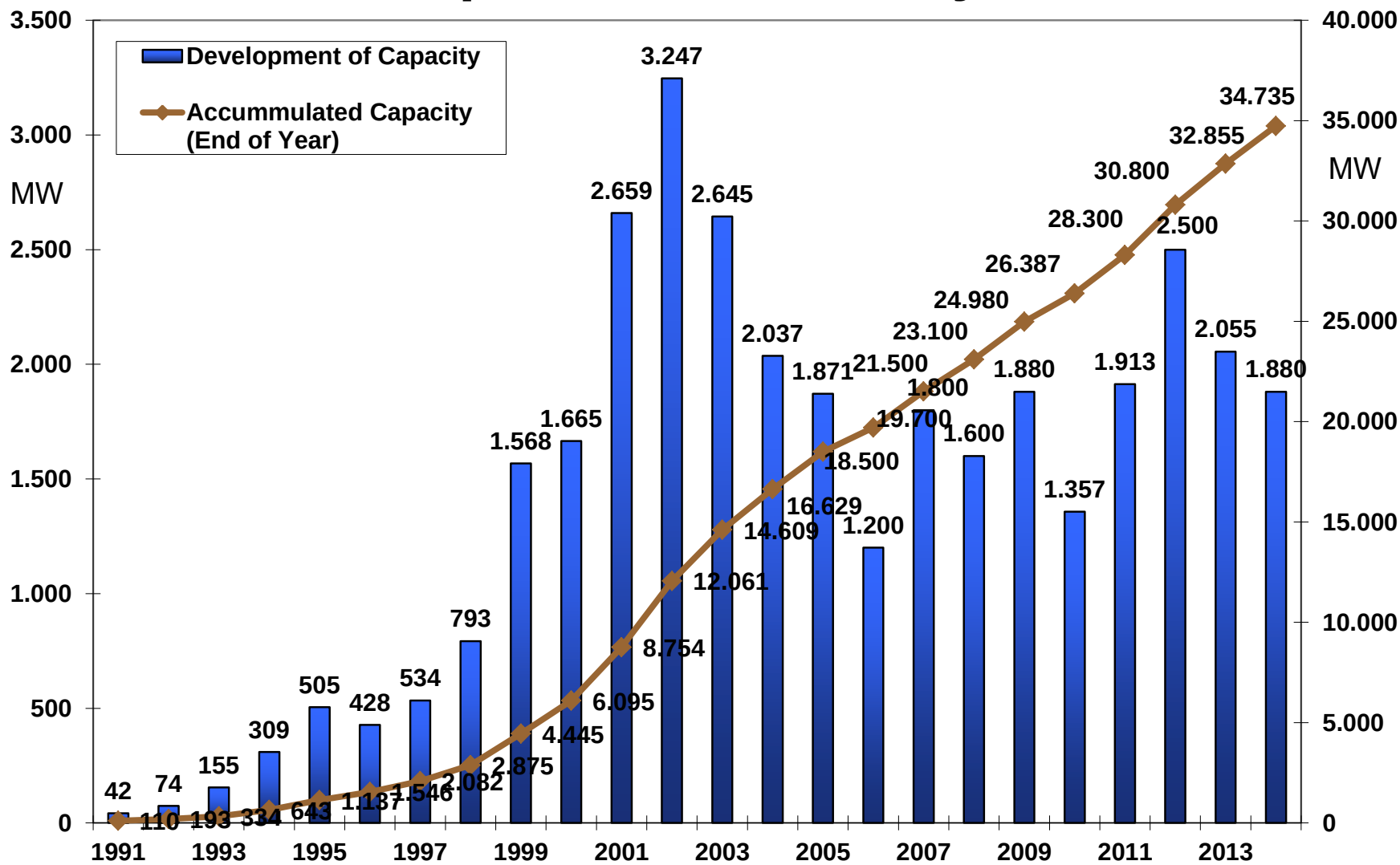
Top 10 Countries by Total Wind Capacity [MW] installed (2012 and 2013)



Source: World Wind Energy Association



Wind Power: Development in Germany

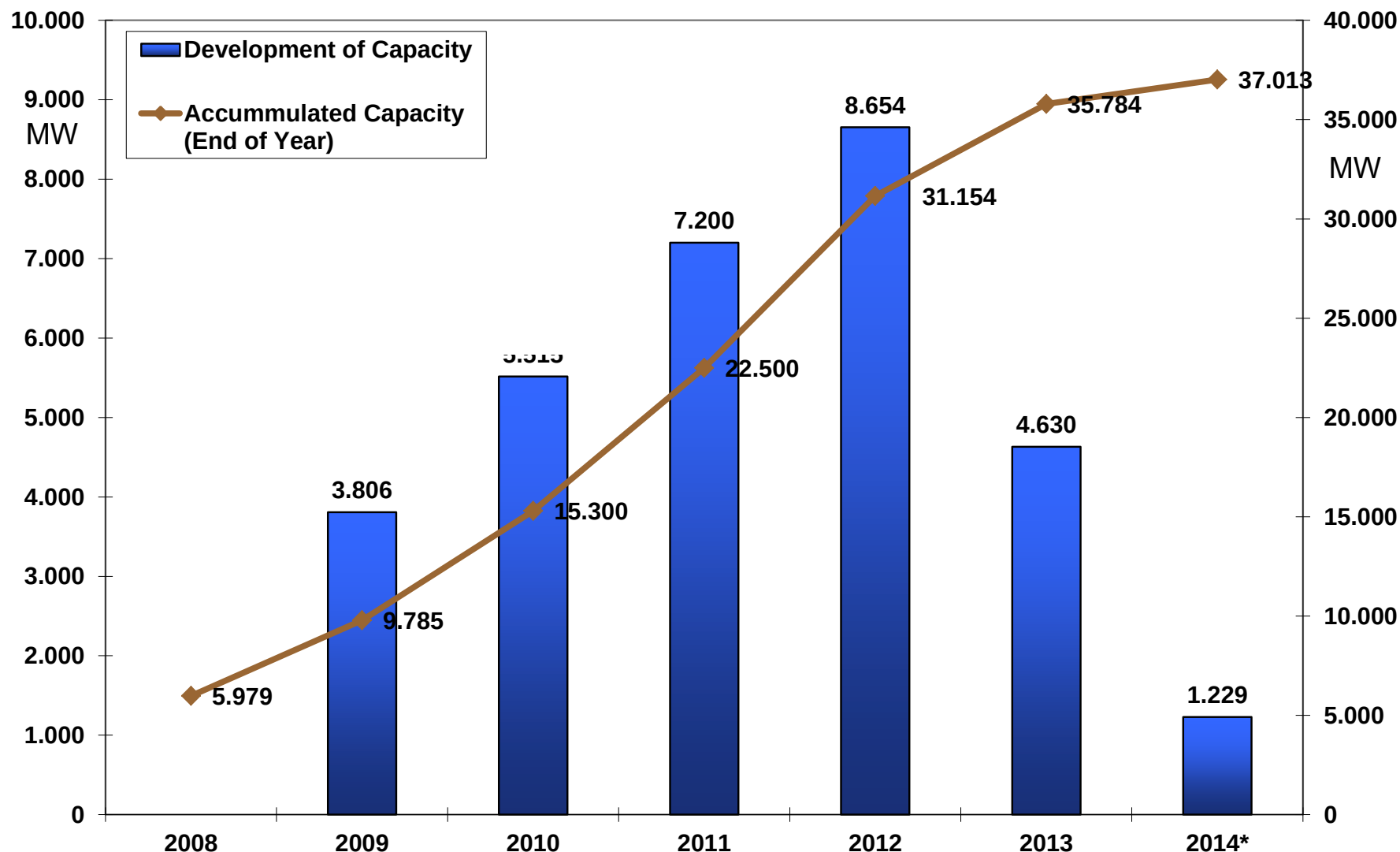


2014*: 1st half

Source: IWES, TSOs



Solar Power: Development in Germany

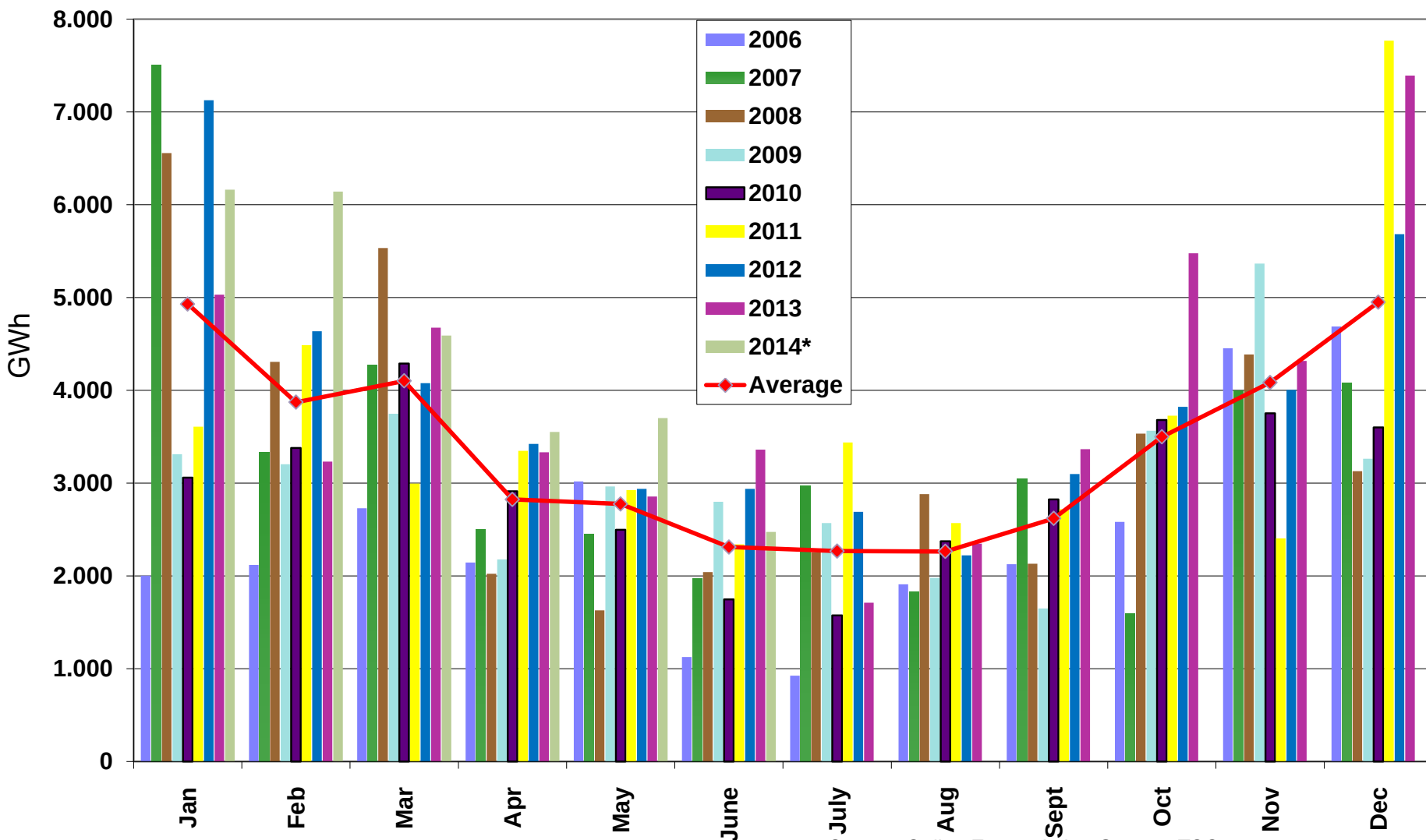


2014*: 1st half

Source: BNetzA, TSOs



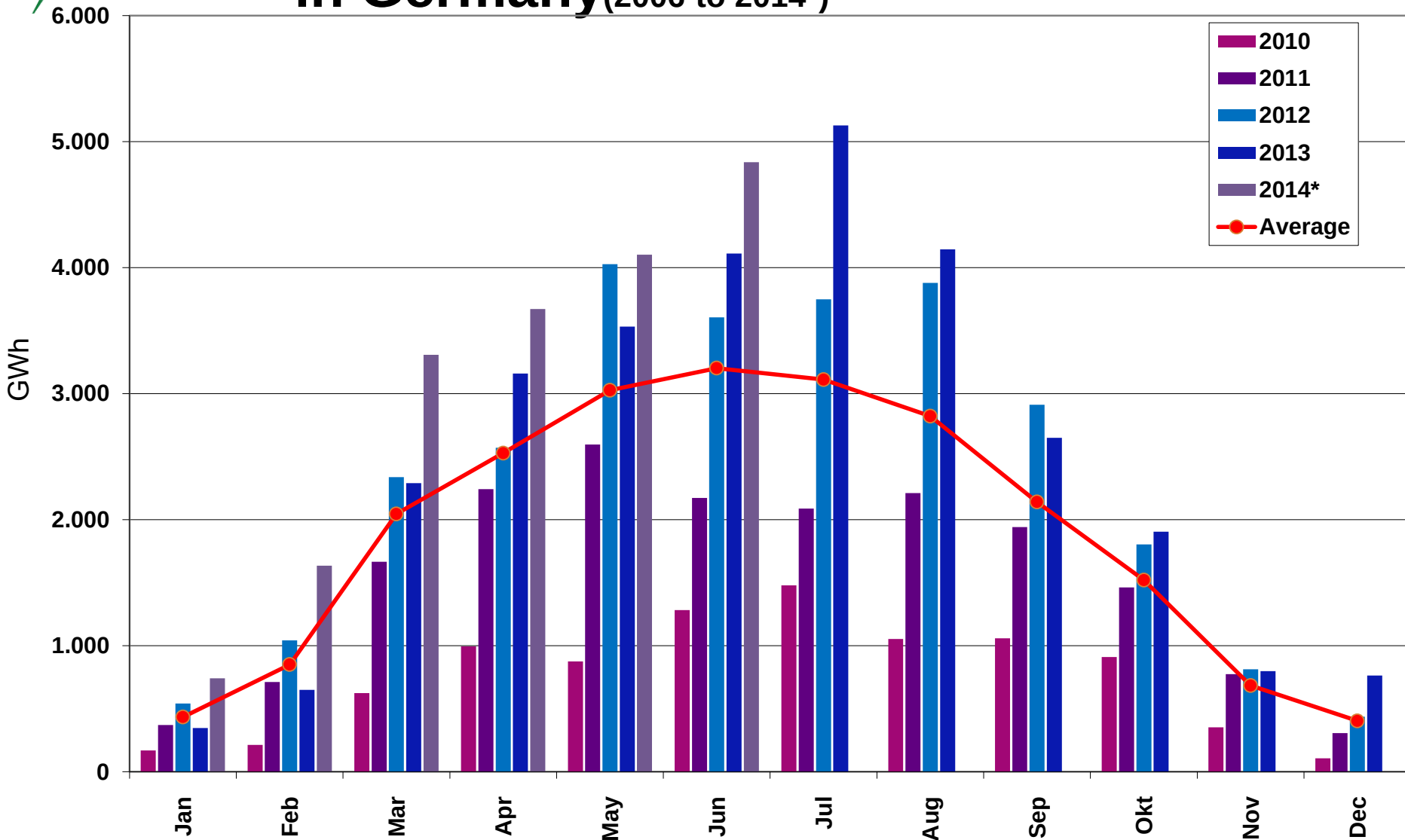
Monthly Production of Wind Energy in Germany (2006 to 2014*)



2014*: 1st half

Source: Online Extrapolation German TSO

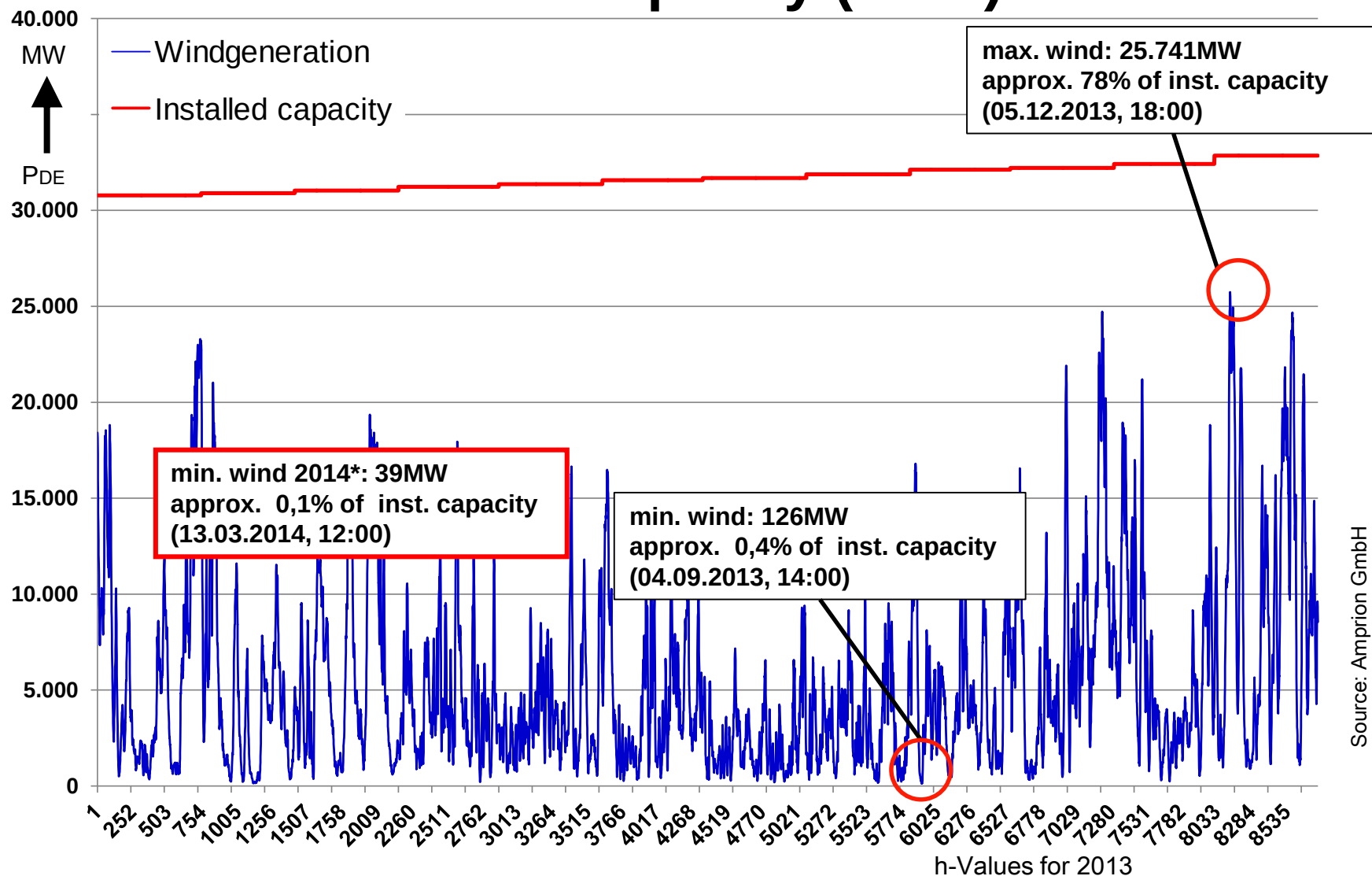
Monthly PV-Generation in Germany (2006 to 2014*)



2014*: 1st half

Source: Online Extrapolation German TSO

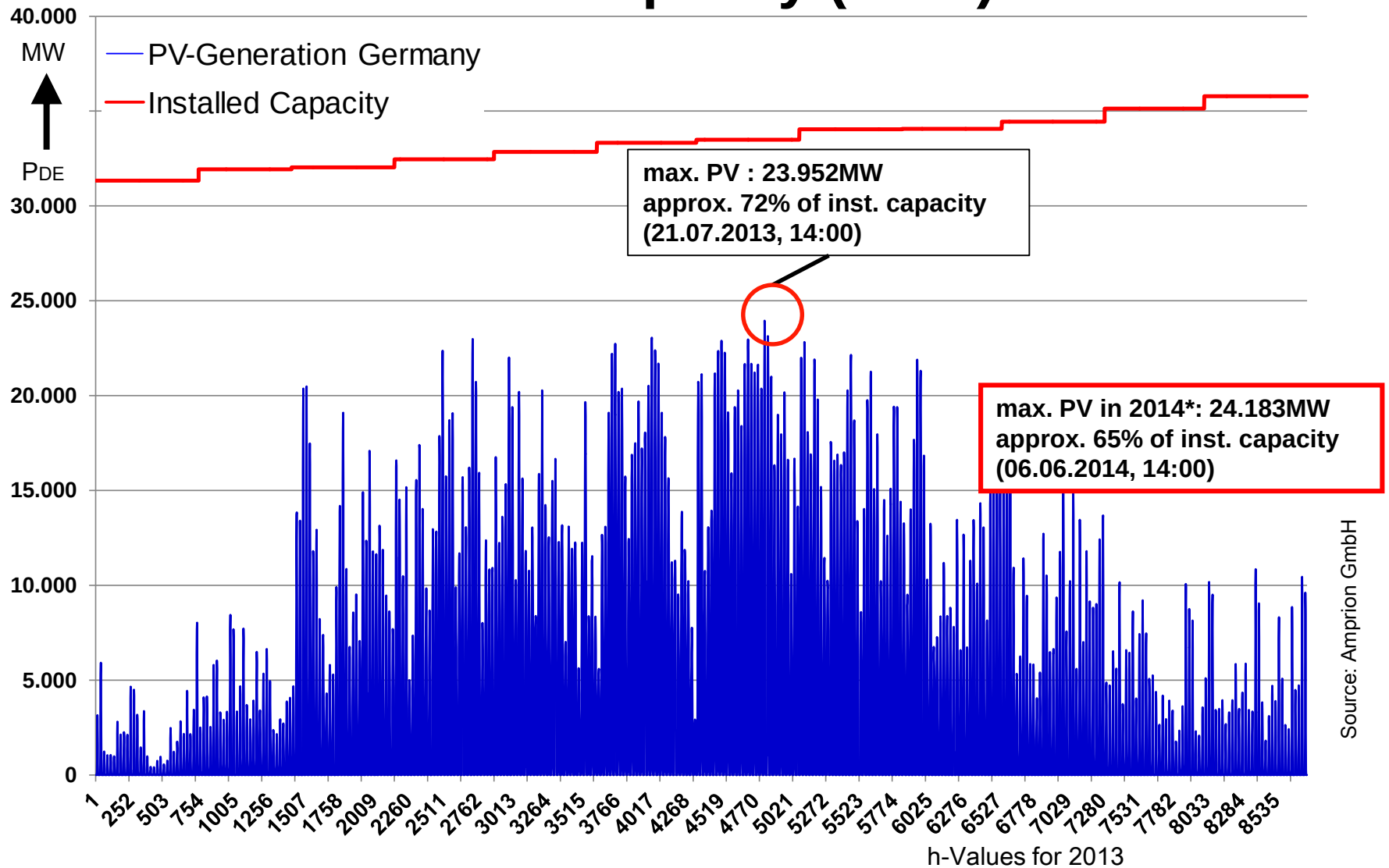
Wind Energy: Installed Capacity versus Real Infeed Capacity (2013)



Source: Amprion GmbH



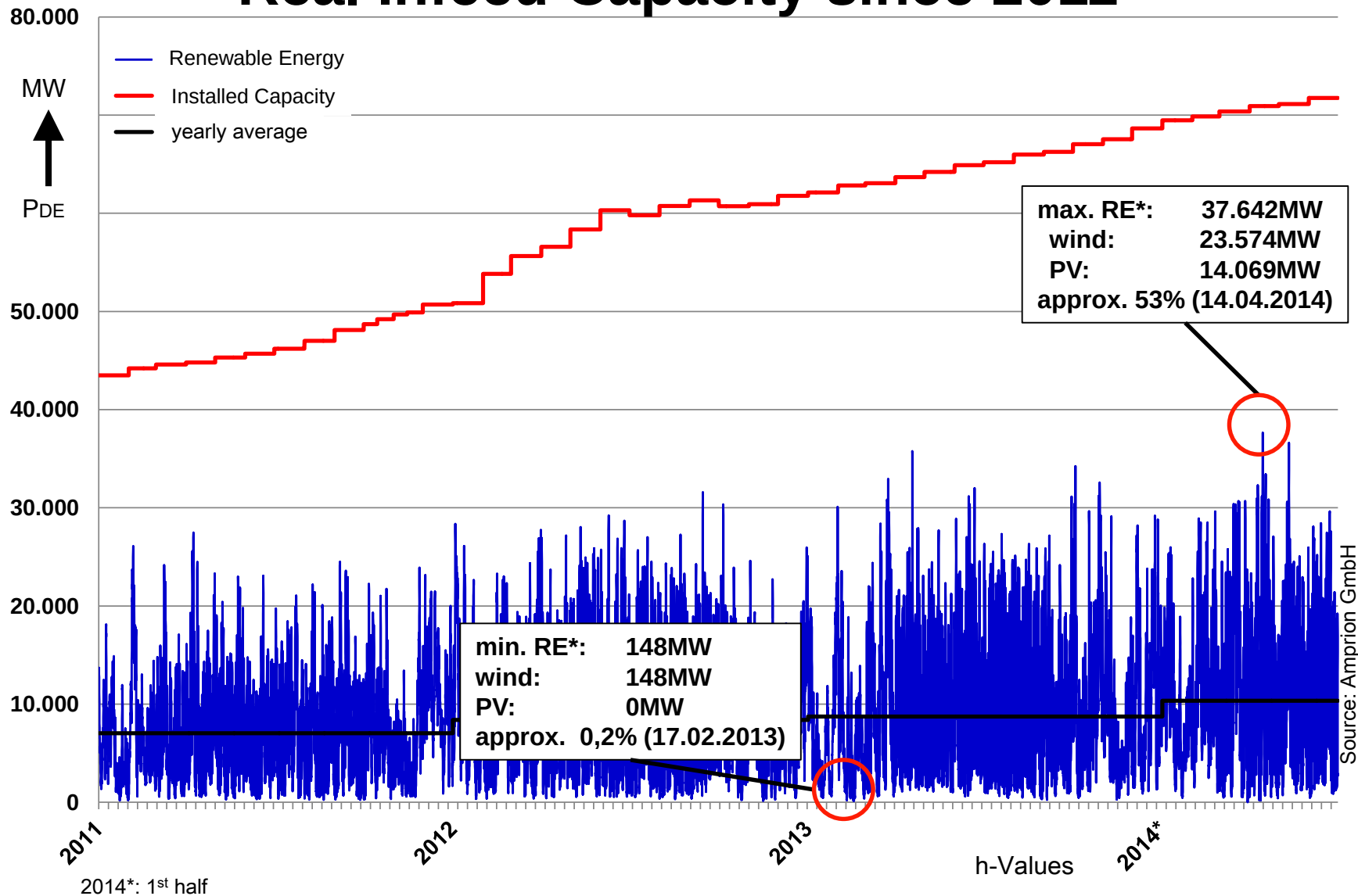
Solar Energy: Installed Capacity versus Real Infeed Capacity (2013)



Source: Amprion GmbH

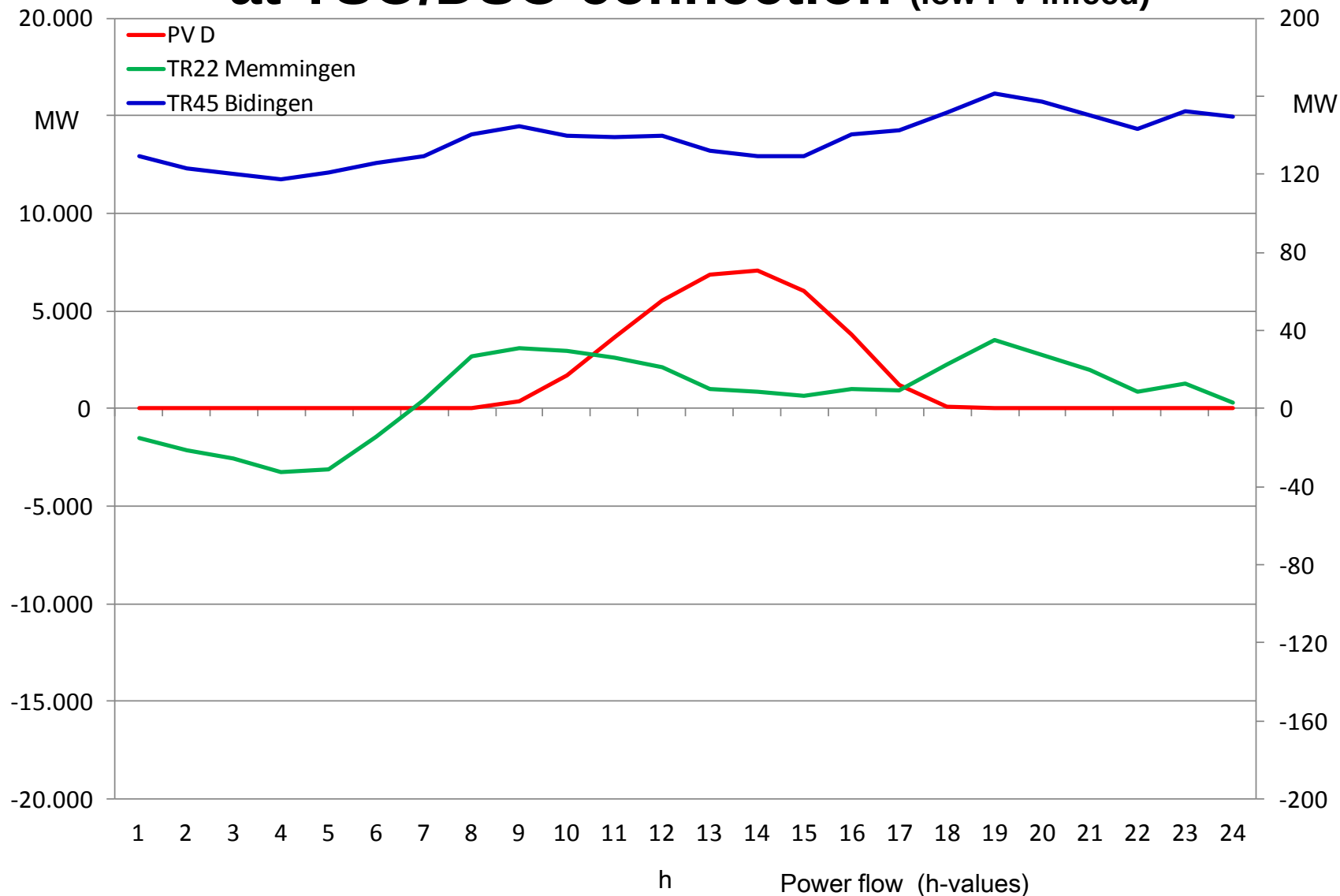


RES: Installed Capacity versus Real Infeed Capacity since 2011



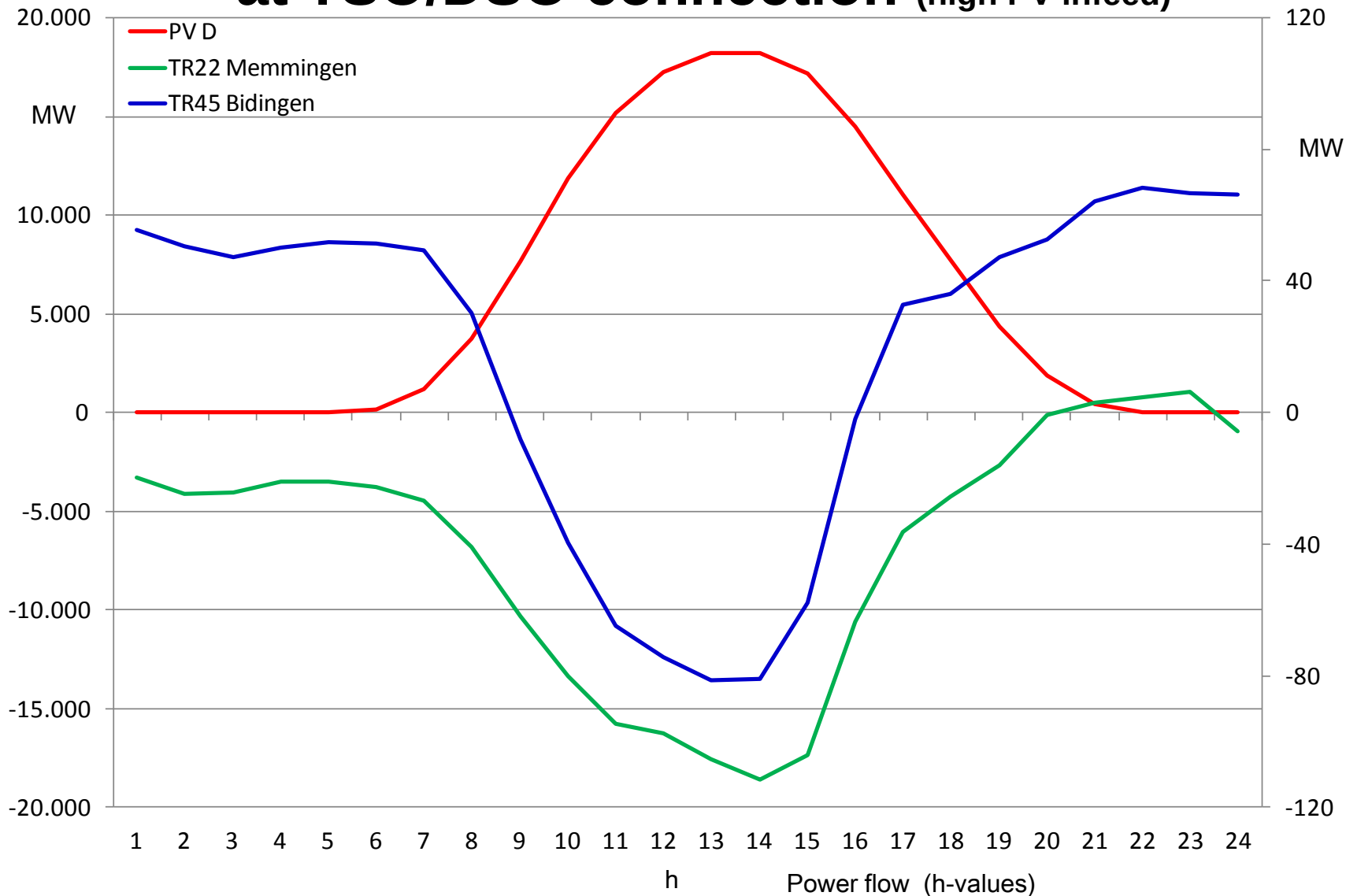


Influence of Dispersed Generation at TSO/DSO connection (low PV infeed)





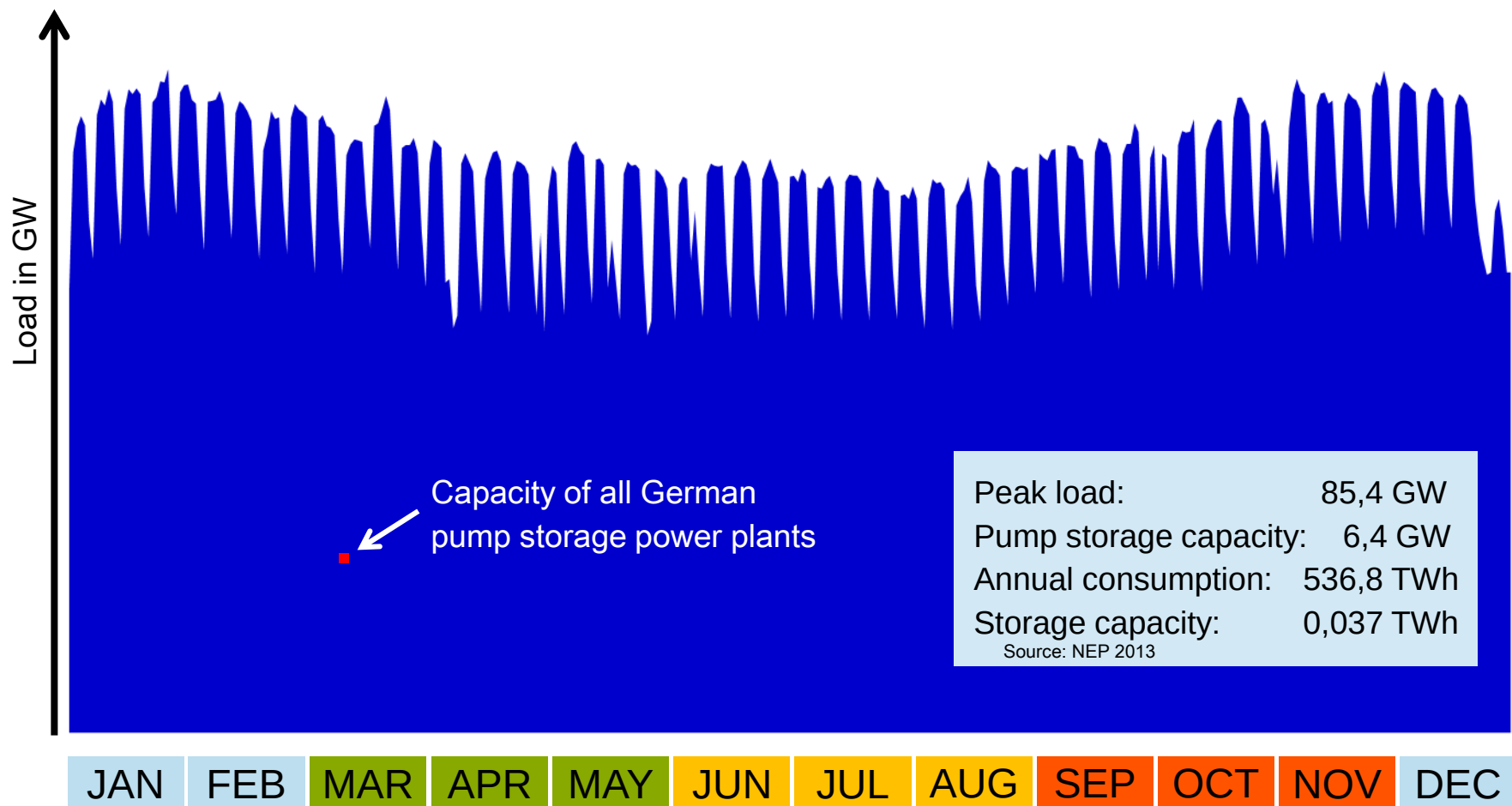
Influence of Dispersed Generation at TSO/DSO connection (high PV infeed)



PV-Generation ↔ Reverse Flow on a Transformer 400/110 KV (measurement by Amprion)



Peak Load versus Capacity of all German pump storage power plants



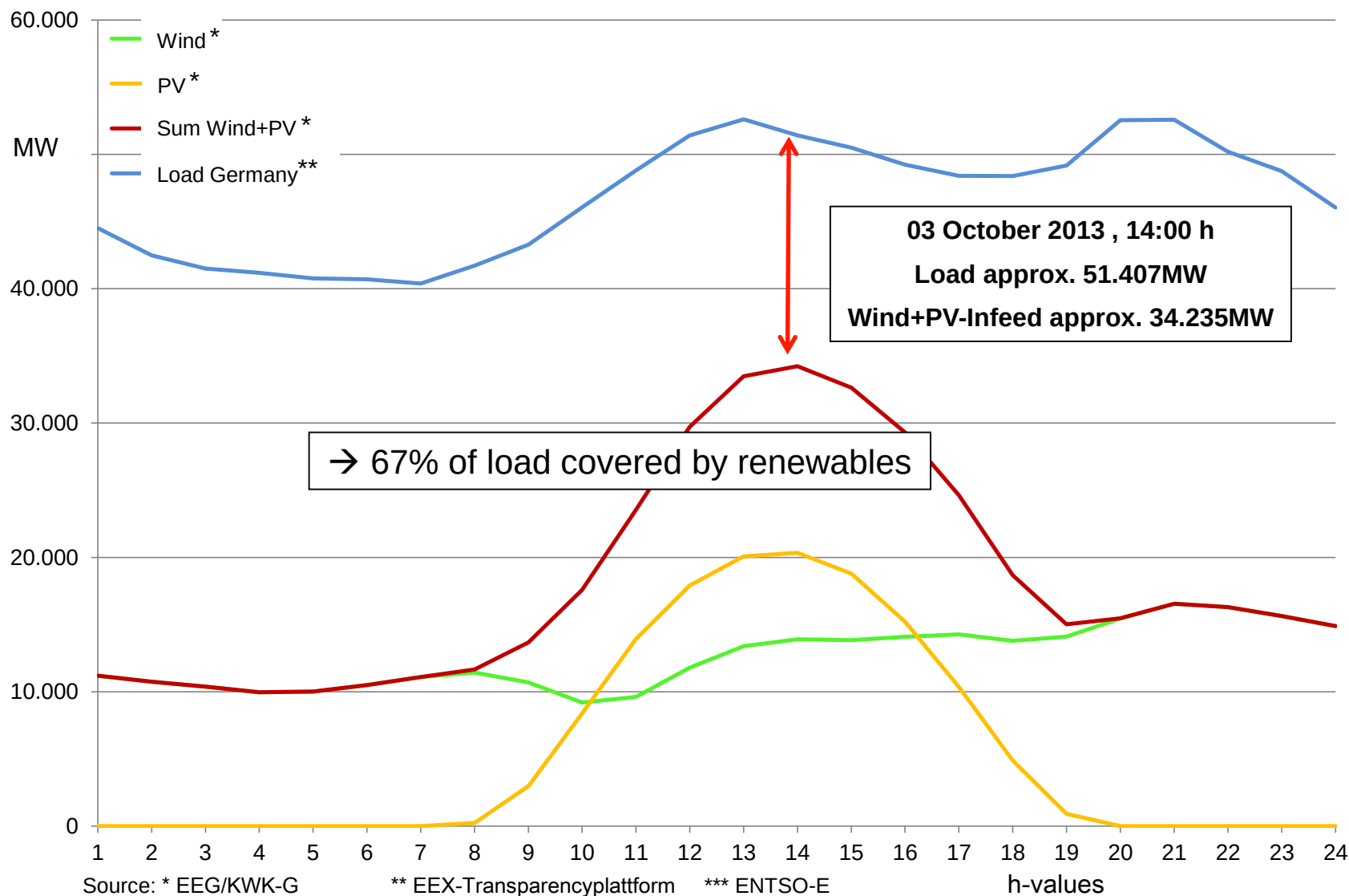
Source: Amprion GmbH

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RES Infeed versus Load in Germany

Date: Thursday, 03 October 2013 (public holiday)

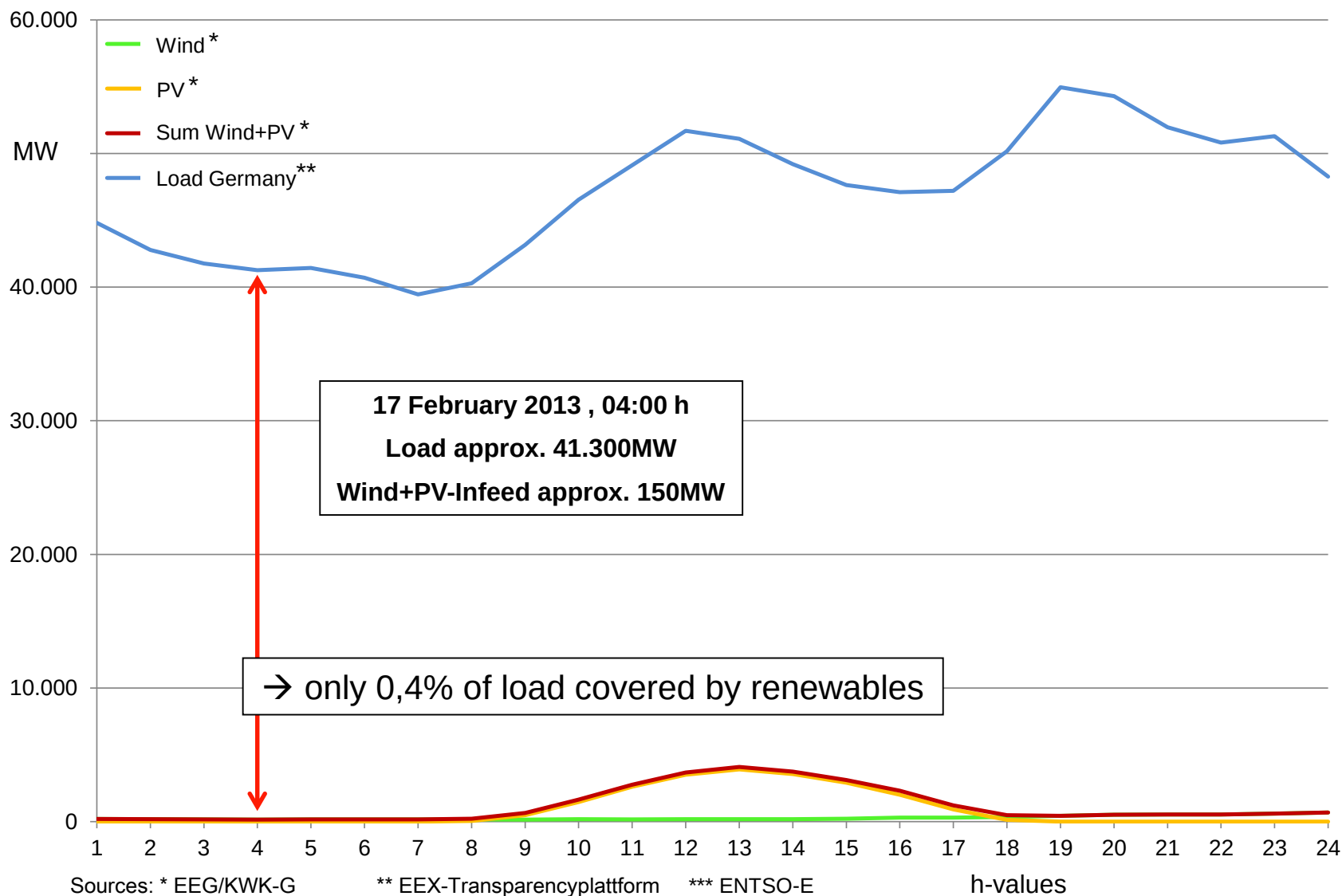


Source: Amprion GmbH

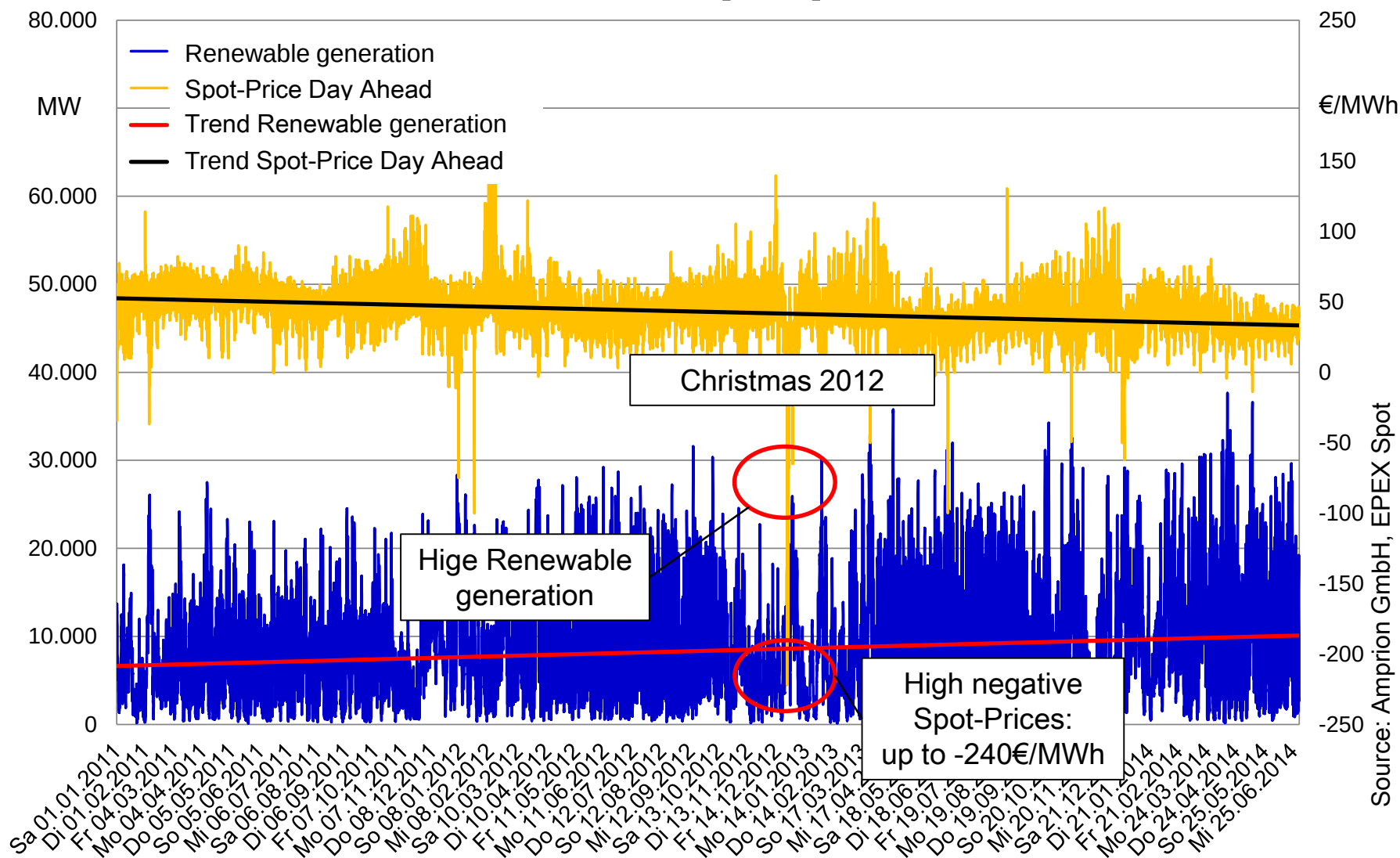


RES Infeed versus Load in Germany

Date: Sunday, 17 February 2013 (lowest renewable infeed)

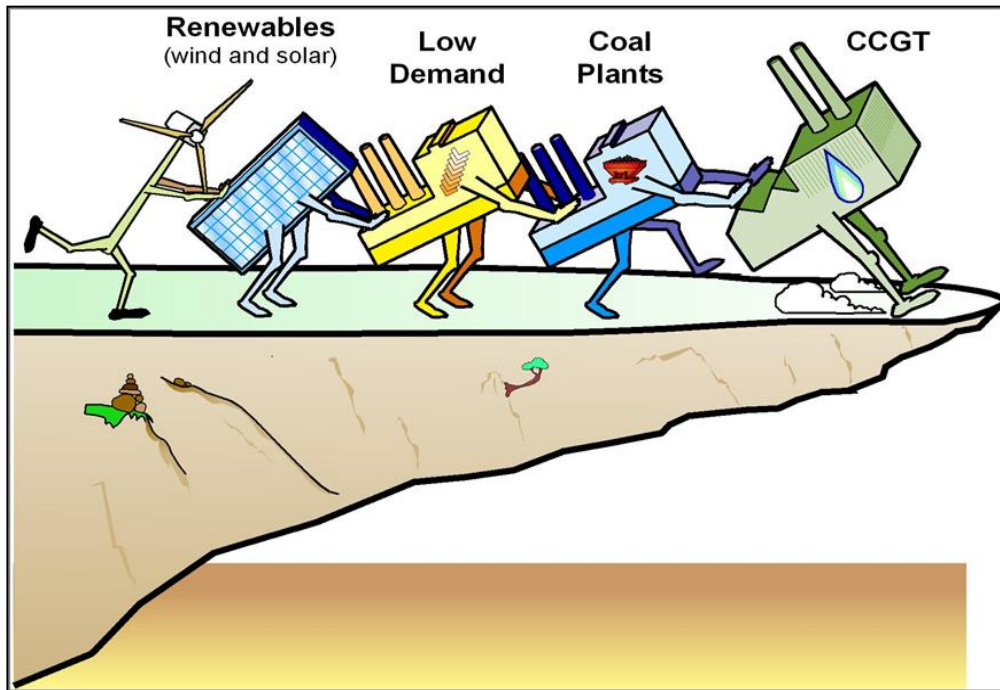


Spot-Price Day Ahead versus RES Generation (1/2)



Source: Amprion GmbH, EPEX Spot

RES push conventional power plants out of the market



The shutdown of thermal generation capacity endangers system stability!

- Increasing share of renewables (Germany: approx. 34 GW PV and 32 GW Wind installed)
- conventional power plants become unviable because of low prices
- Steadily decreasing time of operation of conventional power plants
- just minor peak loads, thereby exposure of the profitability of energy storage

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Summary

- **The current Challenges for Grid Operators are:**
 - Stimulation of the European Electricity Market Integration
 - Market Integration of Renewable Energy Sources (Wind and Solar Power)
 - Change of Generation Pattern (Shutdown of Nuclear PPs and Conventional PPs)
 - Congestion Management and Management of Critical Grid Situations
- **The current and future Challenges for Thermal Power Plants are:**
 - Permanently decreasing utilisation factor due to high priority infeed of RES
 - Flexibility needs and growing load gradients
 - Reliable and flexible thermal generation capacity is essential for security of supply and stability of the transmission grid