Federal Ministry
for Economic Affairs
and Energy

Market & Flexibility

An Electricity Market for Germany‘s Energy Transition

October 2014

Broad discussion process with German and European stakeholders (Green Paper)

Key question: How to help electricity market fullfil its *two* roles:

- Reserve function
- Dispatch function

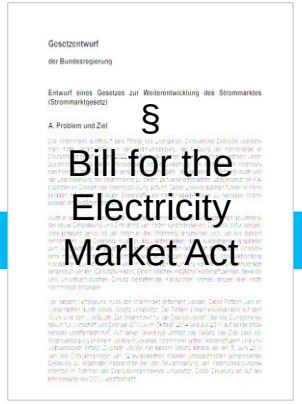
July 2015

Decision for an energy-only market 2.0 (White Paper)

Further consultations in the context of the Electricity Market Platform

Autumn 2015 - Spring 2016

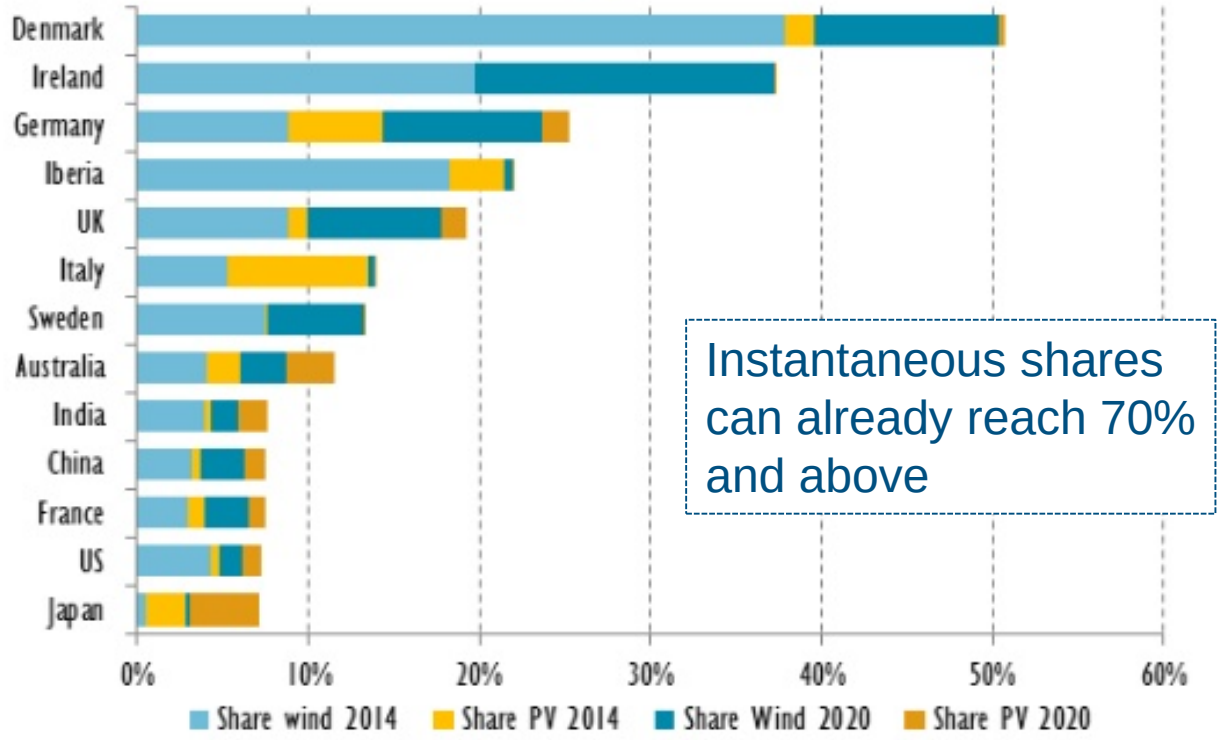
Enactment of legislation



§

Bill for the Electricity Market Act

Share of variable renewables in produced electricity 2014

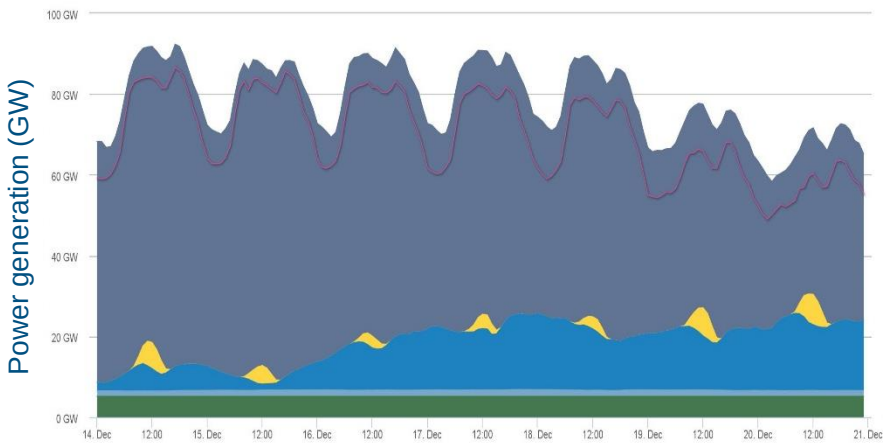


Instantaneous shares can already reach 70% and above

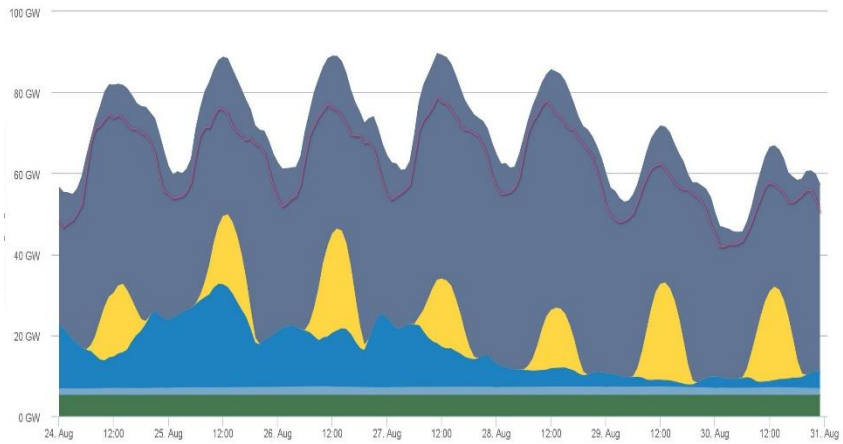
Source: IEA 2015

German electricity system volatility today

Winter 2015 - week no. 51 (December)



Summer 2015 - week no. 35 (August)

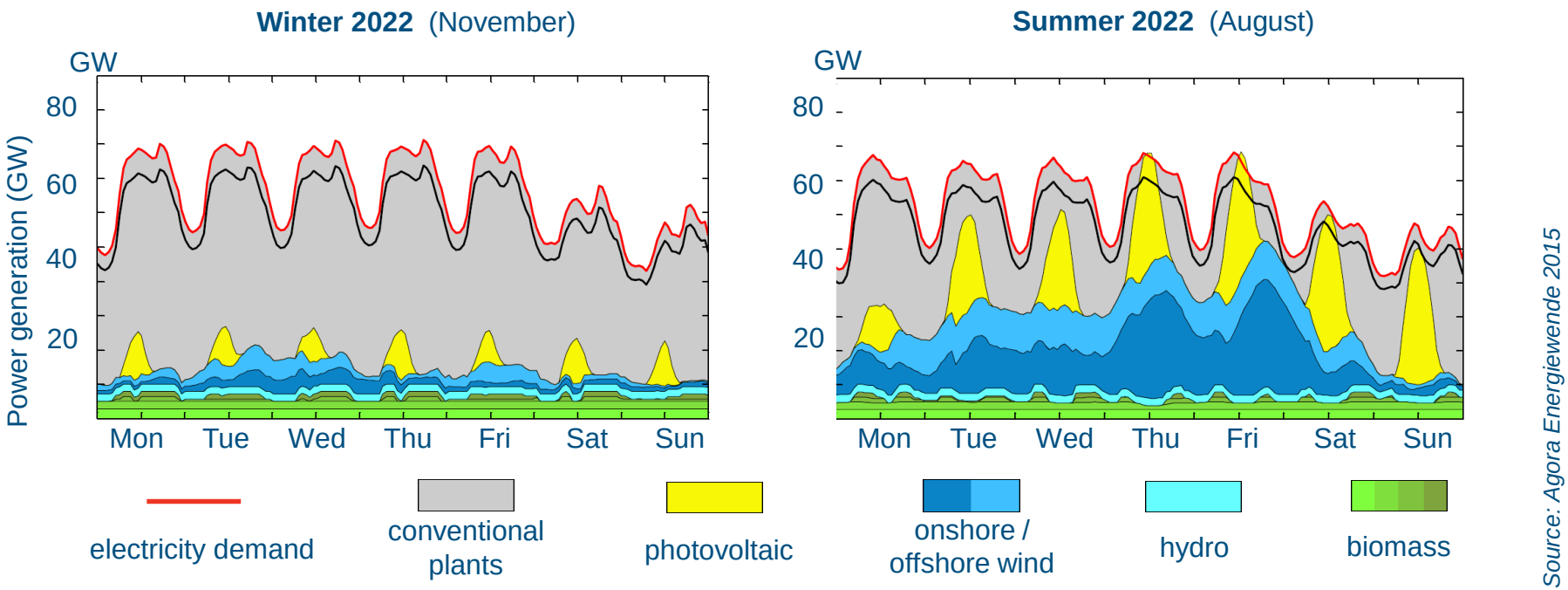


electricity demand | conventional plants | photovoltaic | onshore / offshore wind | hydro | biomass

Source: Agora Energiewende 2015

The contribution of renewables to the electricity system varies widely depending on the season.

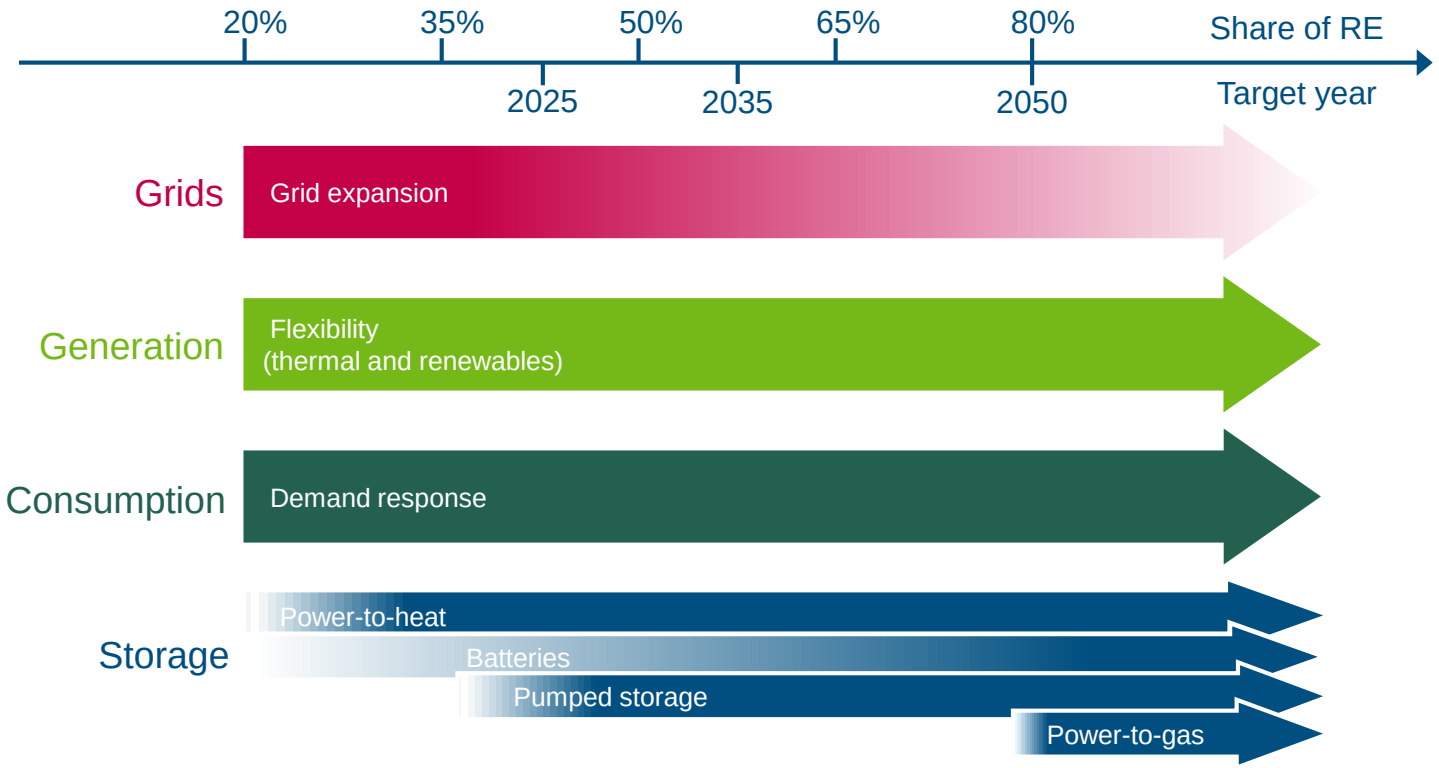
Future: German electricity system volatility in 2022



Source: Agora Energiewende 2015

By 2022 renewables can cover the total demand for certain hours e.g. over midday, but for the calm winter days conventional back-up capacity will still be needed.

Four areas to increase flexibility



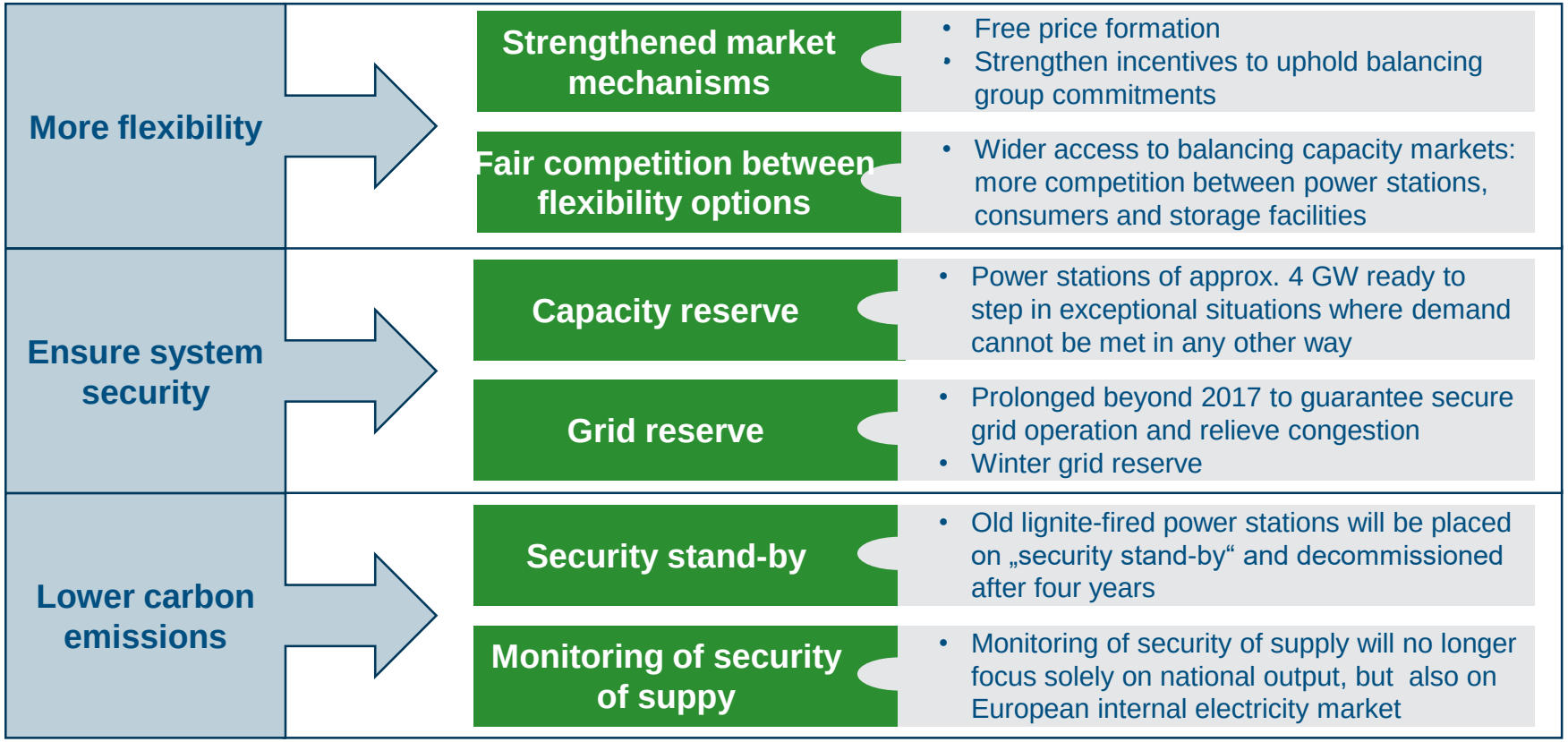
Source: BMU 2014

Technology neutral policies foster innovation: Different flexibility measures are suitable for different challenges to the grid.

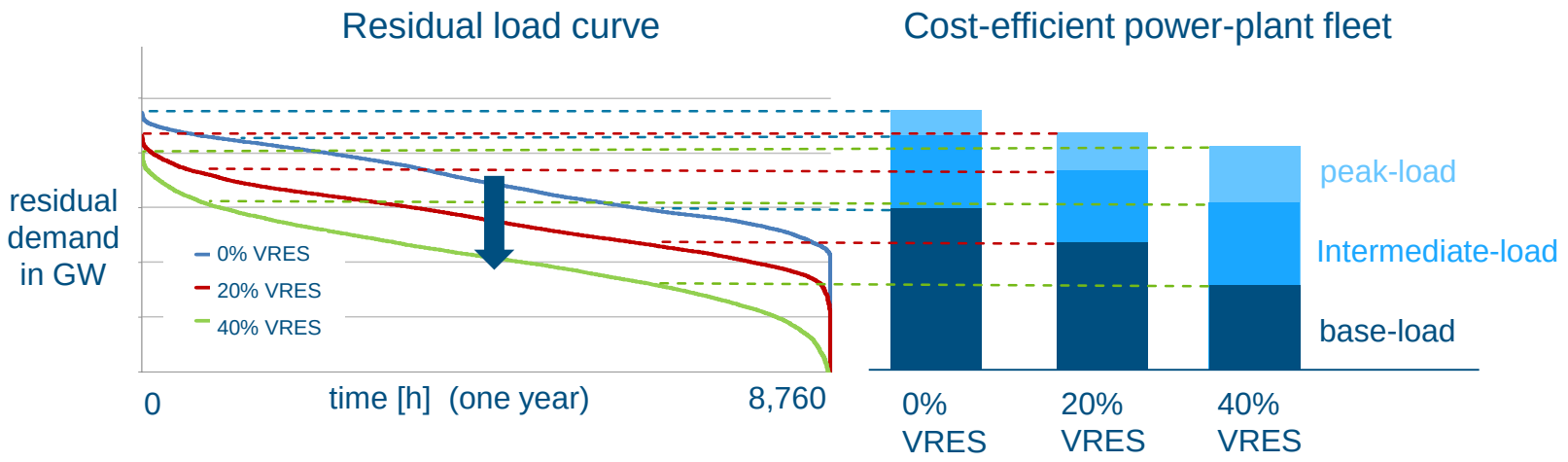
Discussion

Federal Ministry
for Economic Affairs
and Energy

Key elements of the electricity market act 2016



Change of requirements for power plants



Variable renewable energies (VRES) decrease residual demand and full-load hours for conventional power plants.

Need for peak-load increases, while base-load technologies decrease.

Source: Nabe 2006

Due to the energy transition Germany will need less base-load and more intermediate-load in the future.

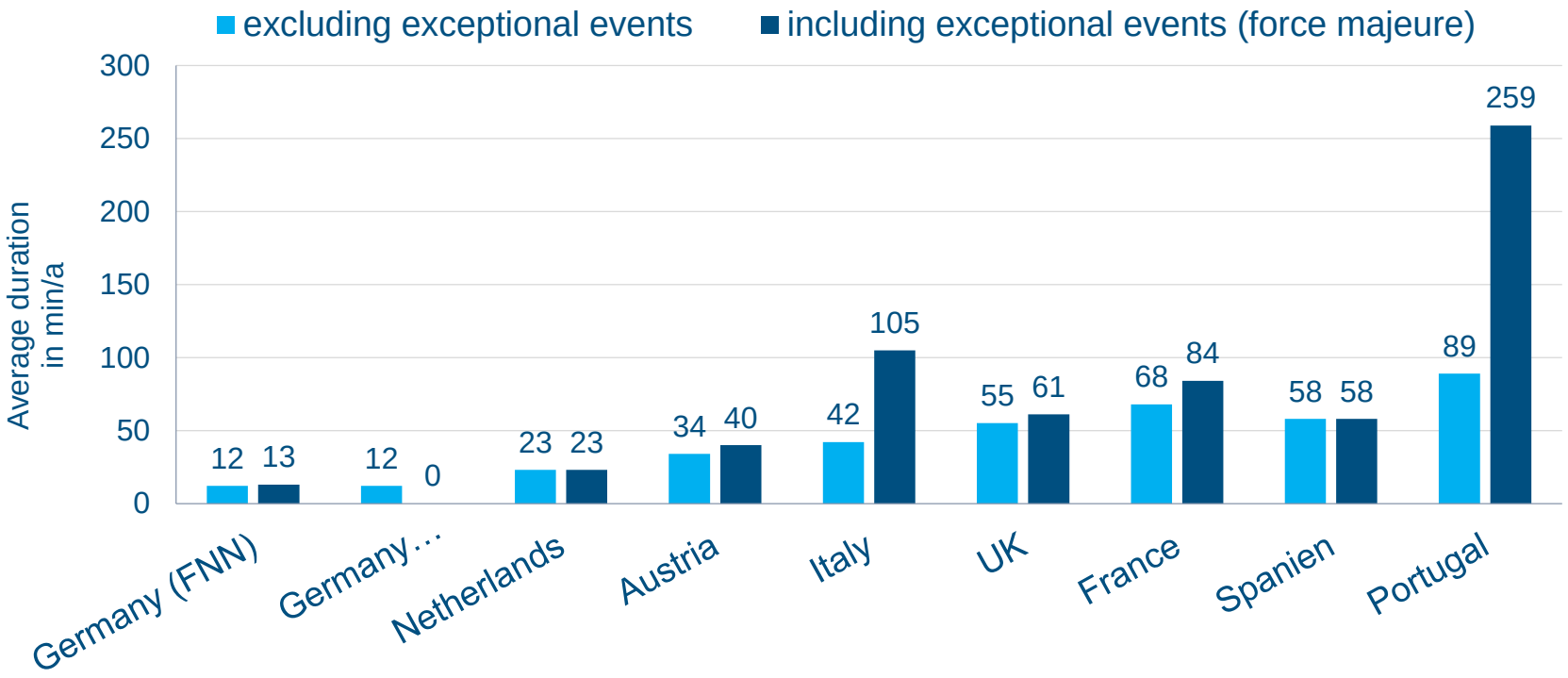
Flexibility of the German power plant fleet

Technical characteristics of conventional power plants							
power plants	cost / installed capacity	efficiency	CO_2 emissions	load change rate	minimum load	warm start up	cold start up
	€/kW	%	kg/MWh$_{el}$	% P_N/min	%/P_N	h	h
Hard coal	1.300	36 - 46 (50)	939 - 735 (676)	1,5 - 4 (6)	40 - 25 (20)	3 - 2,5 (2)	10 - 5 (4)
Lignite	1.400	32 - 43 (44)	1.263 - 940 (804)	1 - 2,5 (4)	60 - 50 (40)	6 - 4 (2)	10 - 8 (6)
CCGT	700	40 - 62	503 - 347	2 - 4 (8)	50 - 40 (30)	1,5 - 1 (0,5)	4 - 3 (2)
GT	400	37,5	640	8 - 12 (15)	50 - 40 (20)	< 0,1	< 0,1

Source: dena 2014

Increasing flexibility of conventional power plants allows balancing volatile renewables.

Energy security: duration of supply failures in Europe 2014



Source: CEER 2015; BMWi 2015

Germany maintains top energy security levels during the energy transition.

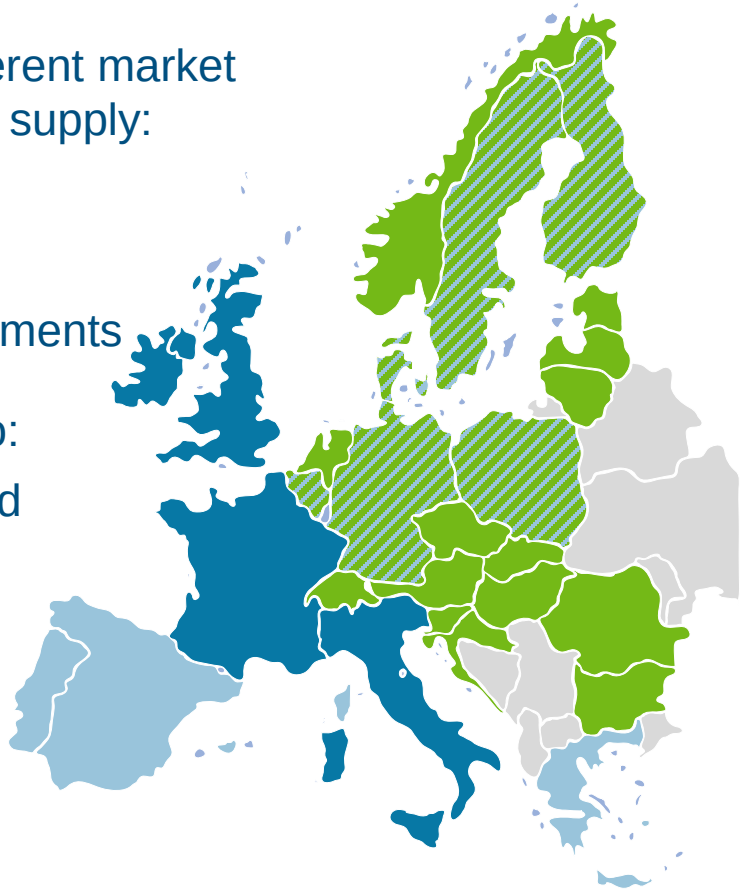
EU energy market design – requirements and solutions

EU countries currently debate different market designs to secure future electricity supply:

- Energy-only markets
- Additional capacity markets
- Other means, e.g. capacity payments

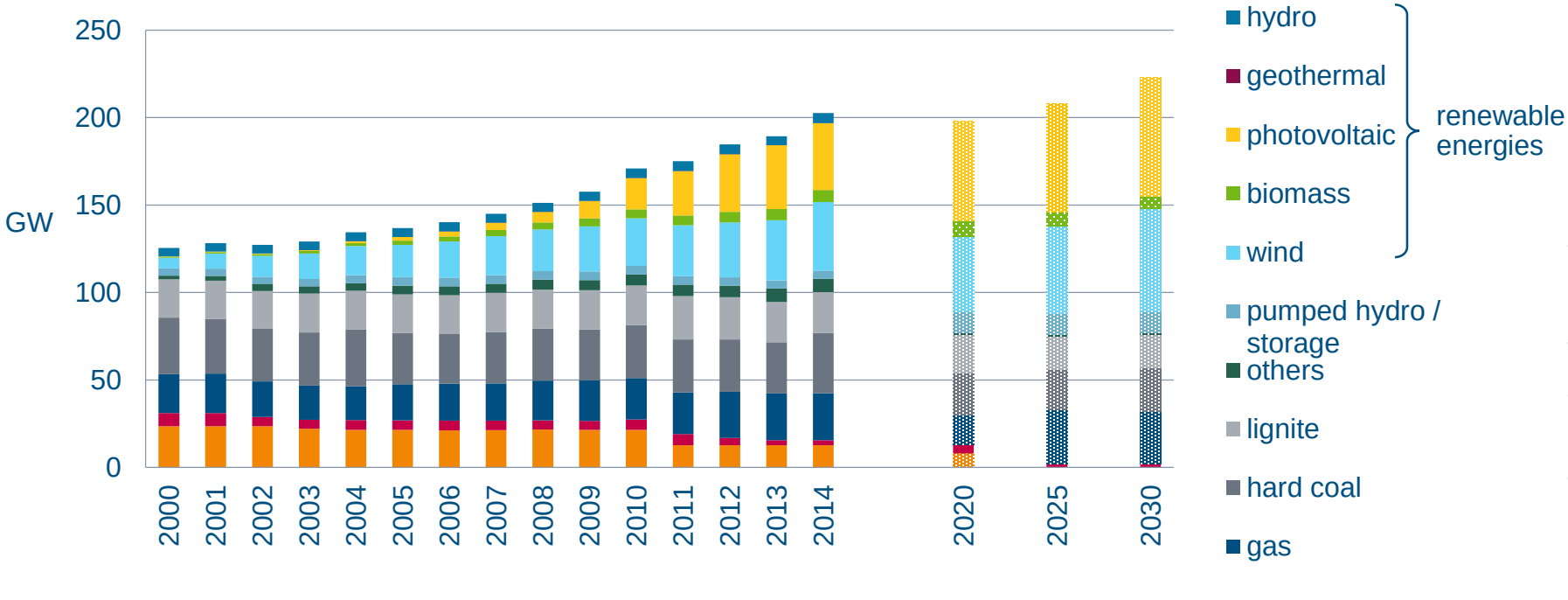
The future energy market needs to:

- be suitable for an inter-connected EU-wide electricity market
- give clear price signals for new investment
- promote regional cooperation, including on support schemes



Source: BMWi based on CEPS 2014, DIW 2013, Frontier 2014

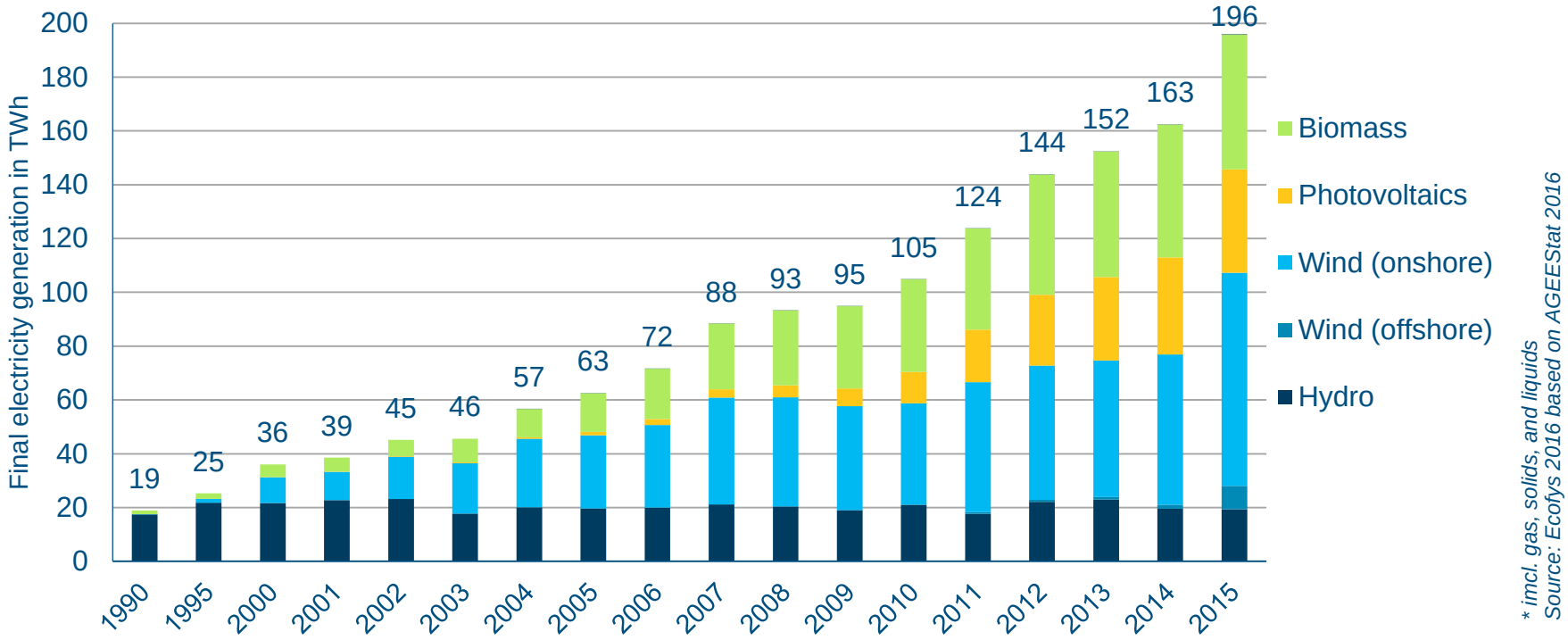
Gross power generation capacities in Germany



Source: Eocfys 2015 based on BMWi 2015, Prognos,EWI,GWS 2014

Renewable expansion has led to a growth in total capacity.

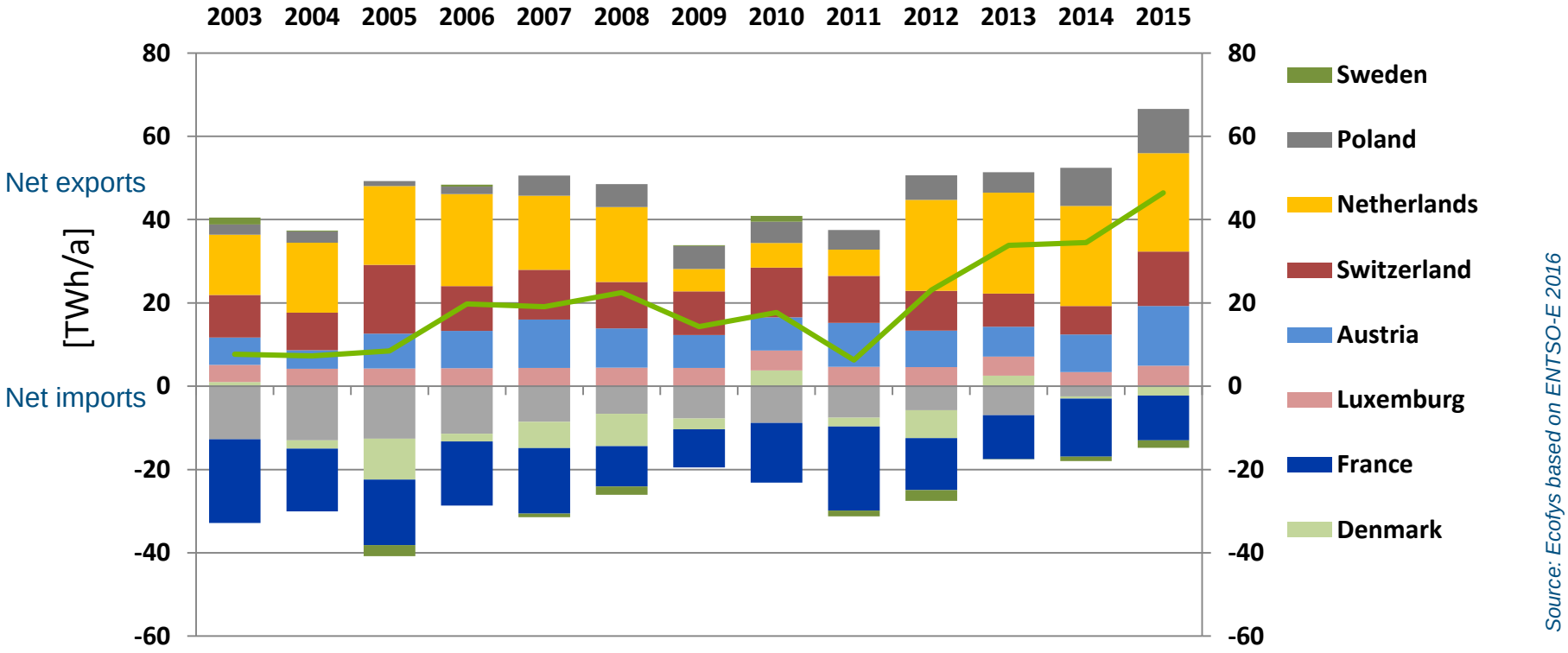
Development of electricity generation from renewable energy sources in Germany



** imcl. gas, solids, and liquids*
Source: Ecofys 2016 based on AGEEStat 2016

While in the 1990s hydro was the only renewable energy source, wind onshore, biomass and solar contribute all to the generation of electricity.

Electricity import and export balance (load flow)



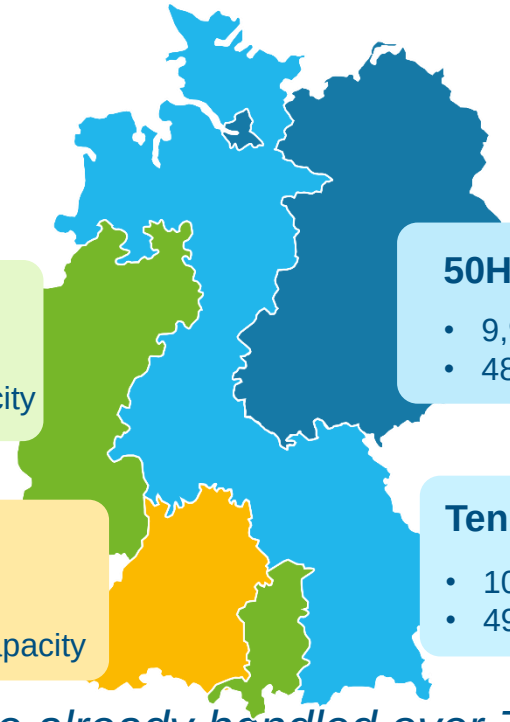
Source: Ecofys based on ENTSO-E 2016

Germany is a net exporter, the Netherlands imports the most electricity from Germany.

Transmission system operators in Germany and share of fluctuating renewables

Germany

- Highest volatile capacity: 42 GW at 60 GW load
- Hourly shares over 65%



Amprion

- 11,000 km
- 24.7% volatile peak capacity

50Hertz

- 9,995 km
- 48% volatile peak capacity

TransnetBW

- 3,420 km
- 31.6% volatile peak capacity

TenneT

- 10,800 km
- 49.5% volatile peak capacity

German TSOs have already handled over 75% of the power in the grid coming from renewables.

Source: Ecofys 2015, based on data from Transmission system operators 2014, Fraunhofer ISE 2014, Agora 2016