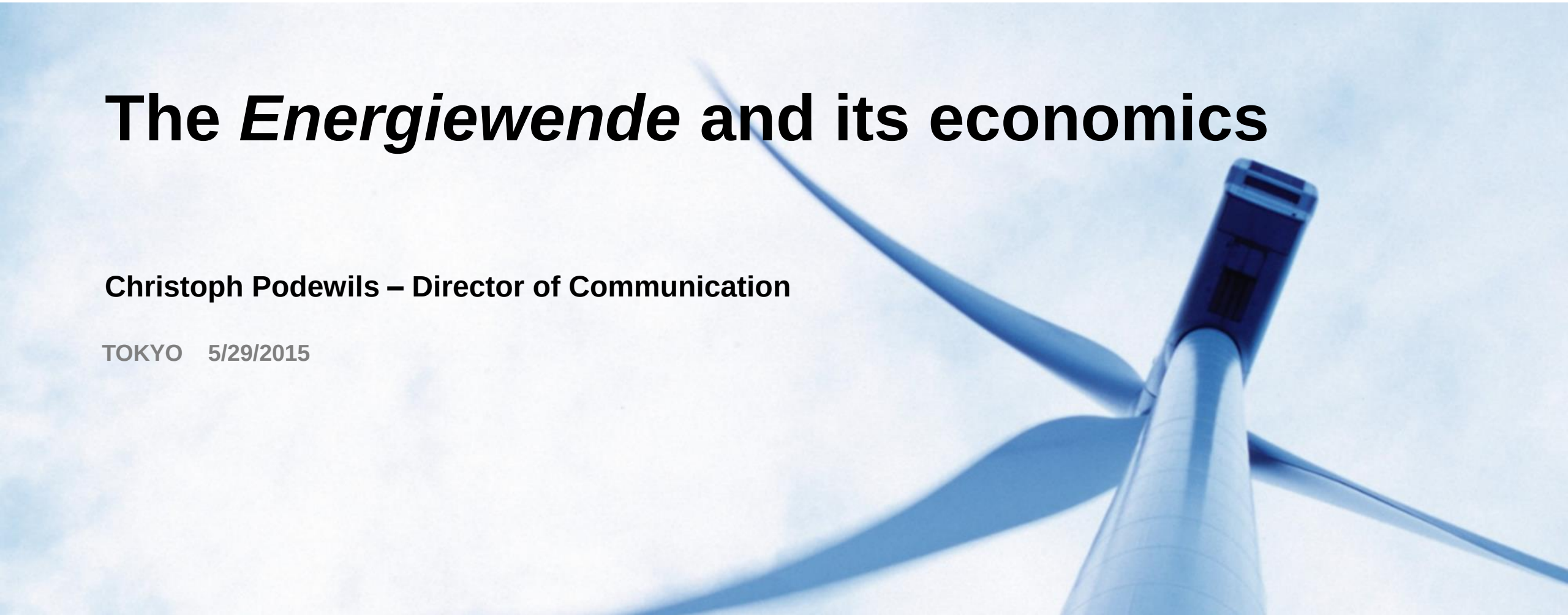
The *Energiewende* and its economics

Christoph Podewils – Director of Communication

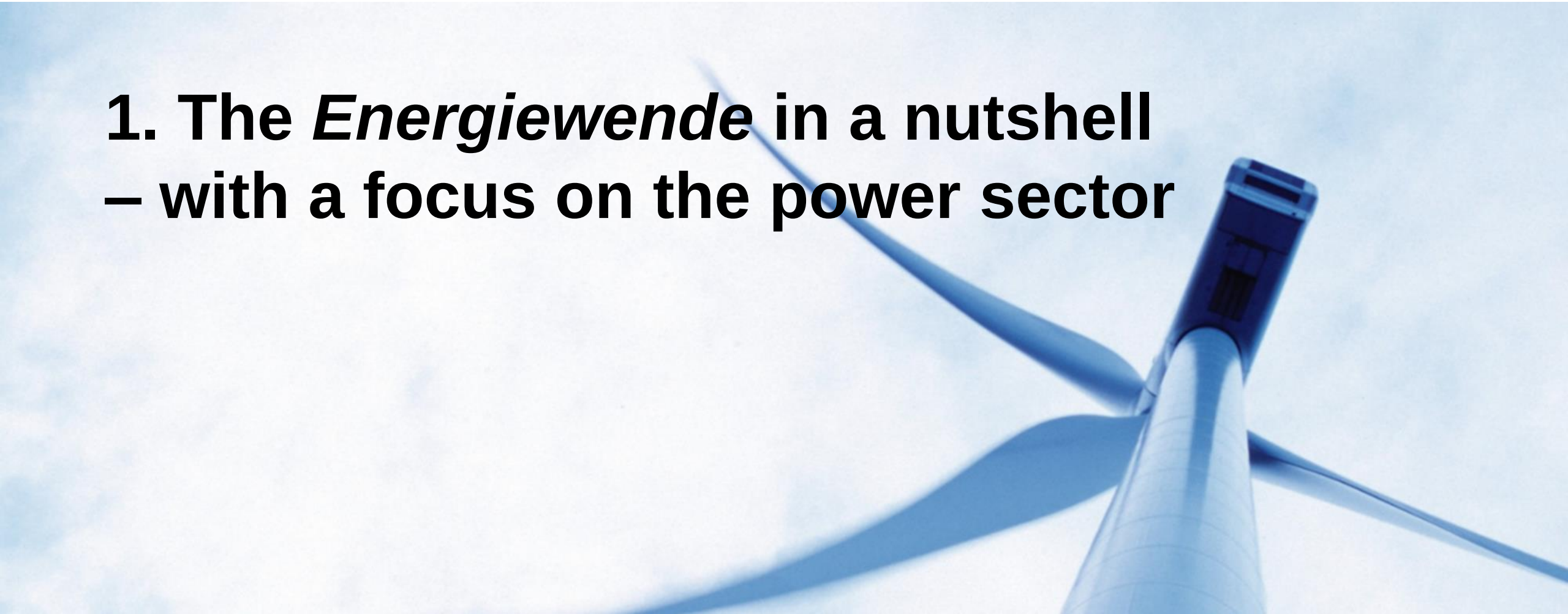
TOKYO 5/29/2015



Who we are

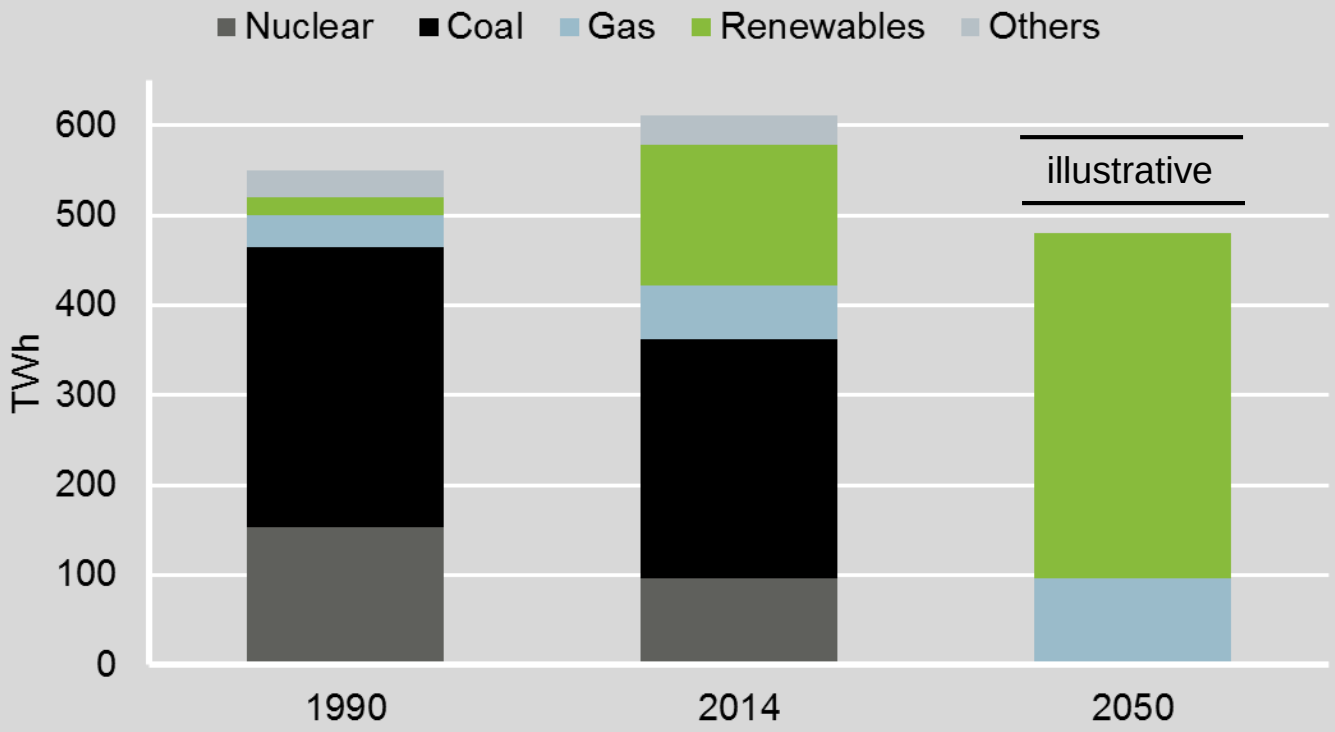
- Independent and non-partisan Think Tank, 18 Experts
- Project duration: 2012-2017 | Financed with 15 million Euro by the Mercator Foundation and the European Climate Foundation
- Mission: How do we make the *Energiewende* in Germany a success story?
- Analyzing, assessing, understanding, discussing, putting forward proposals

1. The *Energiewende* in a nutshell – with a focus on the power sector



The *Energiewende* means fundamentally changing the power system

Gross power production in 1990, 2014 and 2050



AG Energiebilanzen (1990, 2014); illustration based on current targets (2050)

Greenhouse Gas Emissions
Reduction of 40% by 2020 and
80% to 95% by 2050 below 1990 levels

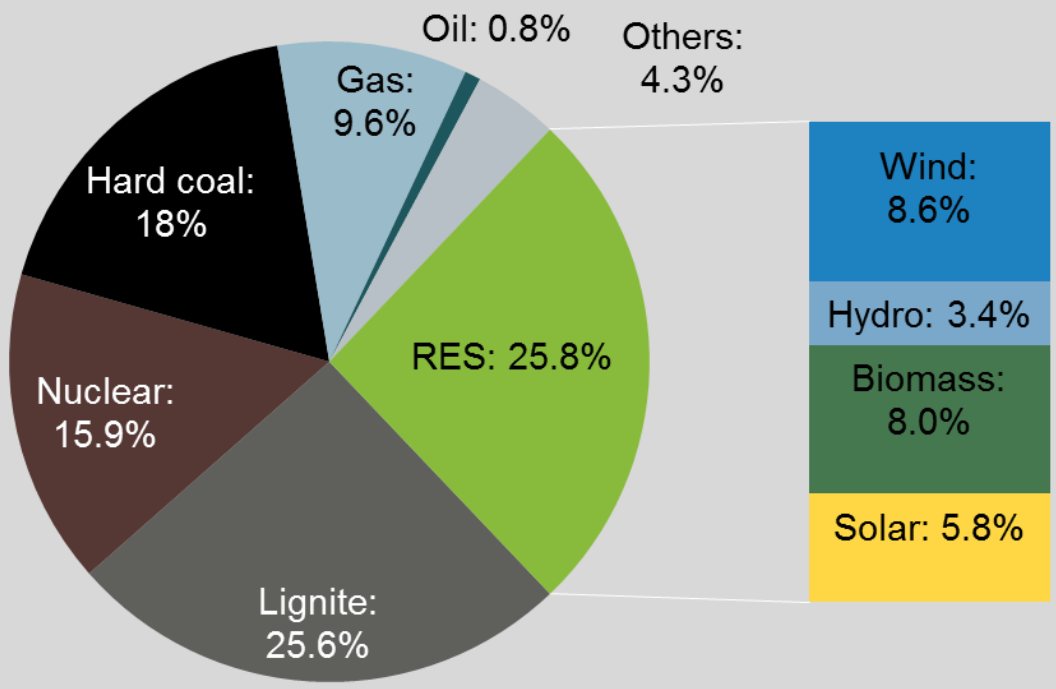
Nuclear
Stepwise shut down of all power plants until 2022

Renewables
Share in gross electricity consumption of 40-45% by 2025, 55-60% by 2035 and at least 80% by 2050

Efficiency
Reduction of electricity demand by 10% by 2020 and 25% by 2050 below 2008 levels

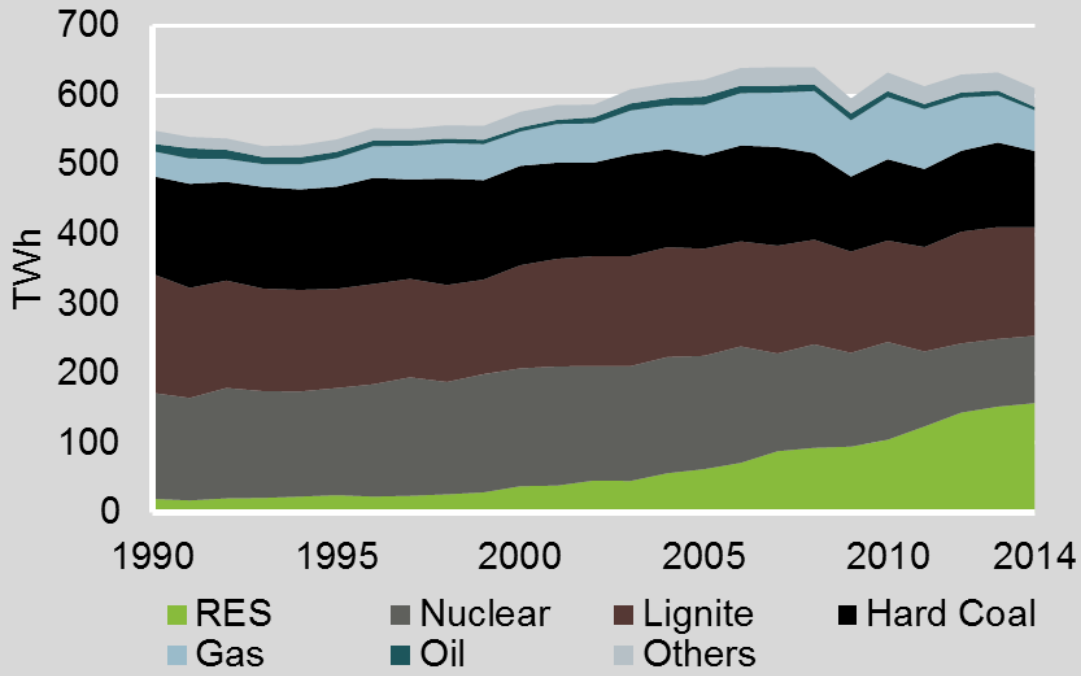
Renewables comprise with 26% the largest share in the German power mix 2014

Share of energy sources in gross power production in 2014



AG Energiebilanzen (2014)

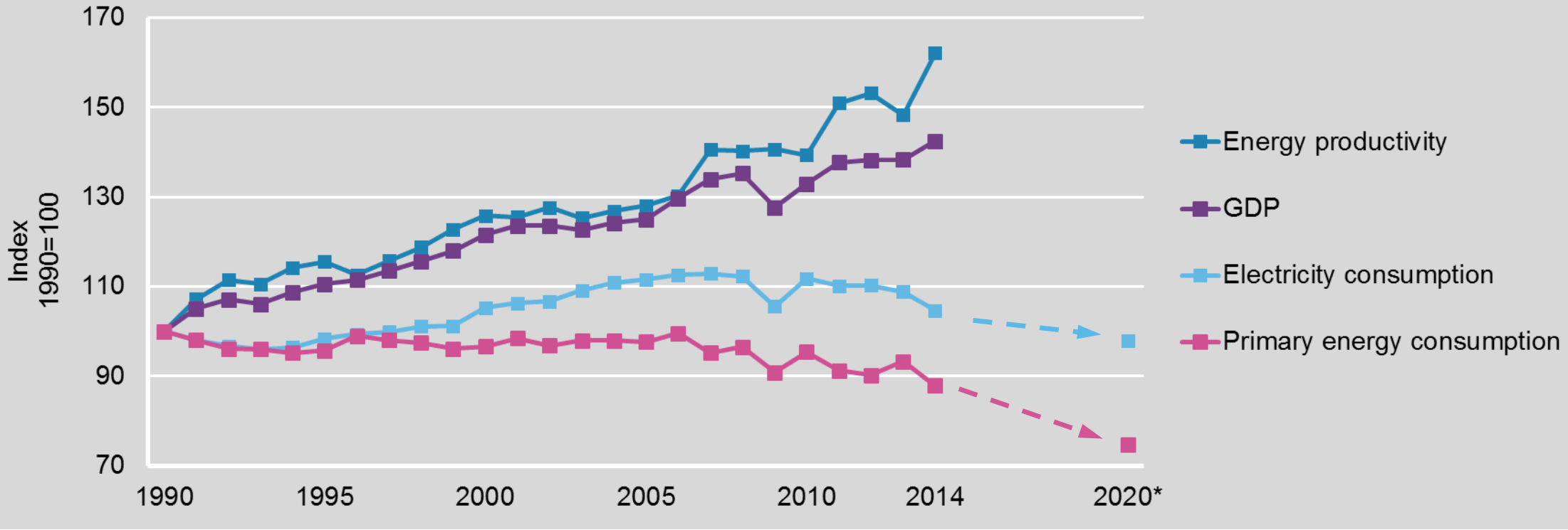
Development of gross power production 1990-2014 in TW



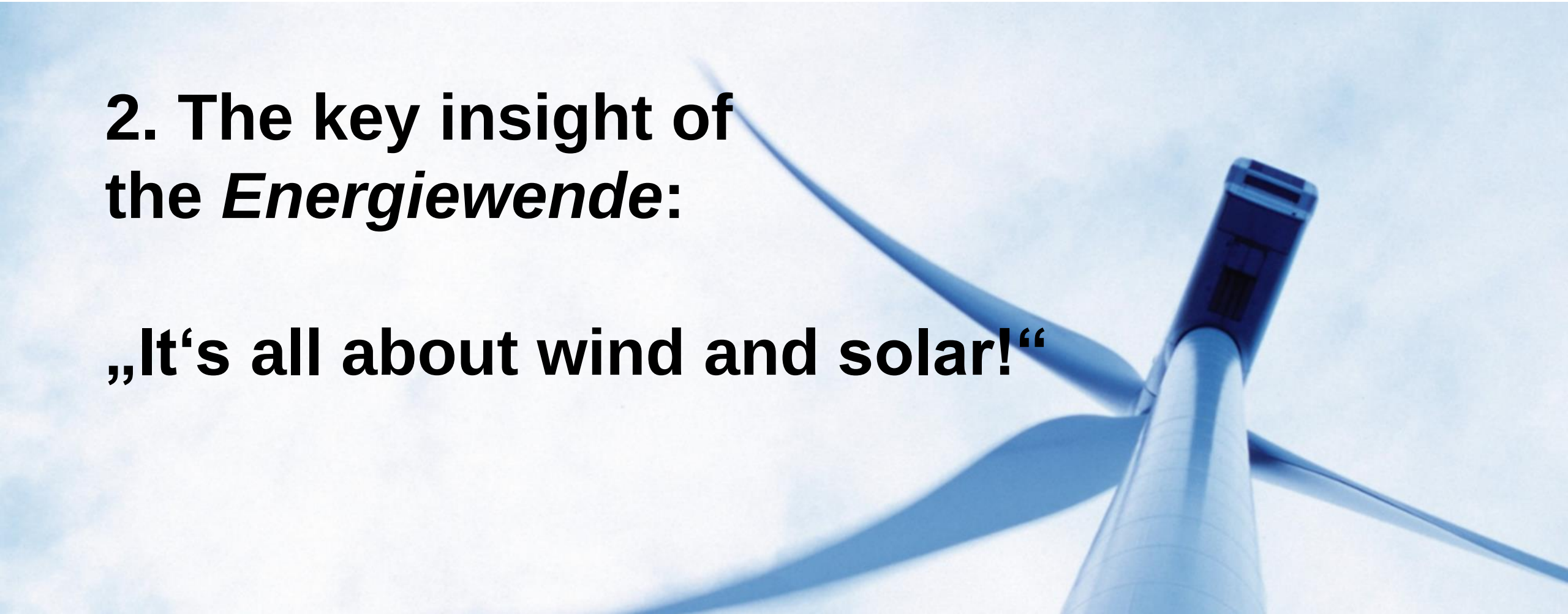
AG Energiebilanzen (2014)

Germany decoupled economic growth from energy and electricity consumption – and increased renewables steadily

Energy productivity and consumption and economic growth 1990 – 2014 (Index, 1990=100)



AG Energiebilanzen (2014), BMWi (2014)

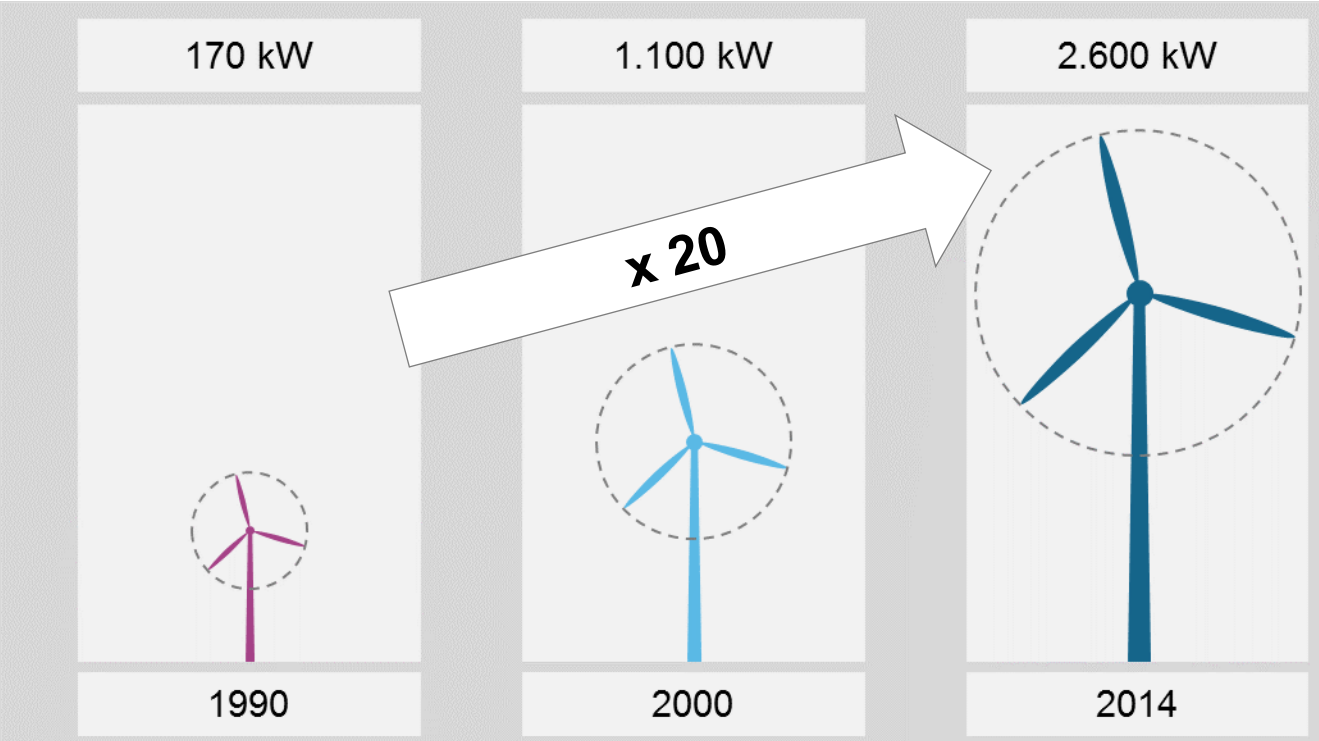


2. The key insight of the *Energiewende*:

„It‘s all about wind and solar!“

Wind Energy has become a mature technology, with windmills of 2-3 MW being standard

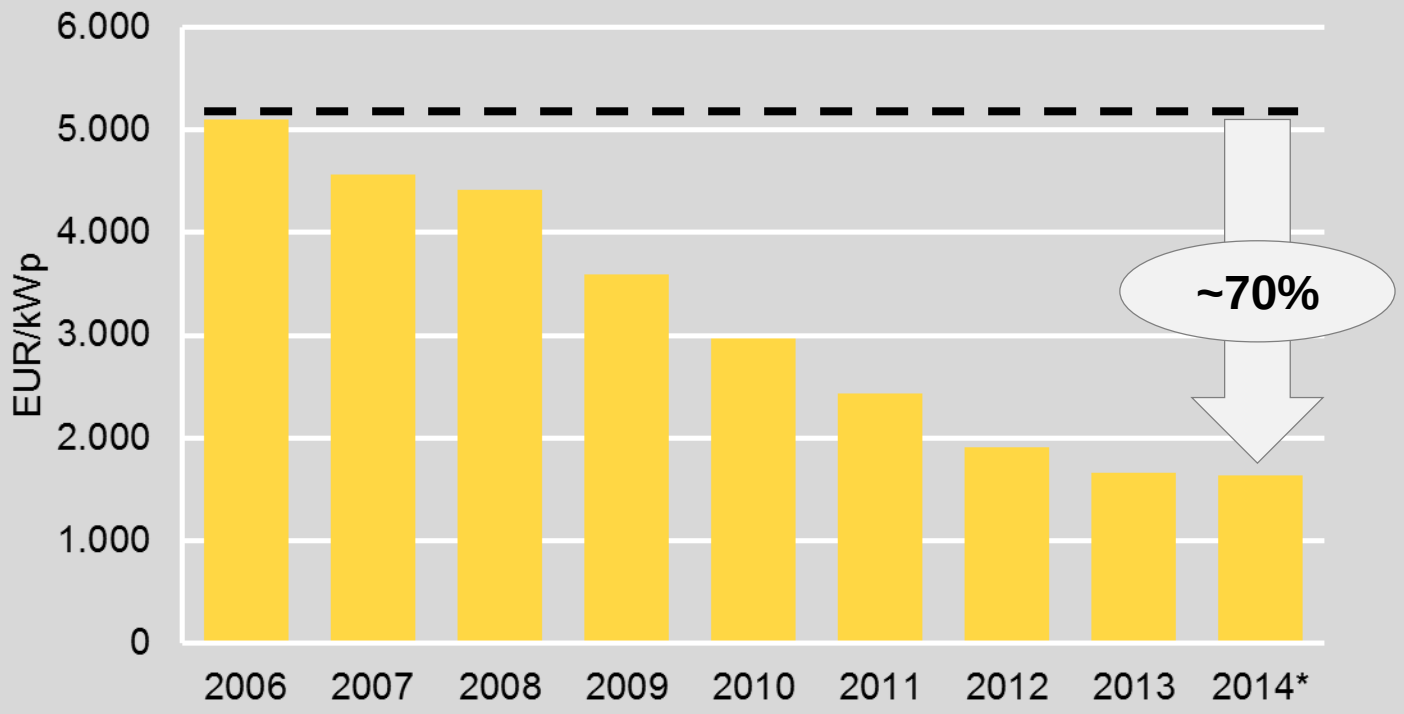
Size development of wind turbines (onshore)



Fraunhofer IWES

Cost breakthrough in solar PV reduced cost by ~70% since 2006 – and further cost reductions of another 50% by 2025 expected

Average system price for new roof-mounted PV in EUR/kWp

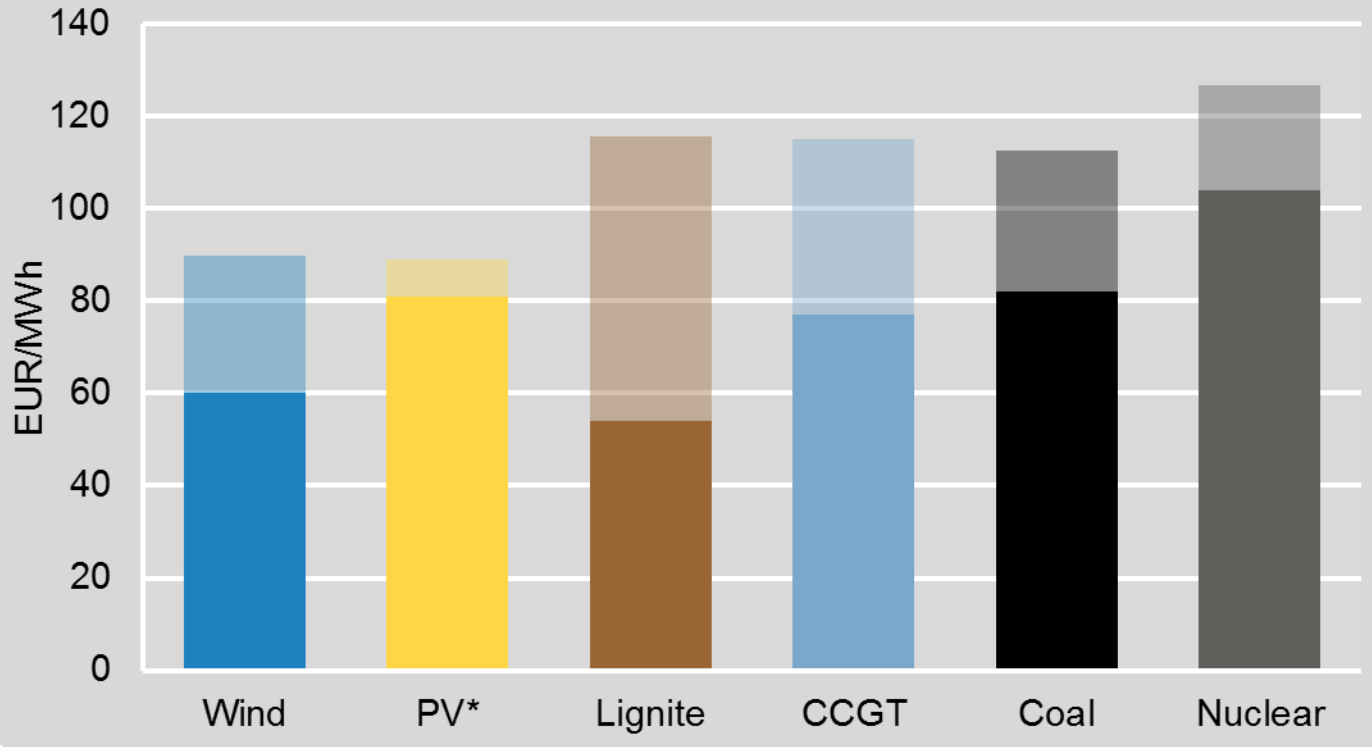


BSW Solar (2014), own calculations

* only Q1 2014

Today, wind and solar are already cost competitive to all other newly built conventional energy sources

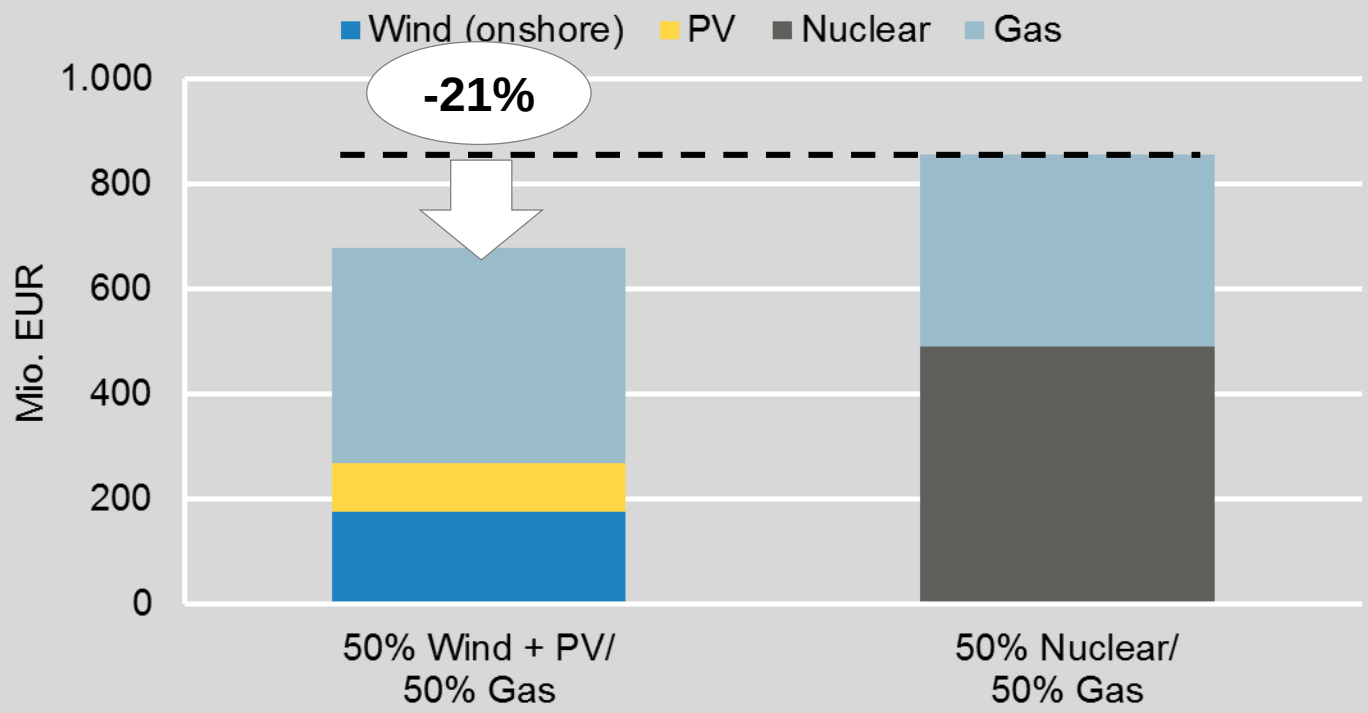
Range of levelized cost of electricity (LCOE) in 2015 in EUR/MWh



Agora Energiewende (2015)

Integration cost of wind and solar do not change the picture

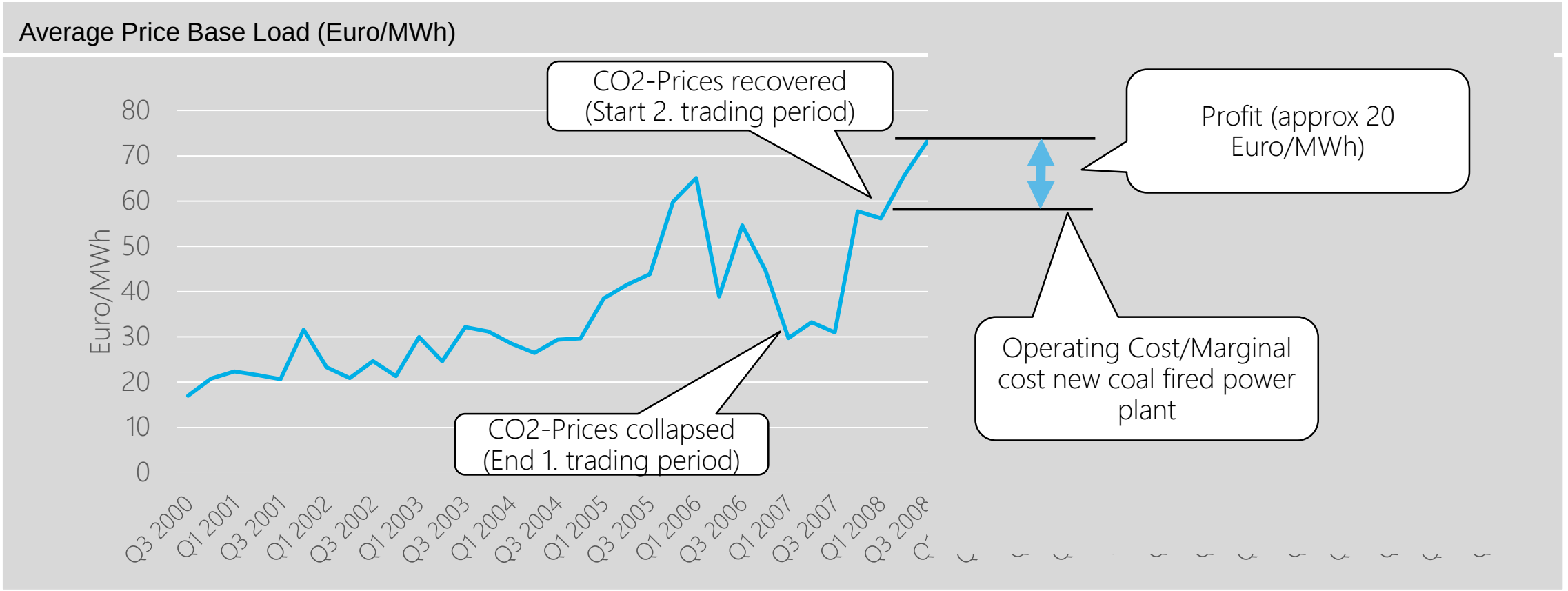
Annual generation costs of two different stylized new power systems, covering 1 GW demand



Agora Energiewende (2014)

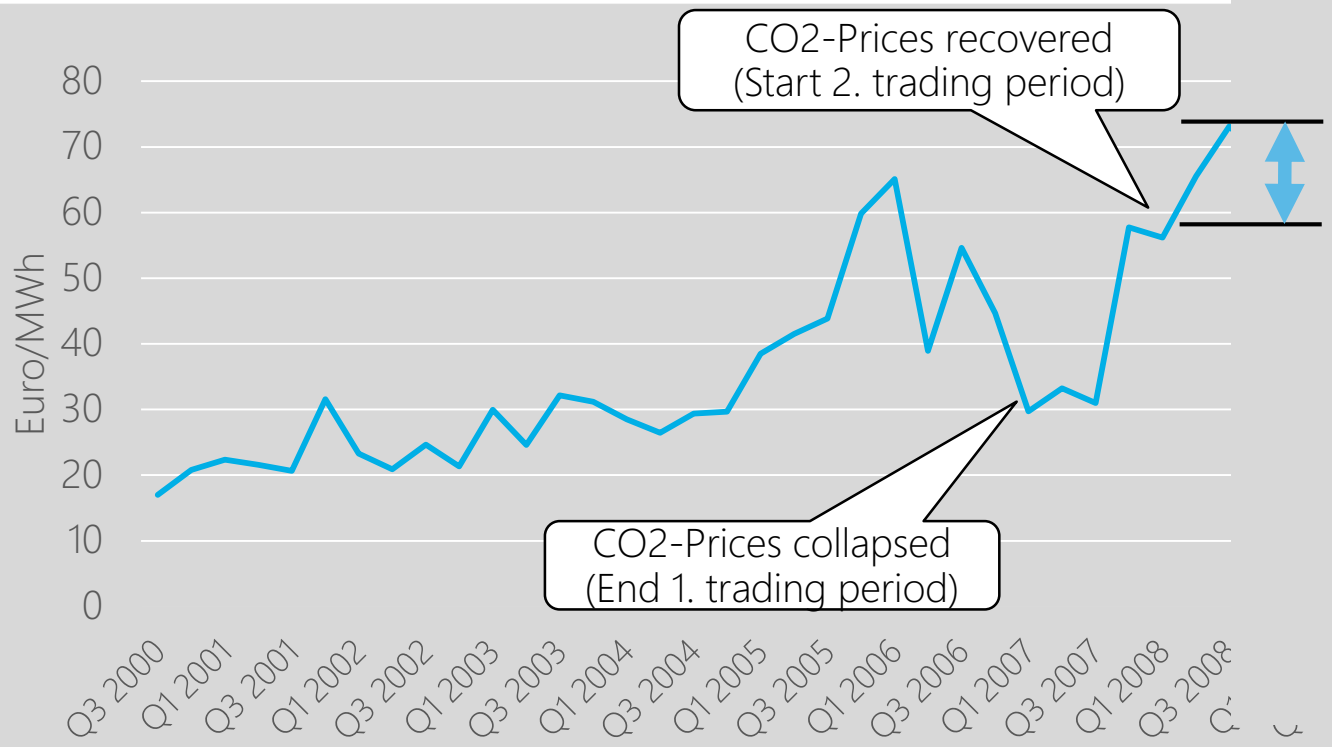
3. The Market Situation for Coal Fired Power Plants in Recent Years

Rising Wholesale Power Prices in First Decade



Attractive environment for investments in new coal fired power plants

Average Price Base Load (Euro/MWh)

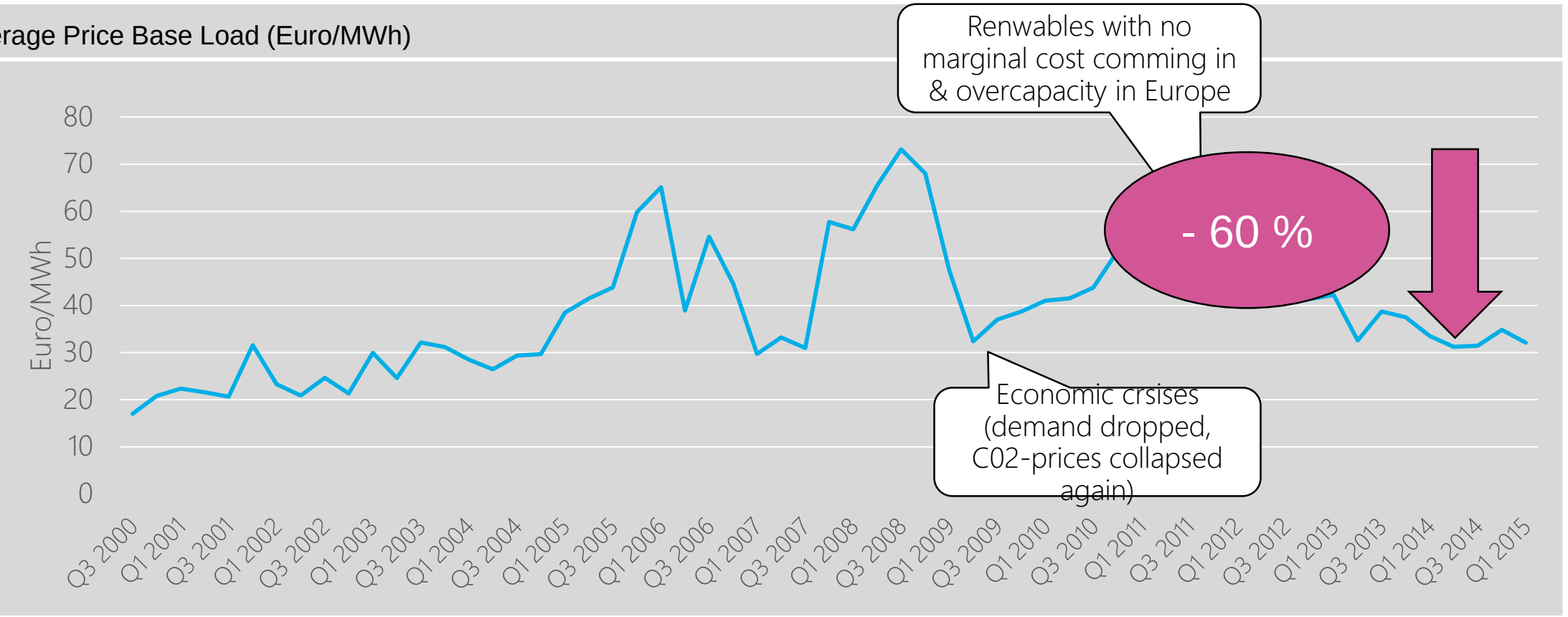


- Approval of 8 new Hard Coal Fired Power Plants 2006 – 2008
- Total Capacity 8,6 GW
- Investment approx. 13,6 Billion Euro

EEX, Deutsche Umwelthilfe

But after 2008 everything changed

Average Price Base Load (Euro/MWh)



EEX; Agora Energiewende

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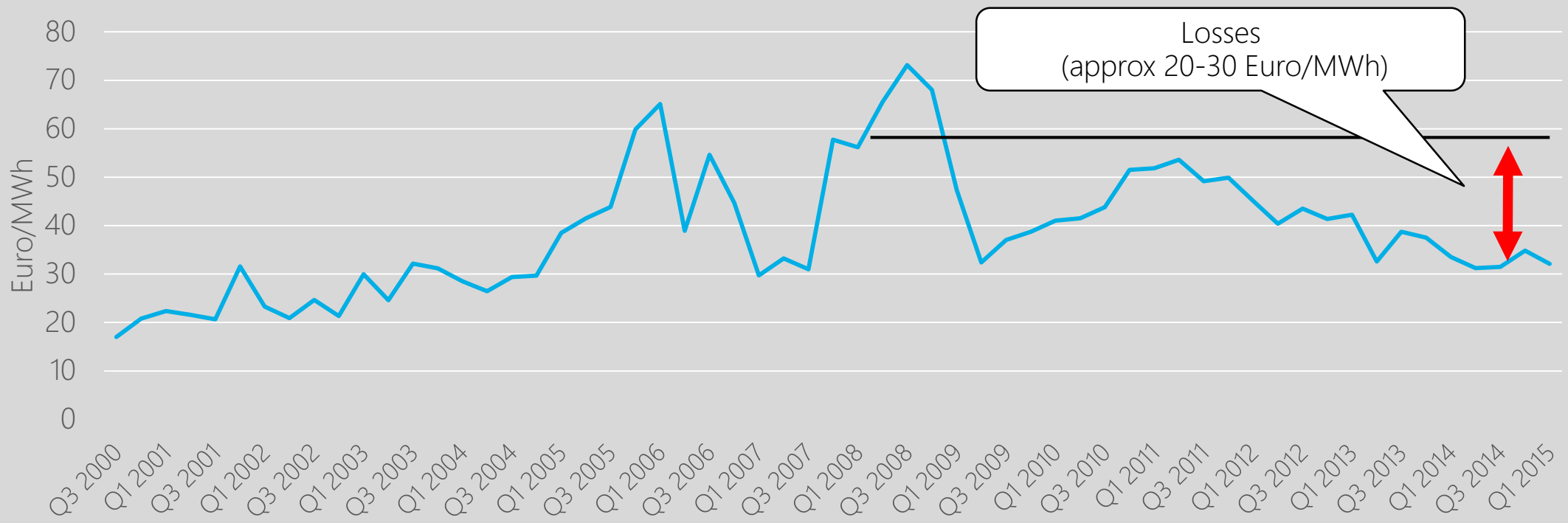
Average Price Base Load (Euro/MWh)



EEX; Agora Energiewende

Stock Prices of Power Companies dropped by more than 80 percent since 2008

E.On – Market Trend 2004 - 2015

Finanzen100.de

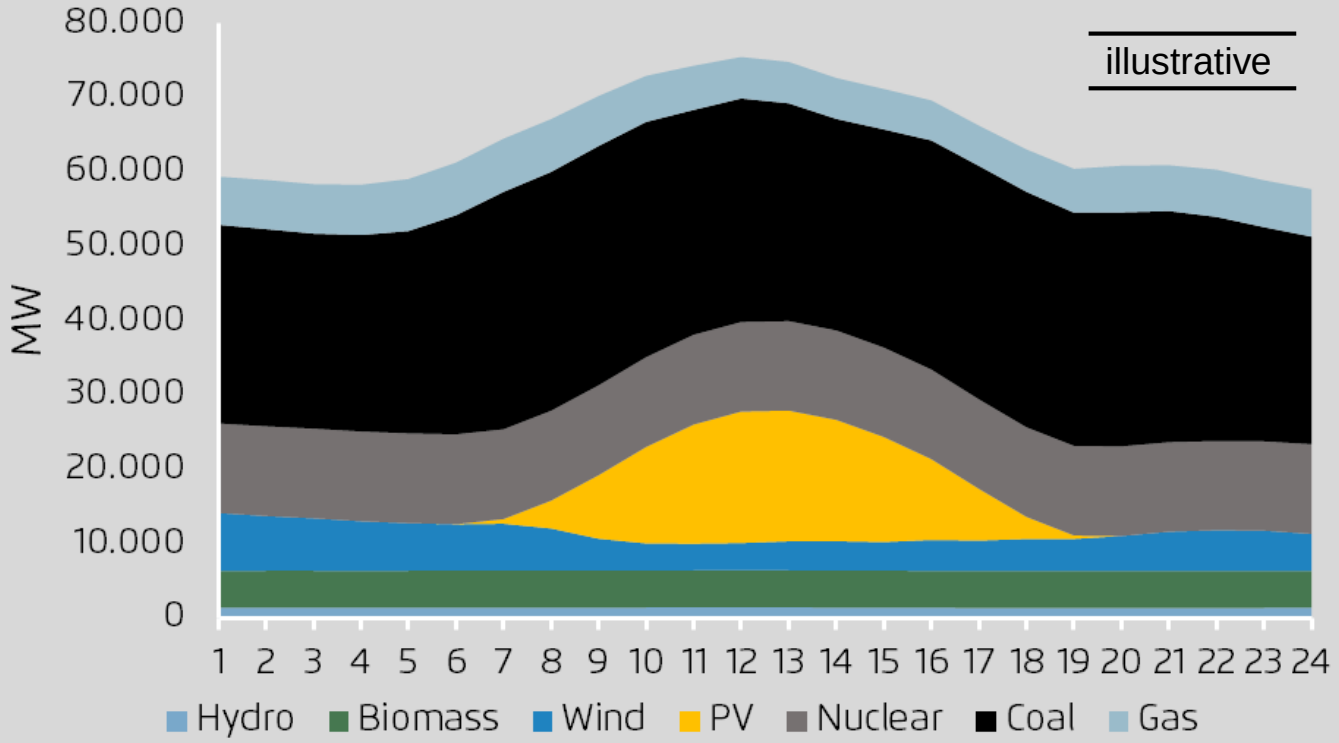
RWE – Market Trend 2004 - 2015

Finanzen100.de

4. Effects of Photovoltaics on the power market

PV represses classical peak load

Illustrative German power generation (March 2014)



Agora Energiewende (2015)

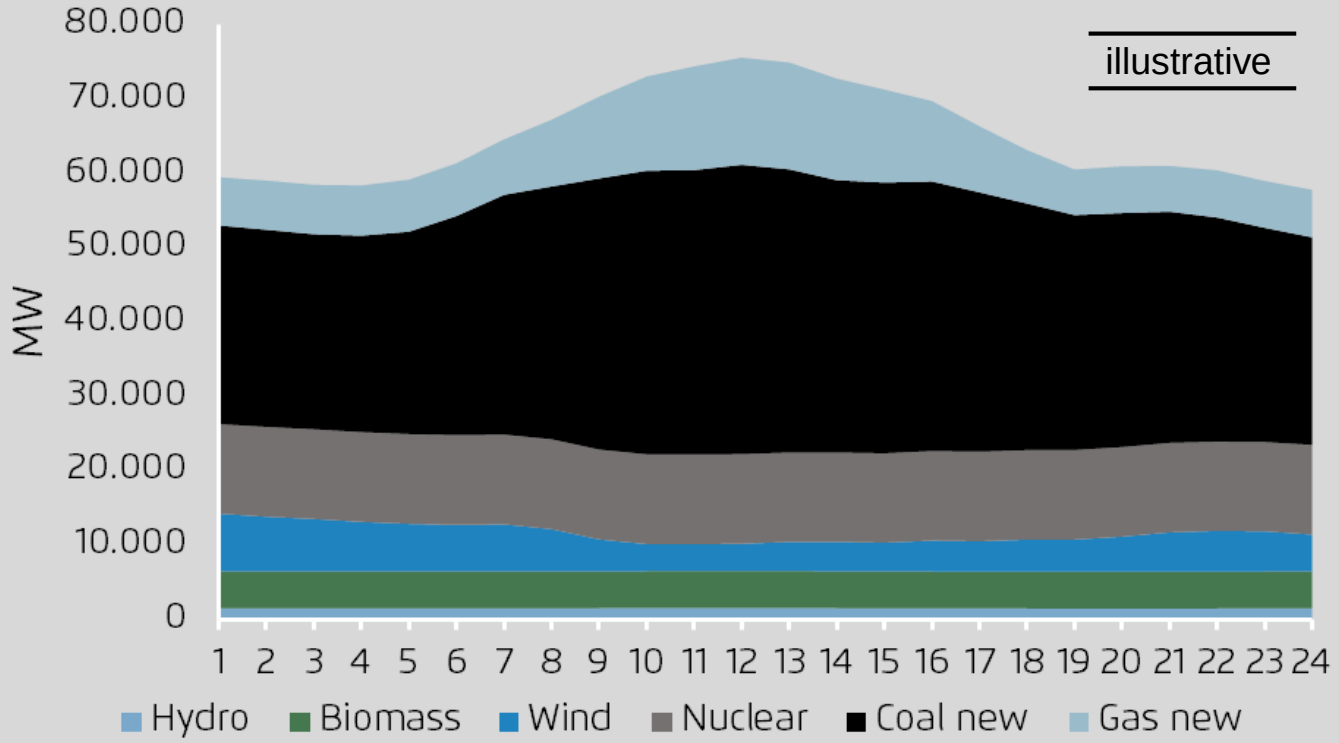
The PV load curve highly corresponds with the average German demand curve

If there would be no PV, peak load demand of conventional power plants would be much higher

In consequence, peak load generation of conventional power plants (i.e. gas) has been significantly decreasing during the last years

PV represses classical peak load

Illustrative German power generation (March 2014) without PV



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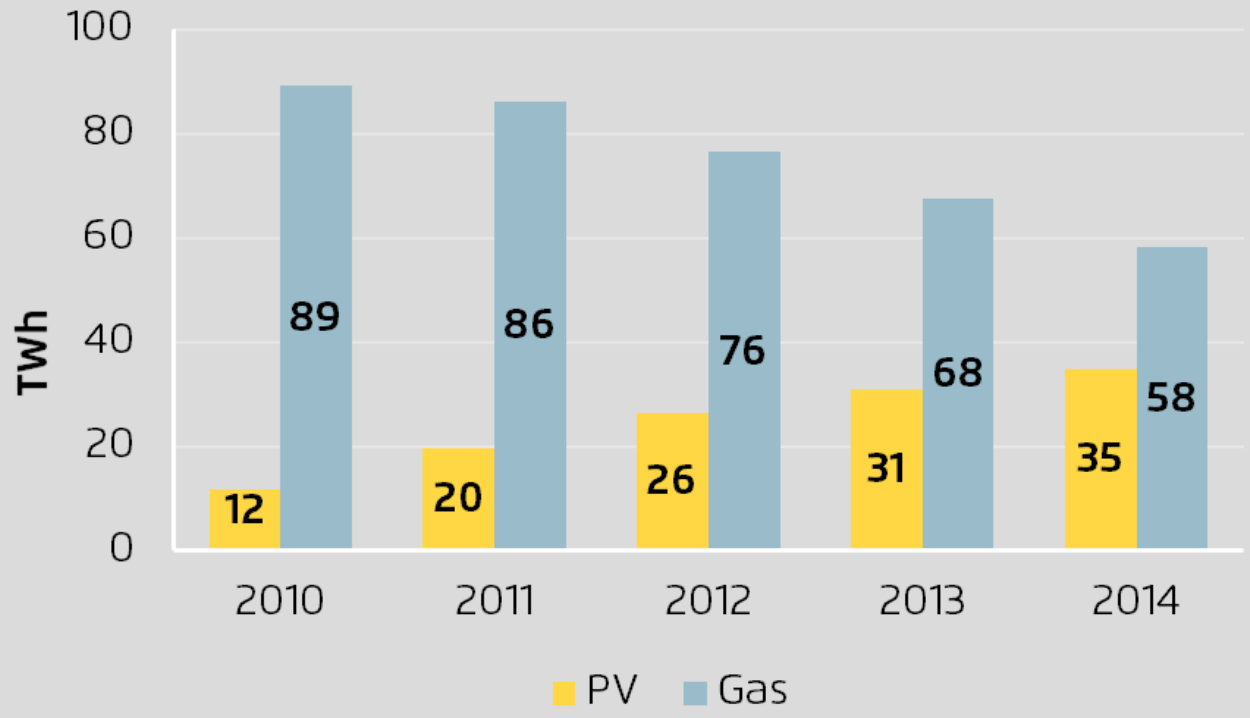
Solar power has substituted power from natural gas

Gross power generation 2010 - 2014



AG Energiebilanzen (2015)

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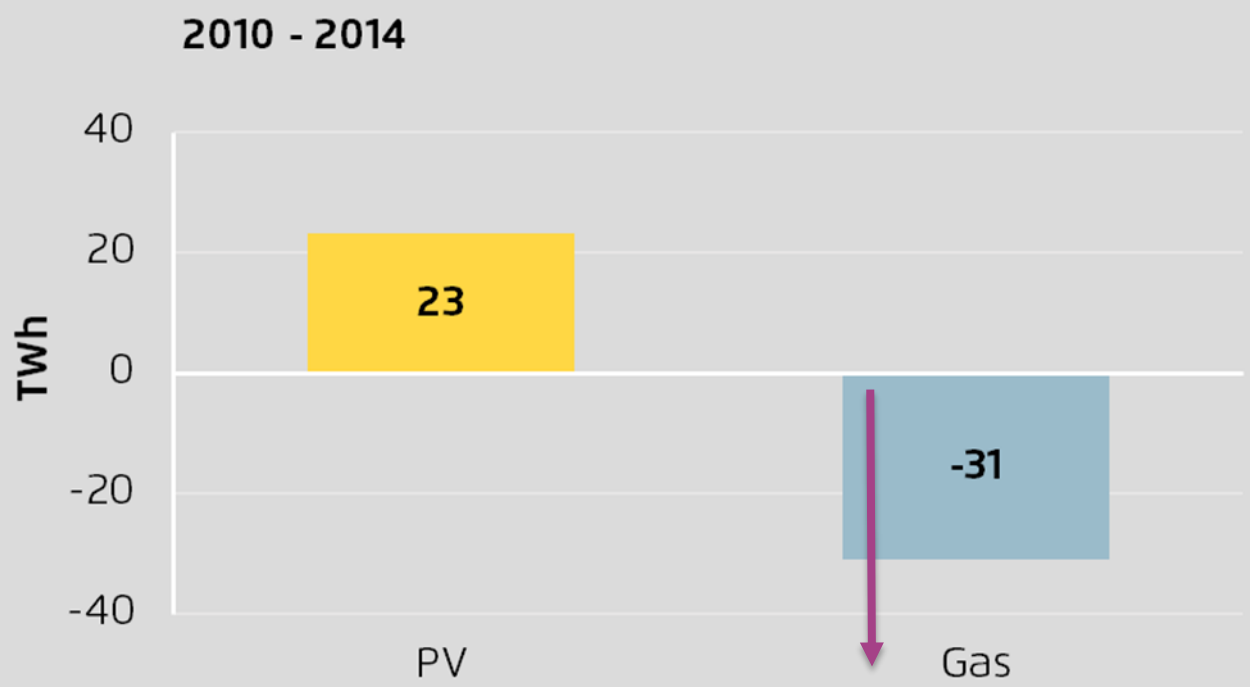
Change in gross power generation 2010 - 2014



AG Energiebilanzen (2015)

= 6% of German demand

The PV load curve highly corresponds with the average German demand curve

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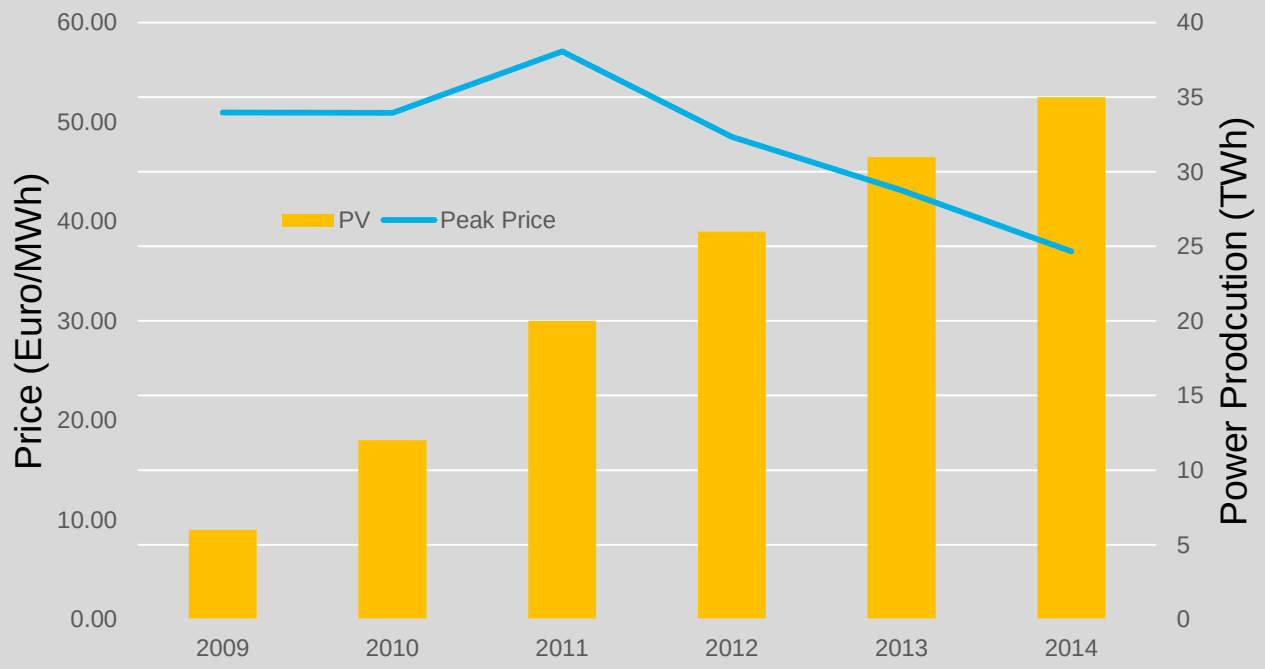
In consequence, peak load generation of conventional power plants (i.e. gas) has been significantly decreasing during the last years

Solar PV + other RES contributed to decline of wholesale power prices

Average wholesale price on EPEX-Spot vs. volume of solar power



Agora Energiewende (2015)

Average wholesale price of peak power delinced by more than 20% since 2009

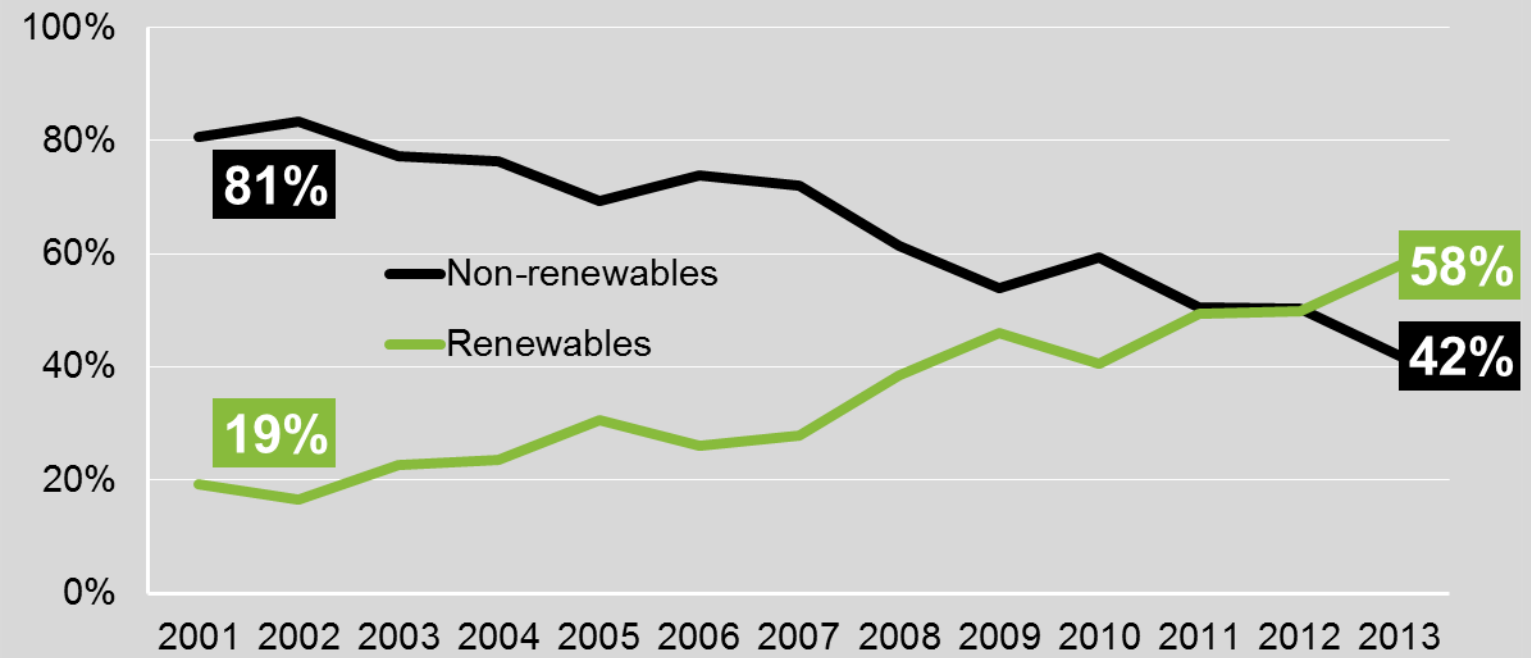
Wind power and PV are main drivers, accompained by efficiency

Situation on the power market accelerated green transformation of big utilities in (e.on)

5. Is Germany a special case?

Global investments in renewables have overtaken fossil investments

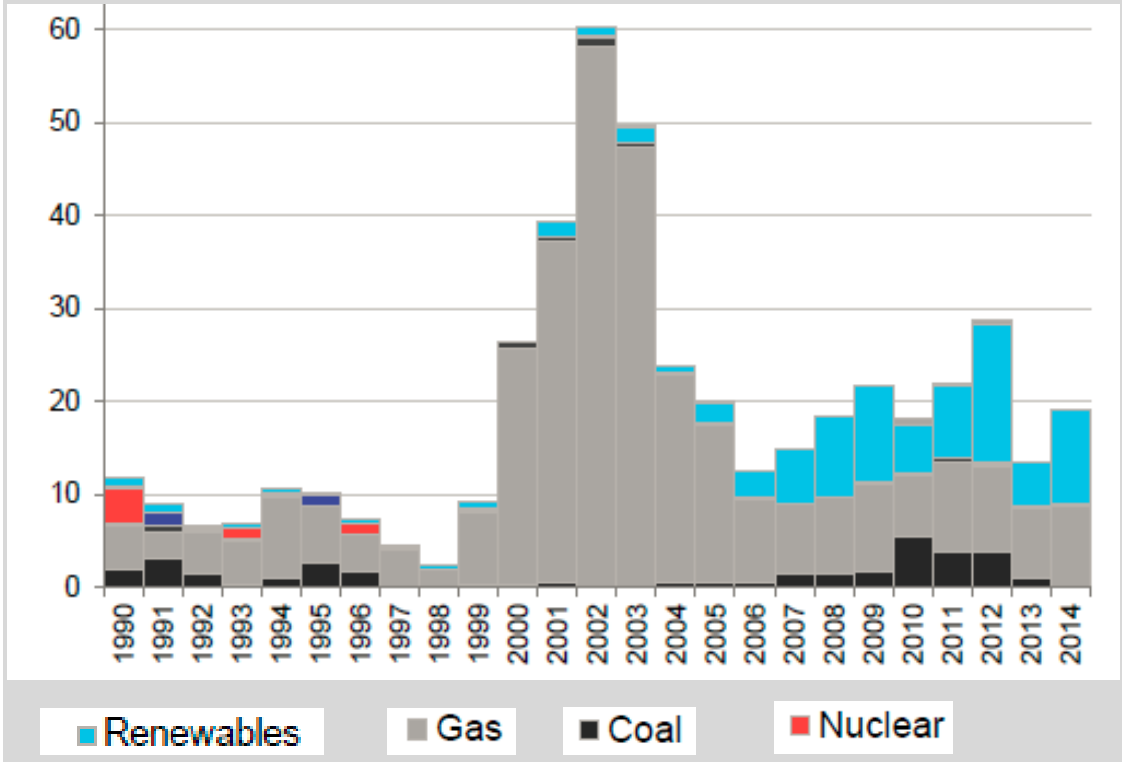
Share in global capacity investments 2001 - 2013



IRENA (2014)

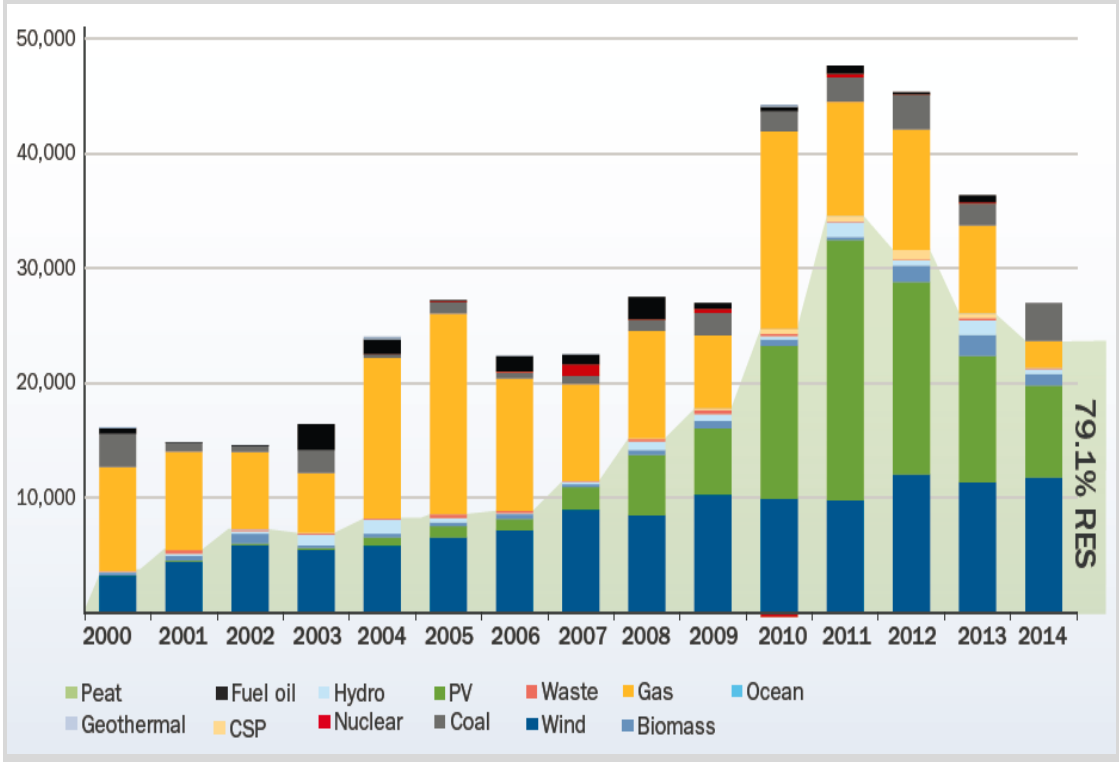
Investments in renewables have overtaken conventionals in USA, Europe and China

New Power Plant Installations in the U.S. 1990-2014 (in GW)



Frankfurt School-UNEP Centre/BNEF (2015)

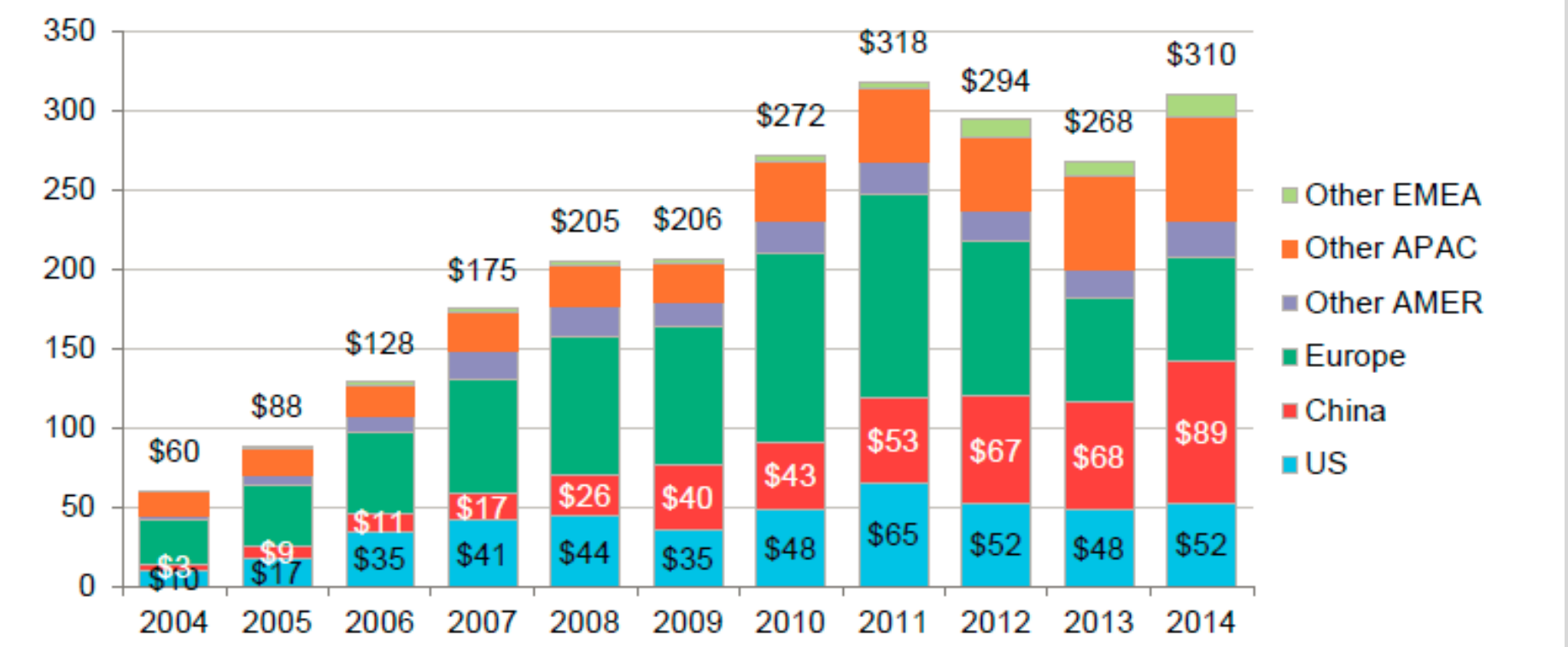
New Power Plant Installations in Europe 2000-2014 (in MW)



EWEA (2015)

Renewables Deployment is now a global market in both the developed and the developing world

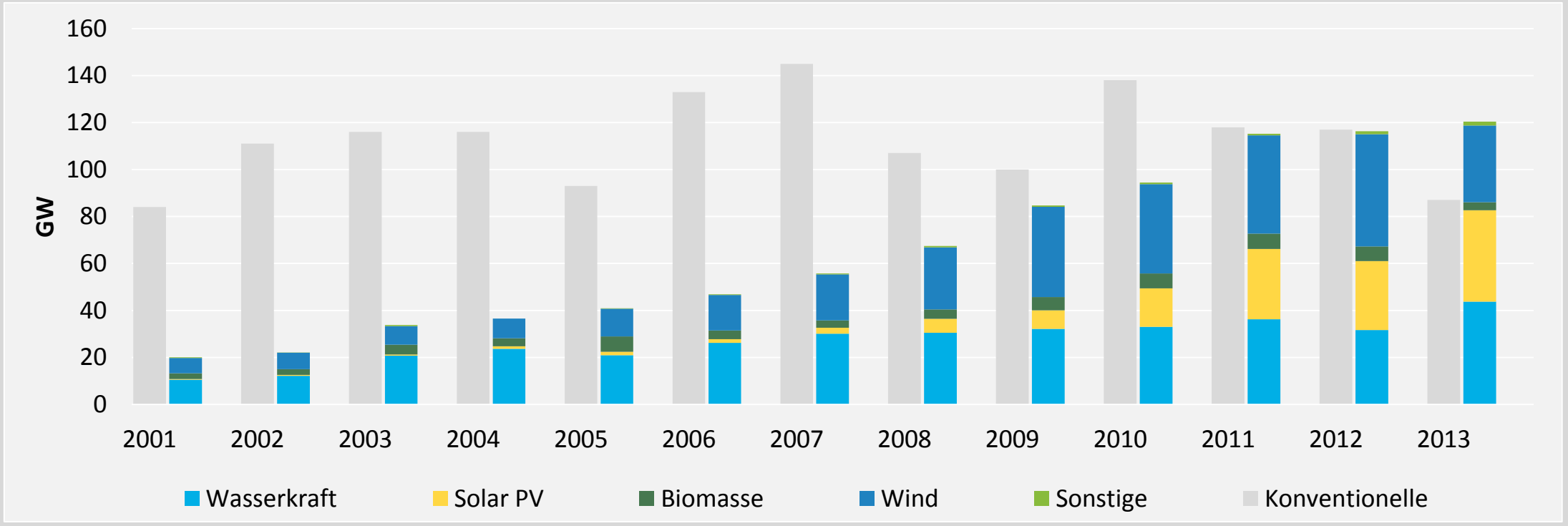
Global Investments in Renewable Energy in Billion US$



Bloomberg New Energy Finance (2015)

Wind and Solar are now predominant energy sources in global new power installations

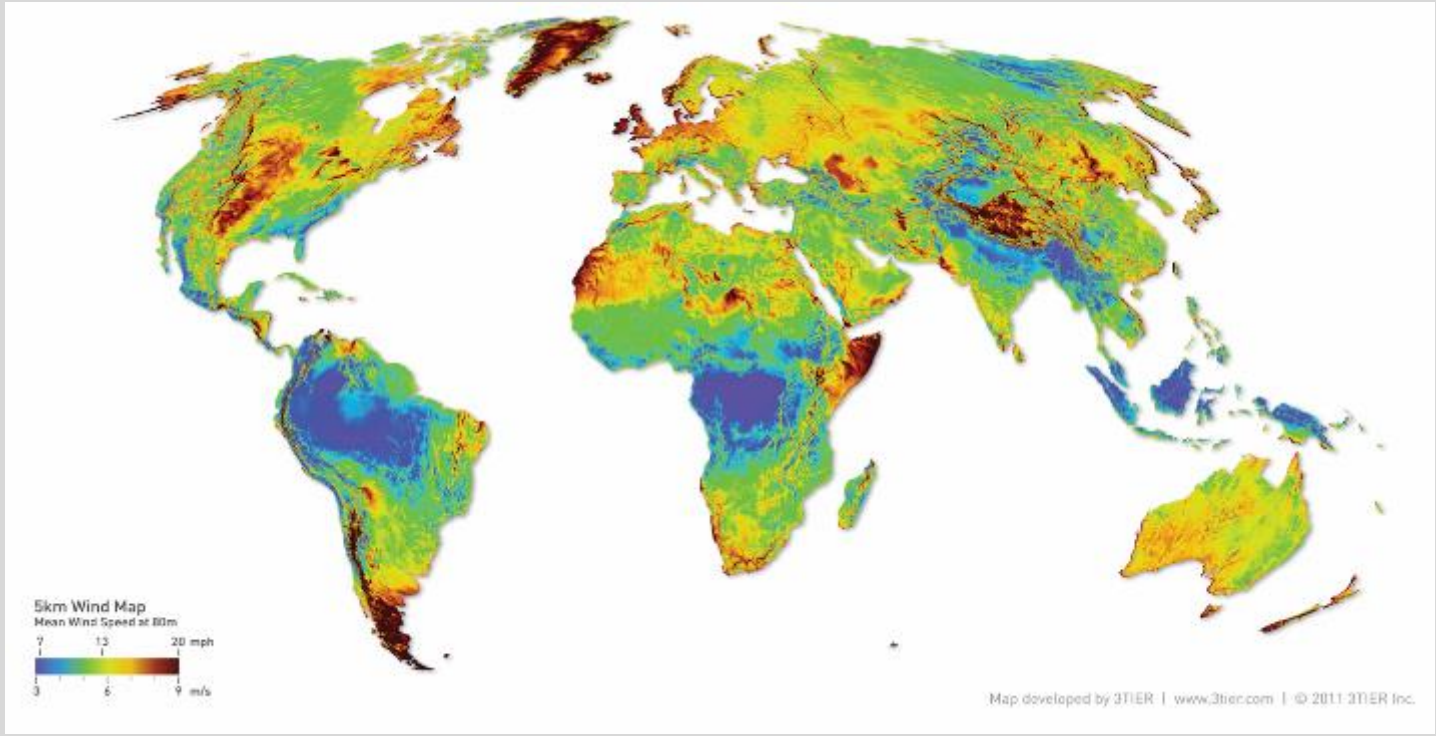
Global power capacity additions by type, 2001-2013



IRENA (2014)

The reason is simple: There is wind available all over the world…

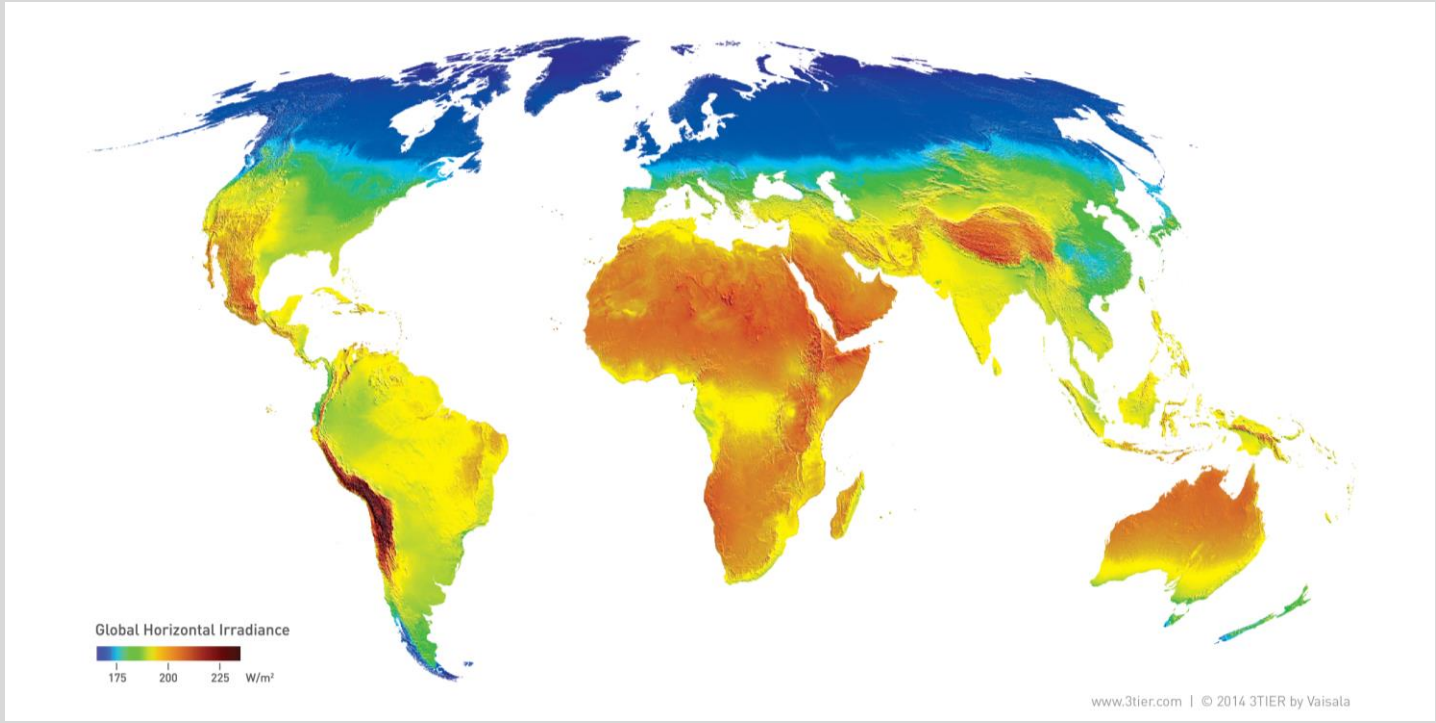
Average wind speed on 80m



3TIER (2011)

…and almost everywhere there is more sun than in Germany!

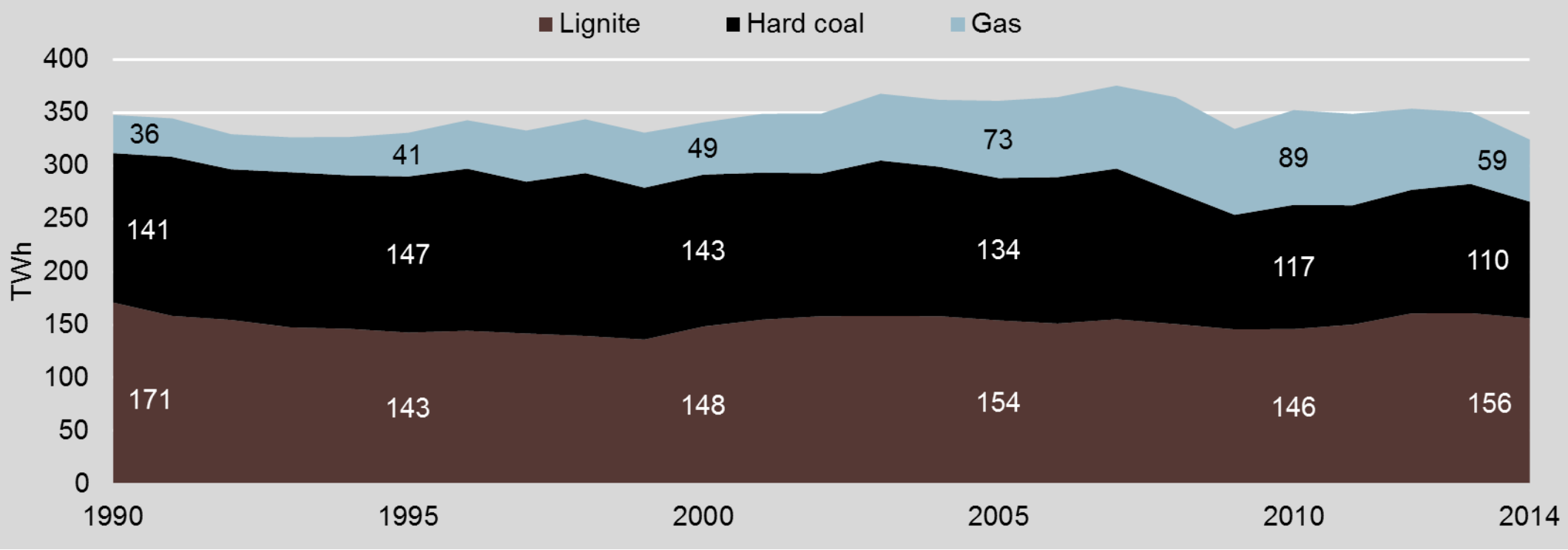
Annual solar radiation in W/m2



3TIER (2011)

Thus, Germany needs a coherent strategy towards fossil-fuel power plants, especially coal

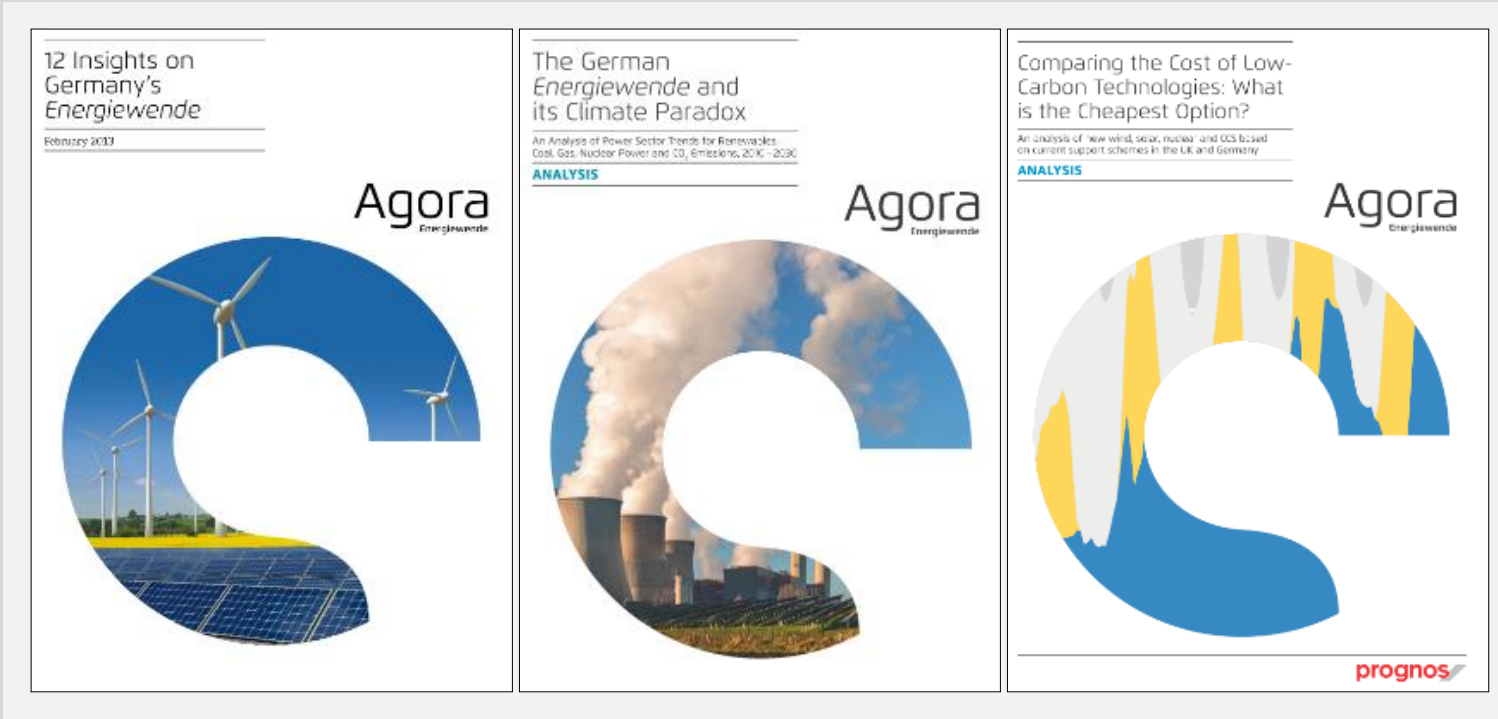
Gross Electricity Production from Lignite, Hard Coal and Gas Power Plants 1990-2014



AG Energiebilanzen (2014)

More information and studies available at our website

www.agora-energiewende.org



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Thank you for your attention!

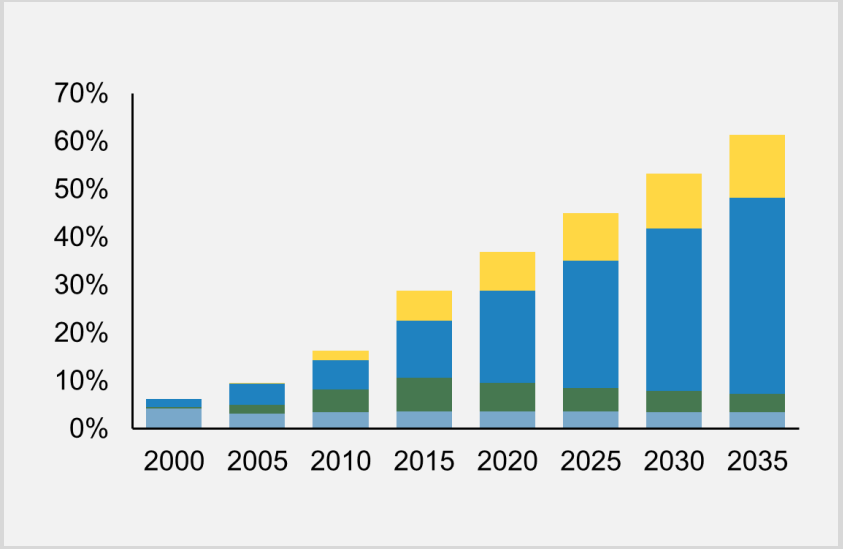
Questions or Comments? Feel free to contact me:
xxx.xxx@agora-energiewende.de

Agora Energiewende is a joint initiative
of the Mercator Foundation and
the European Climate Foundation.

Backup I

The flexibility challenge

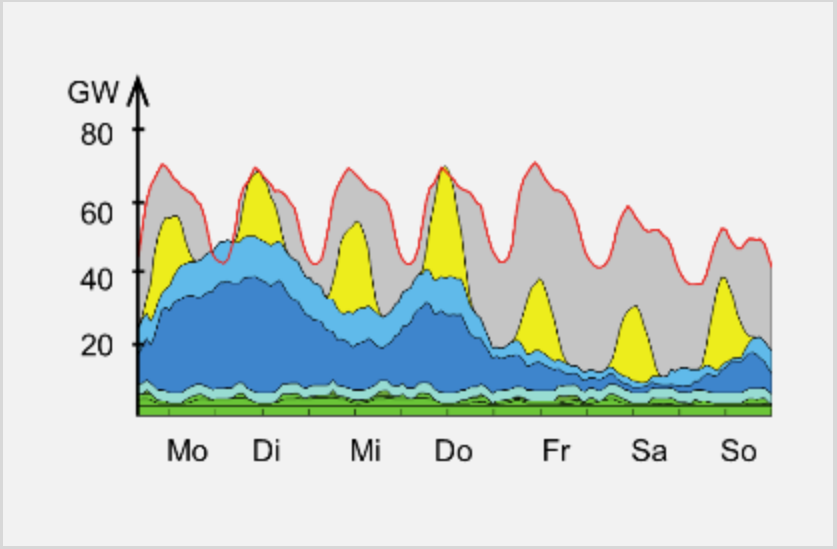
Variable Renewables (Wind and Solar PV) alter the way power systems work



weather-dependent

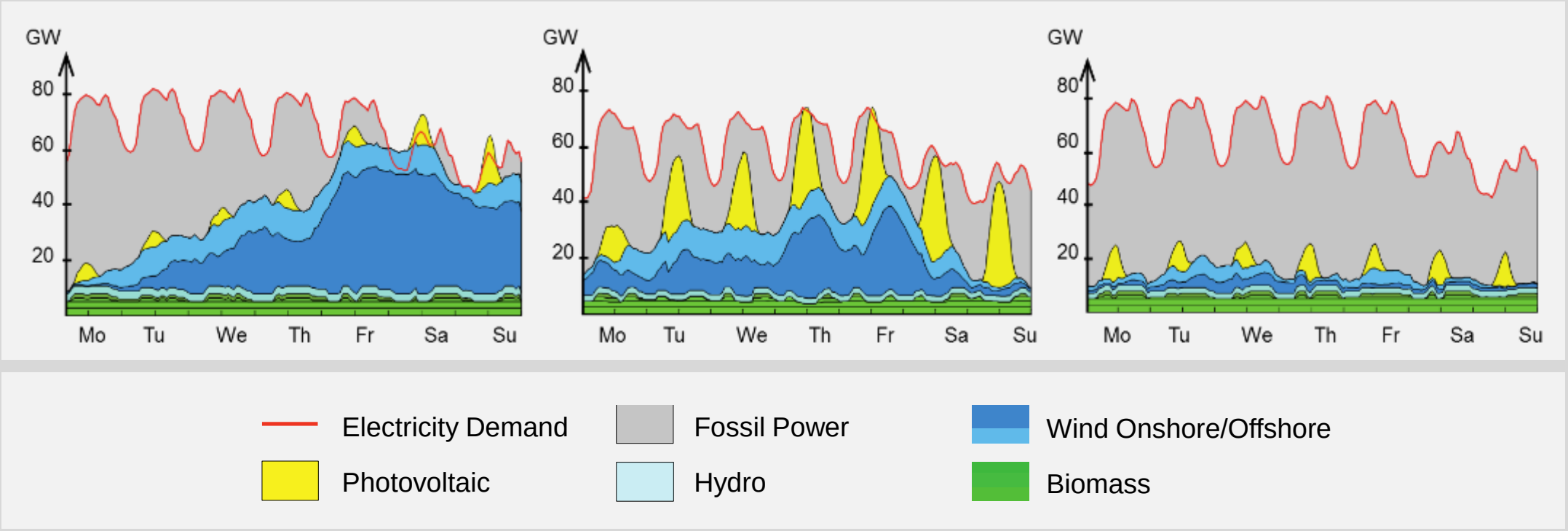
capital-intensive

zero marginal cost



Future power system needs to integrate variable electricity generation from wind and solar PV

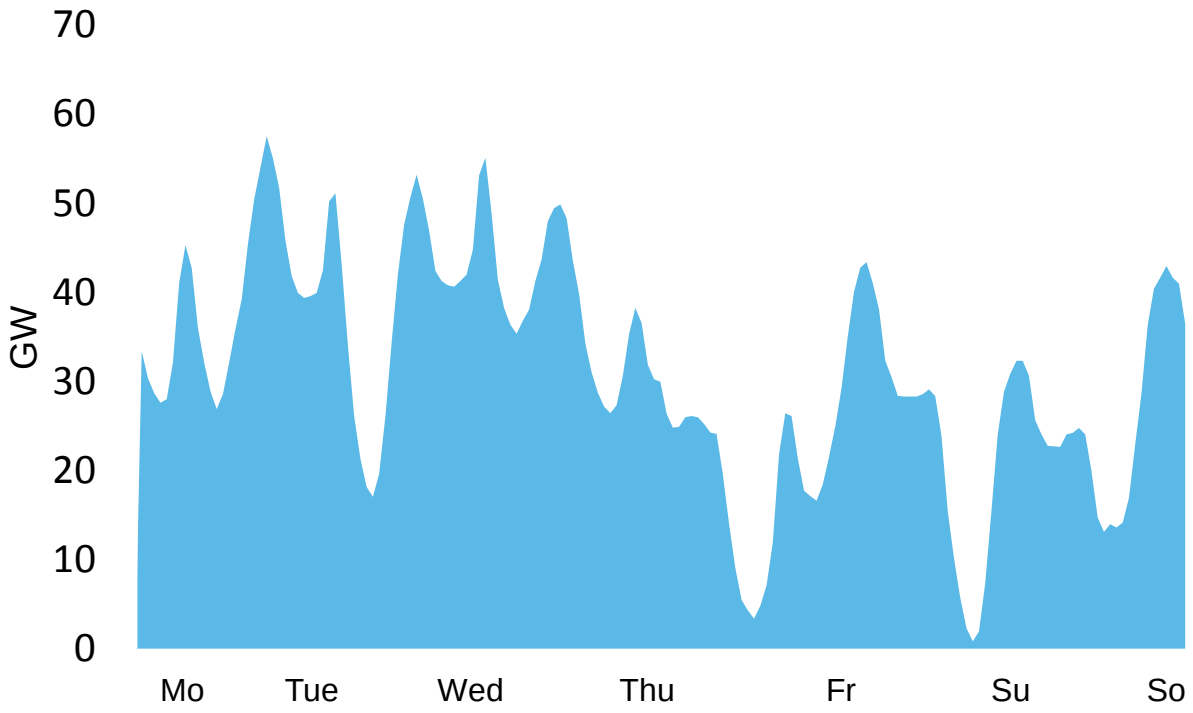
Electricity generation and demand in sample weeks of February, August and November 2023*



Agora Energiewende (2013)

Residual load will become the key variable

Residual load in a sample week in February 2023 in GW



Agora Energiewende/RAP (2013)

With growing shares of variable renewable energy, baseload capacities will less and less be needed

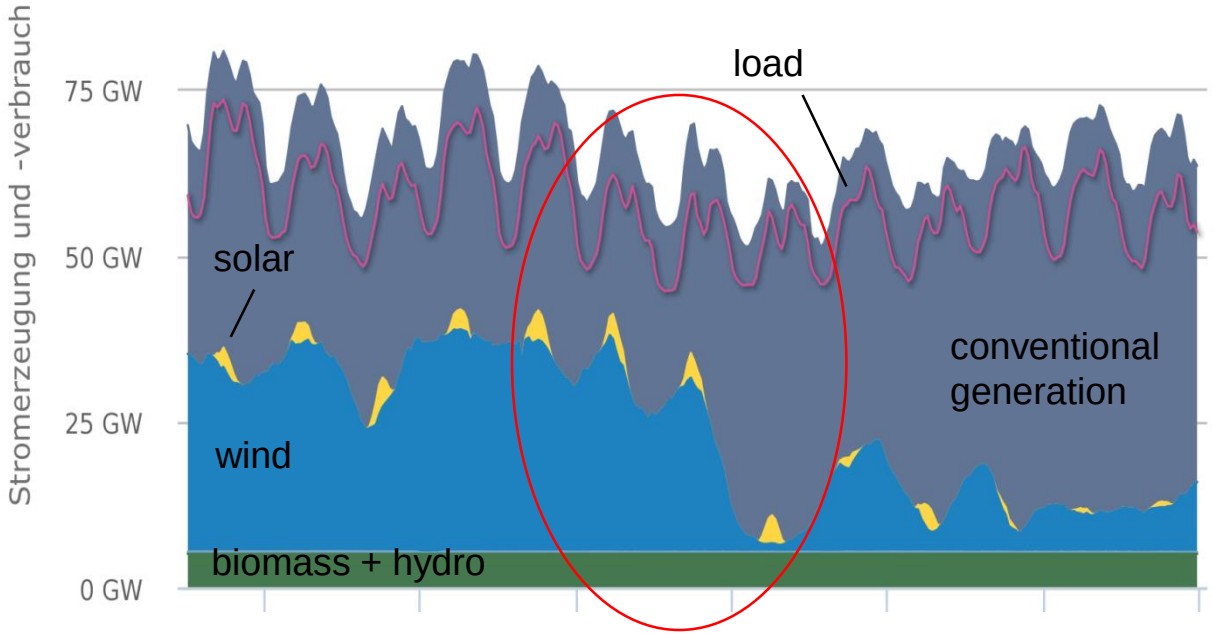
Instead, flexible resources (both on the supply and demand side) are required to cover the residual load

Residual load is defined as ‚load minus renewables“

Case Study 1
Flexibility of conventional generation at Christmas 2014

Electricity generation in Germany 20th to 31 December 2014

Electricity generation and demand



Agora Energiewende 2015

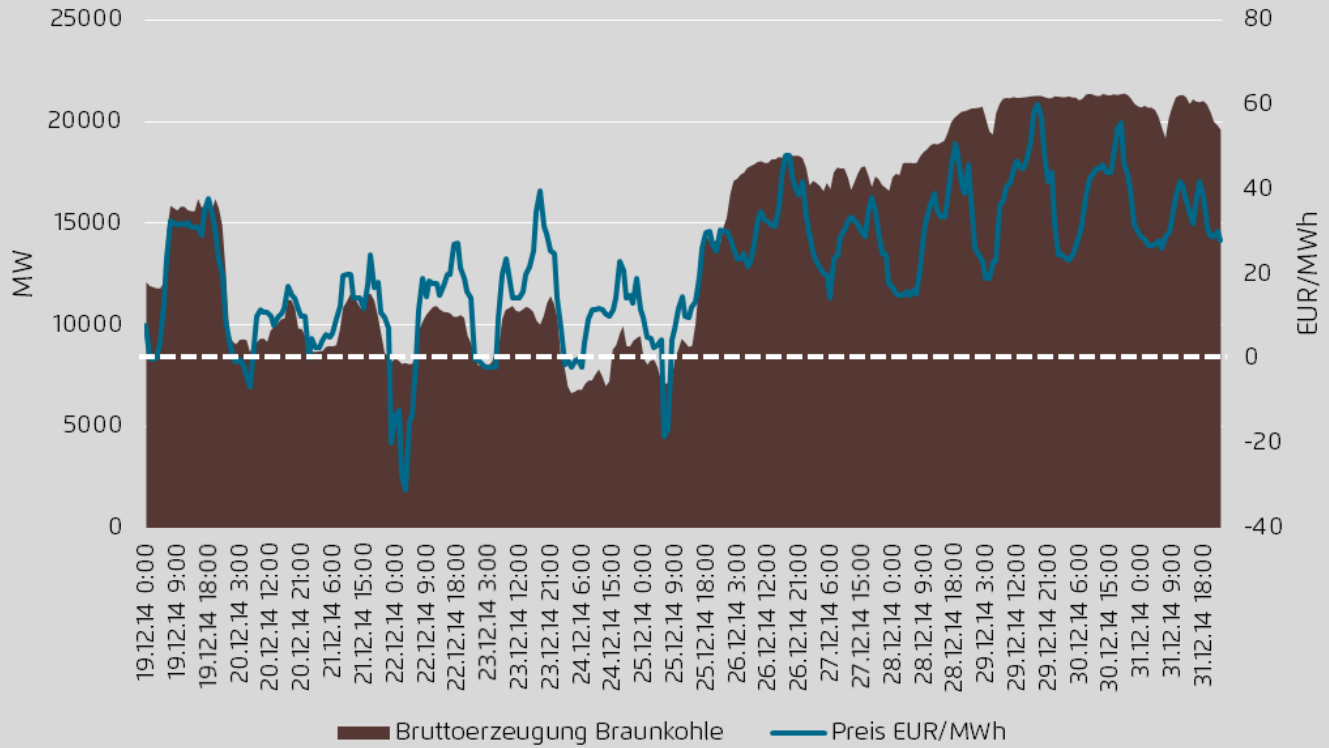
High generation from wind at 24th/25th December

Low demand at 24th/25th December due to Christmas festival (minimum of 44,5 GW)

Drastic drop of electricity generation from wind at night 25th/26th December

Reaction of conventional generation: lignite

Electricity generation from lignite plants and market prices 19th to 31 Dec. 2014



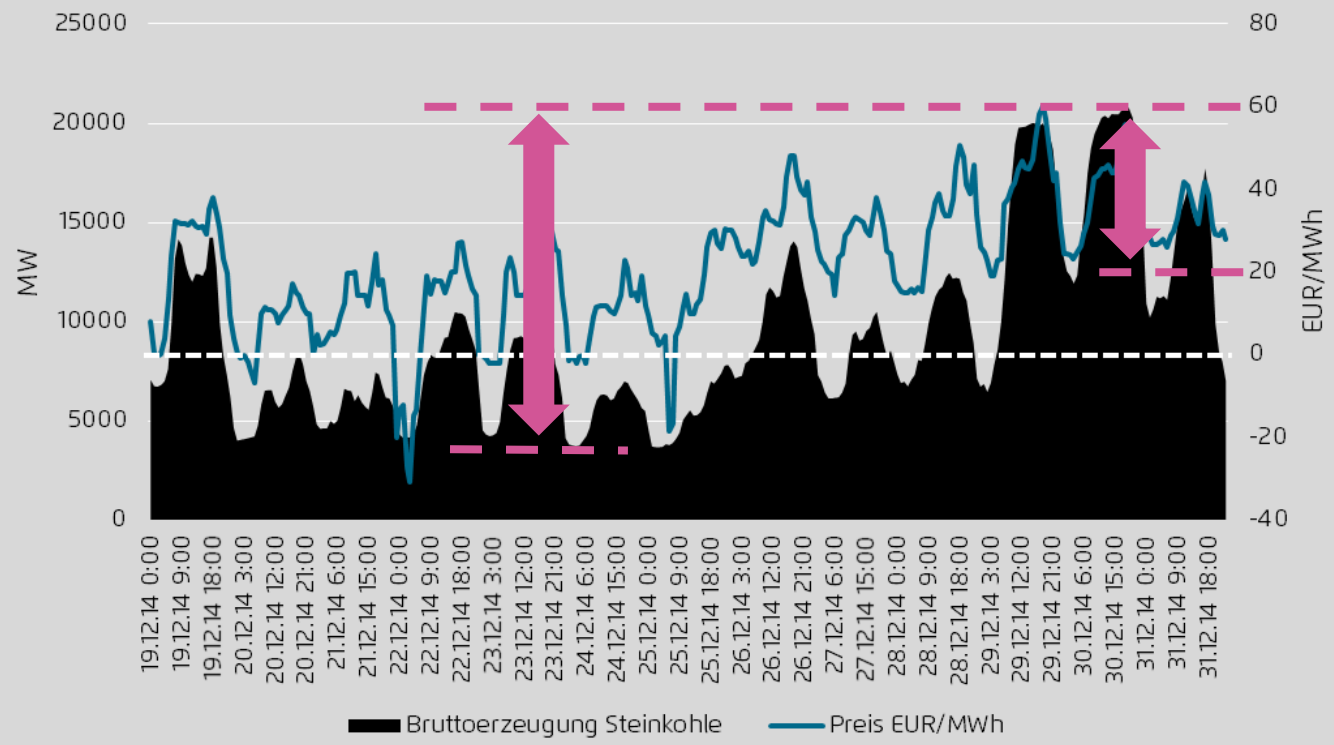
Agorameter 2015

Very unusual: Lignite plants reacted relatively flexibel and reduced their generation to a minimum level of only 6.2 GW.

From 26th onwards, lignite production was back to normal (around 20 GW)

Reaction of conventional generation: Hard Coal

Electricity generation from hard coal plants and market prices 19th to 31 Dec. 2014



Agorameter 2015

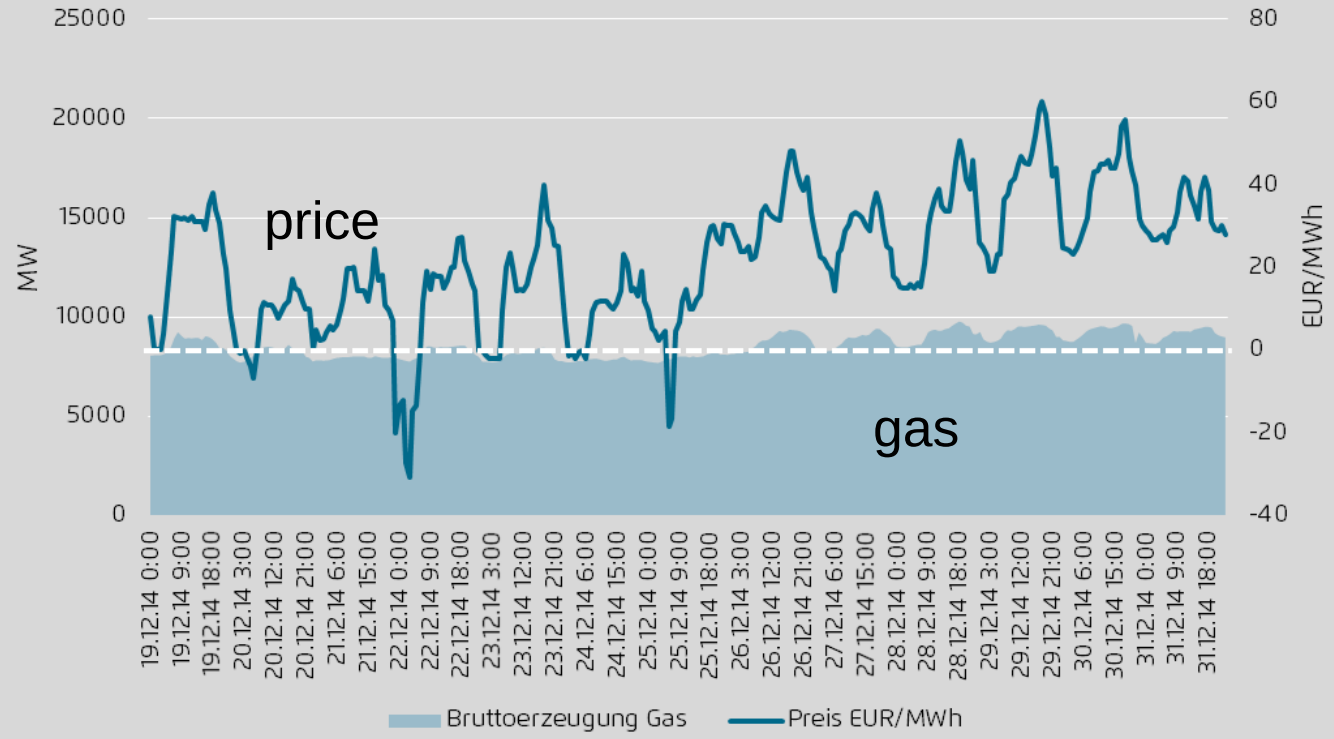
As flexible gas plants are still to expensive, hard coal plants have to provide the flexibility to the system.

Hard coal plants proof to be able to ramp up and down 15 GW within a week, and 8 GW within a day.

Must-run capacity apparently relatively low (less than 5,000 MW)

Reaction of conventional generation: Gas

Electricity generation from gas plants and market prices 19th to 31 Dec. 2014



Agorameter 2015

Gas plants – as the conventional technology with the highest marginal costs – were not necessary (approx. 30 GW capacity available).

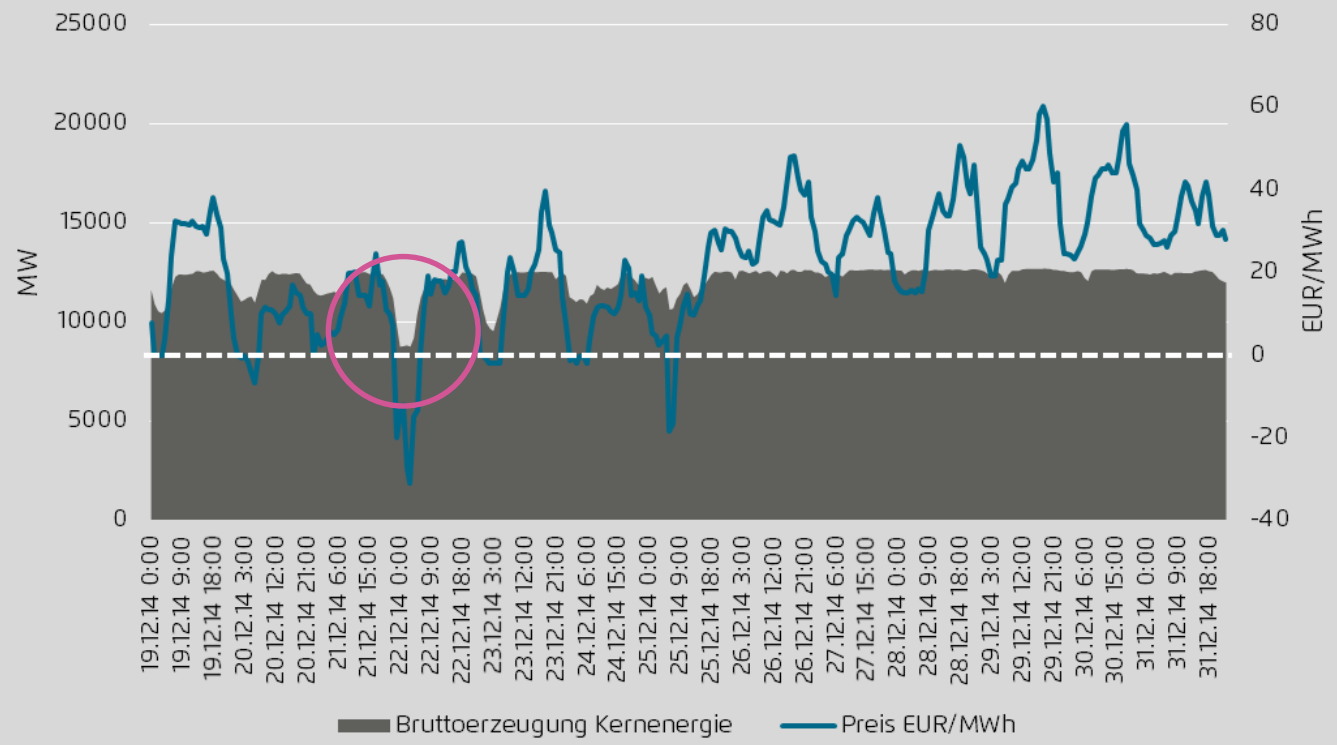
Sole exception: approx. 7,500 MW ‚must run' CCGTs (co-generation) - inflexible

Slightly increasing generation from gas plants only in times of higher prices and less RES (26th to 31st Dec.)

The market price dropped to zero seven times within six days – twice to -20 EUR/MWh and below.

Reaction of conventional generation: nuclear

Electricity generation from nuclear plants and market prices 19th to 31 Dec. 2014



Agorameter 2015

Nuclear plants – the conventional technology with lowest marginal costs – react relatively inflexible

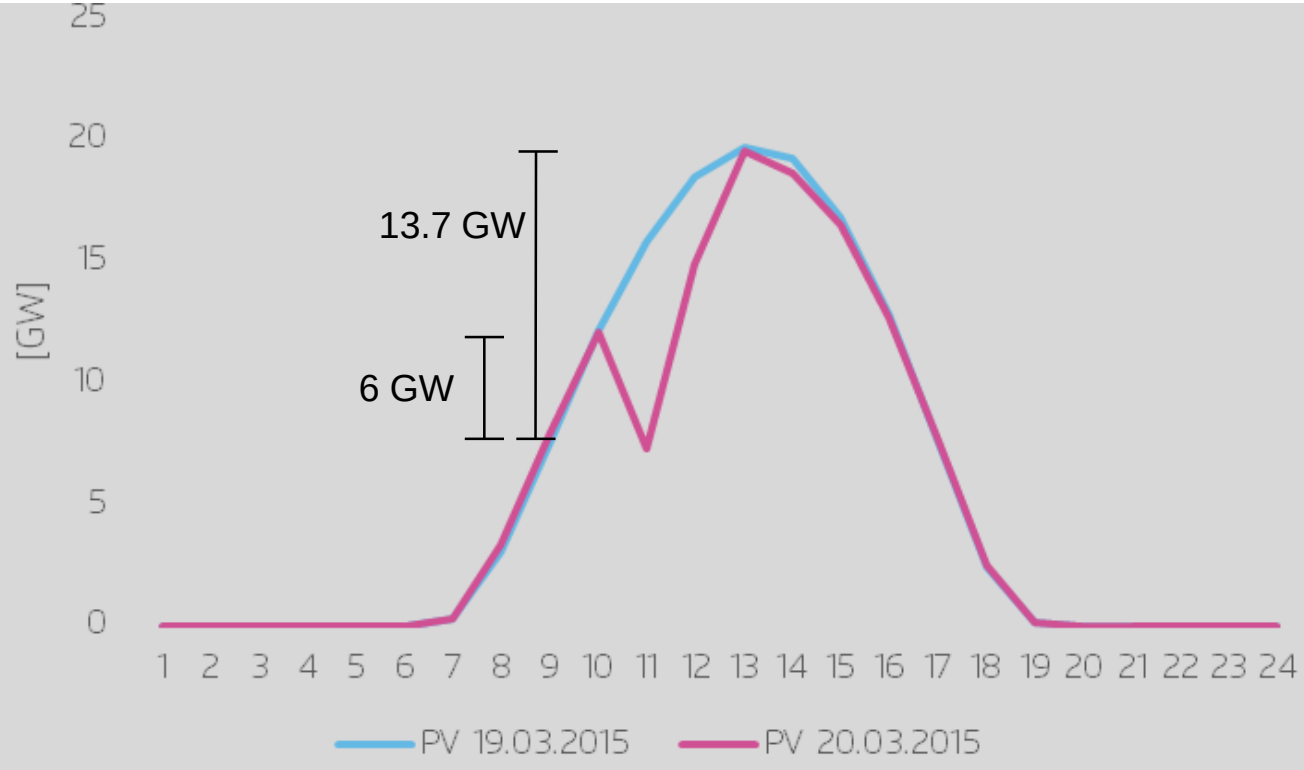
Only in times of very low/ negative market prices, nuclear plants slightly reduce their generation.

Market price dropped to zero seven times within six days; twice to -20 EUR/MWh and below.

Case Study 2
Solar Eclipse – 20 March 2015

The challenge: extraordinary ramping rates

Electricity production of solar PV on 19/20 March 2015



Own; data: EEX

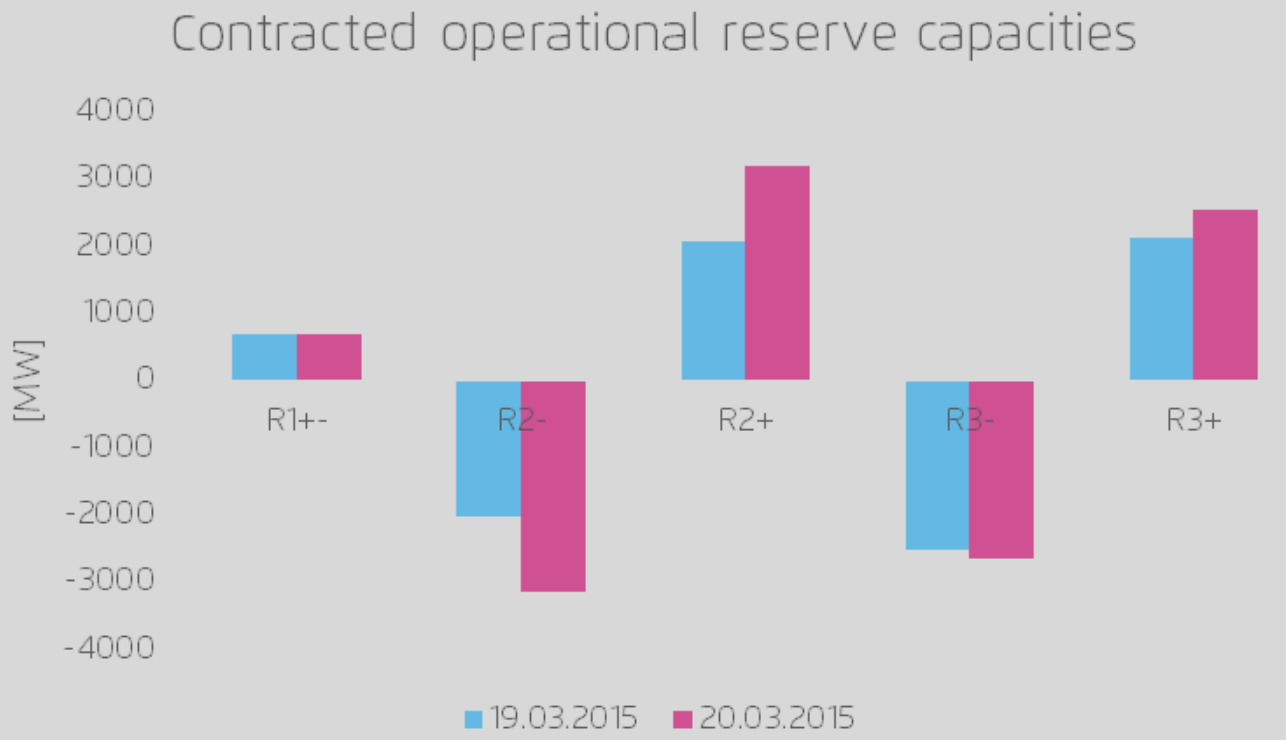
Due to the solar eclipse, electricity production from solar PV ramped down 6 GW within 65 minutes (between 10 a.m. and 11.30 a.m.), and ramped up again roughly 13.7 GW within 75 minutes (between 11.30 a.m. and 1 p.m.)

No shortages in the German power system occured.

These ramps are unusual today, but are expected frequently in 2030 in Germany, when roughly 50% of electricity will be produced by Renewables (according to current law).

Balancing energy hardly needed

Comparisson of contracted balancing power on 19/20 March

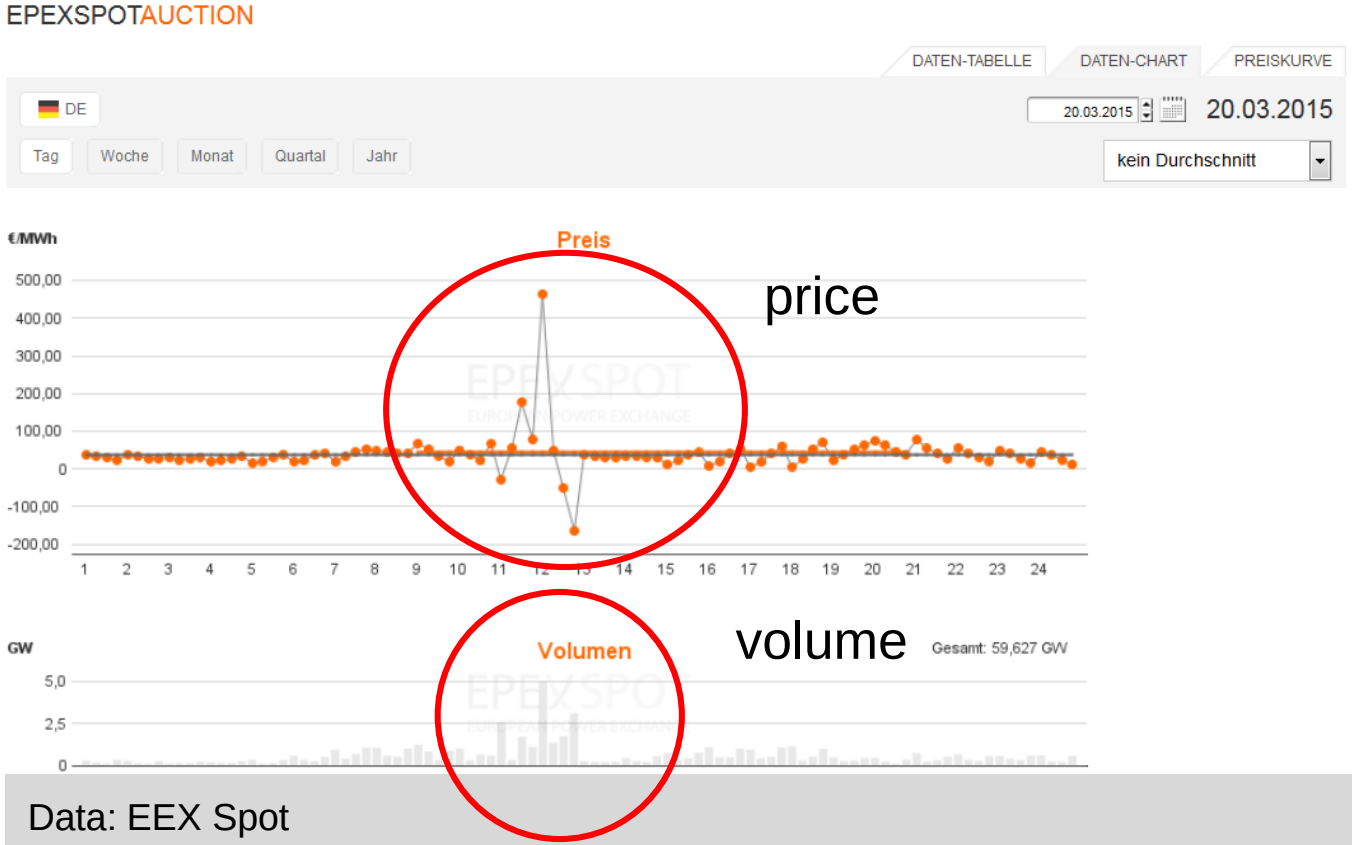


data: TSOs

System operators contracted only slightly more balancing reserve capacity than the previous day: only 1.5 GW.

Flexibility was traded in the intra-day market

Intra-Day Market in Germany on 20 March



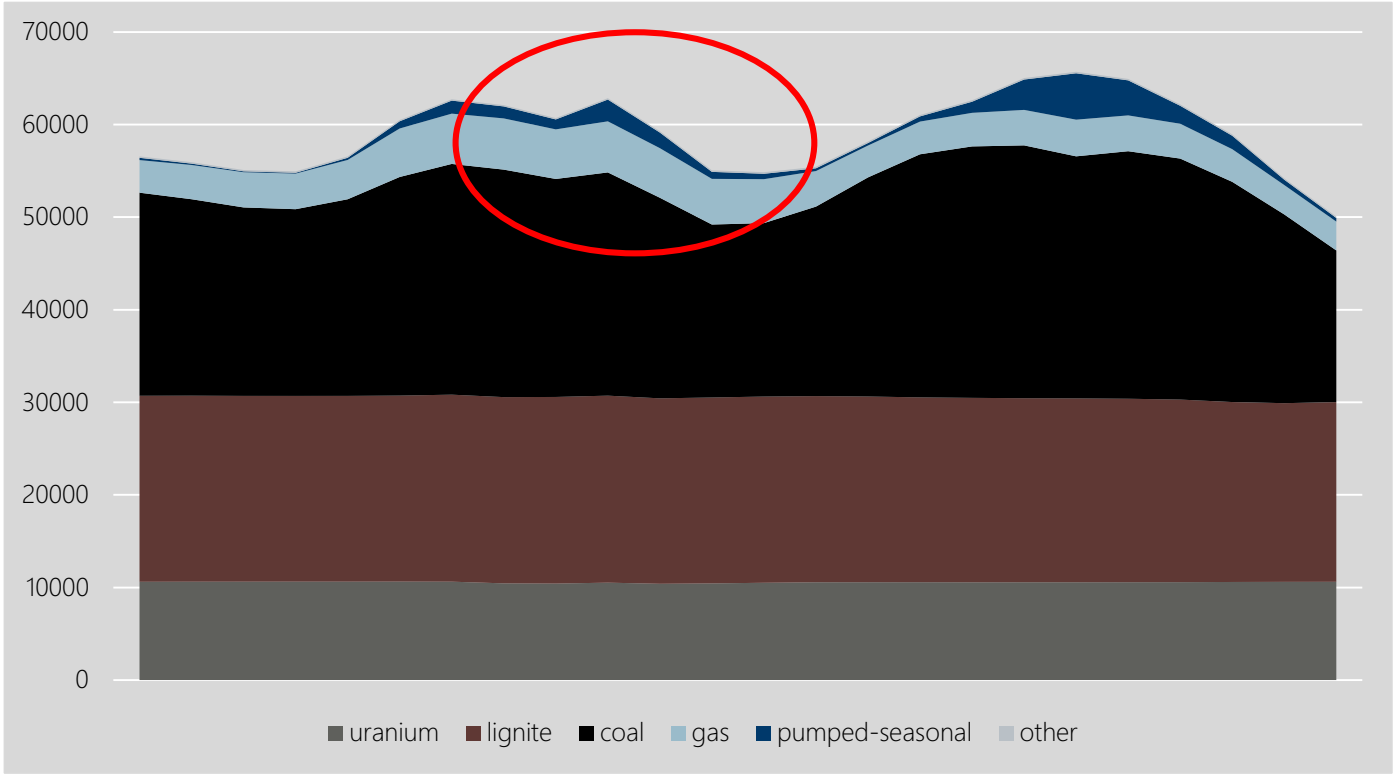
Data: EEX Spot

The day-ahead market saw slightly higher volumes and prices than usual.

The biggest effect was seen at the intra-day market where tranches of 15 minutes can be traded. Both volume and price showed significant variations – compared to normal levels.

flexible fossil capacity

Electricity production from conventional sources



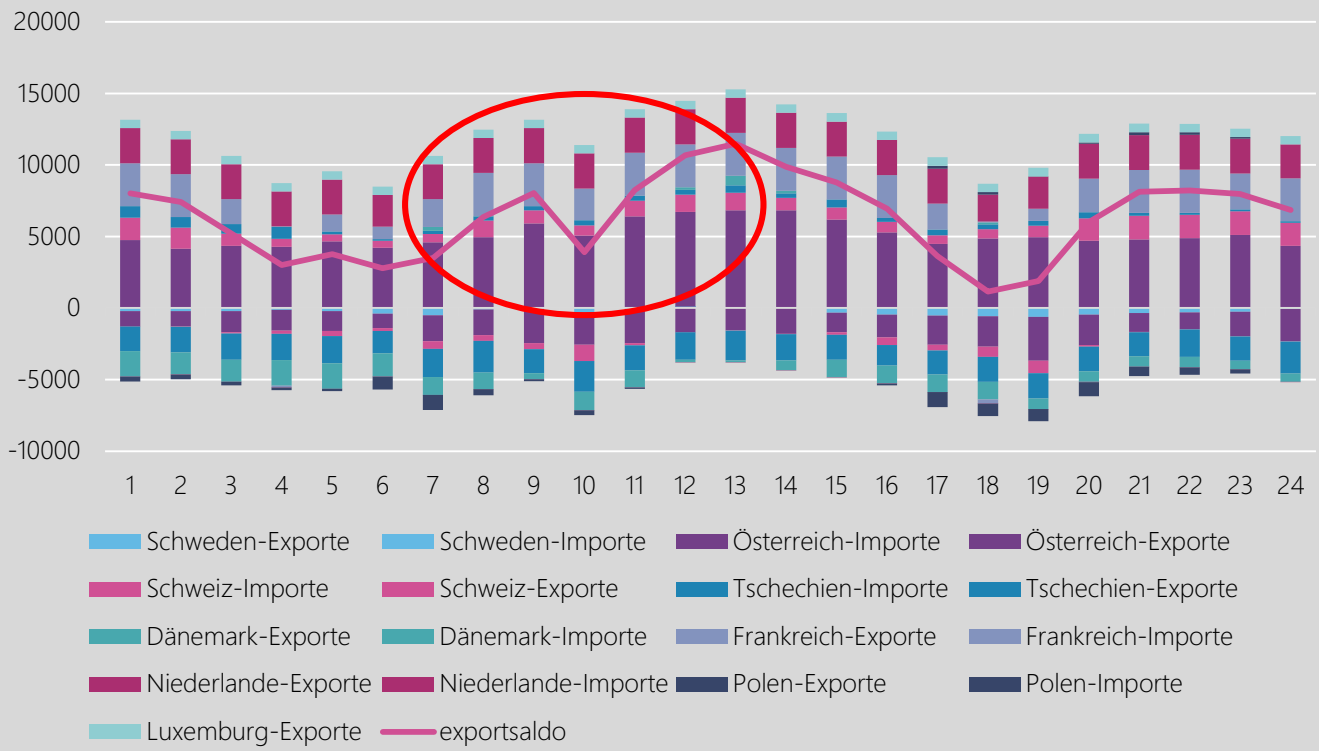
Among the conventional plants, it was mainly hard coal that slightly increased its production; to a lesser extend pumped hydro.

Nuclear and lignite continuted to run full load.

Only few gas plants were able to increase their production (being more expansive than hard coal plants)

System reaction: reduced exports

Electricity trade – Germany and neighbouring countries

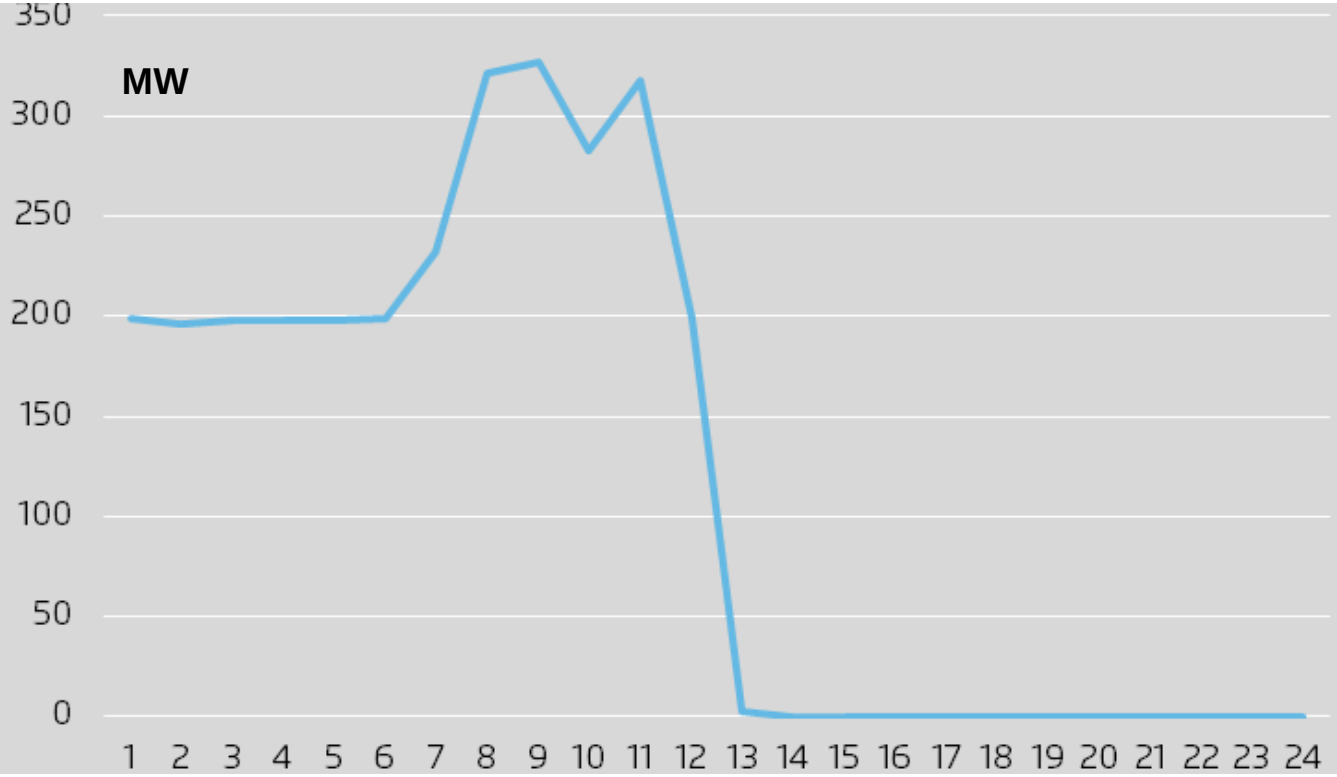


Own; EEX data

Exports to neighbouring countries were reduced by approx. 4 GW.

Example of one gas plant

Electricity production, gas plant „KW Donaustadt – DO3“ (Austria)



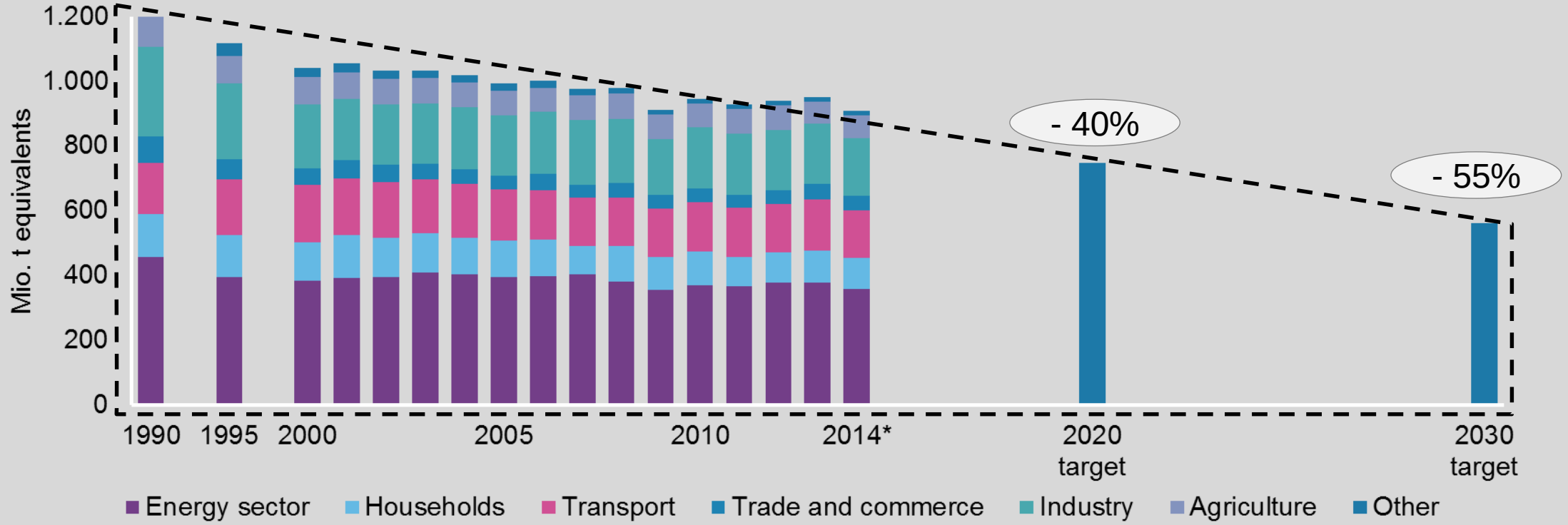
Data: EEX

Some gas plants increased their capacity – but had to entirely leave the system right after the end of the solar eclipse.

A word on:
Greenhouse Gas Emissions

Greenhouse gas emissions are currently at -26% compared to 1990 levels – with the power sector being the largest emitter

Greenhouse gas emissions by sector 1990 – 2014 and 2020/2030 targets

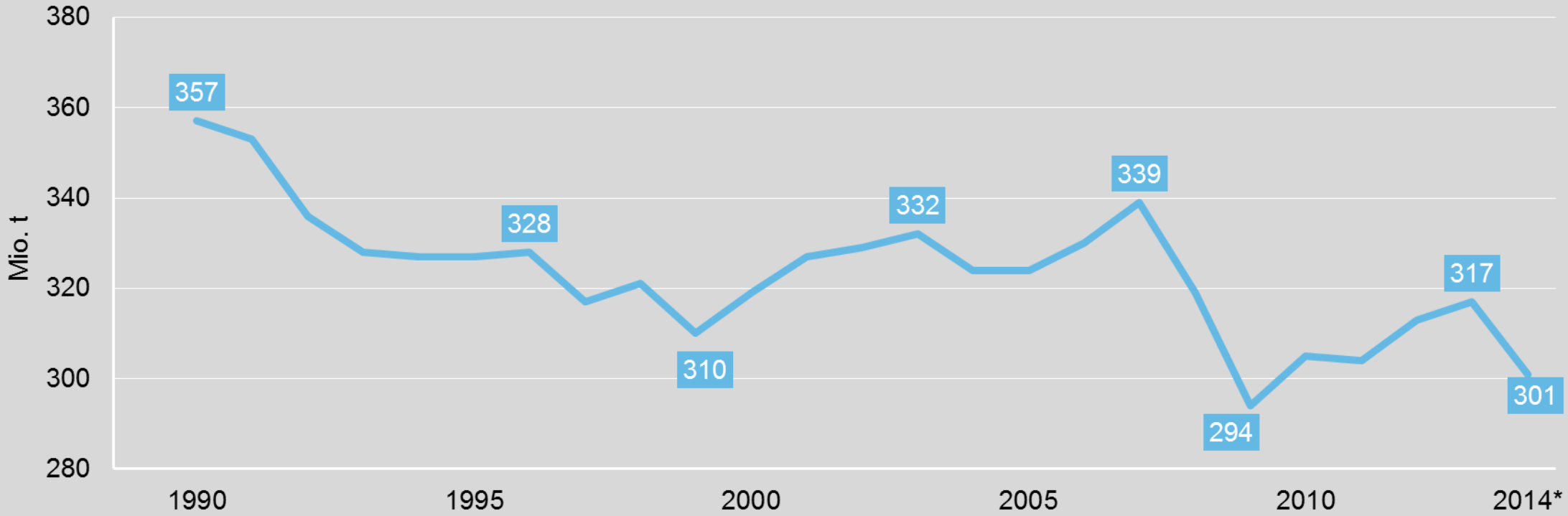


AG Energiebilanzen (2014), UBA (2014)

*Prognosis for 2014

After two years of rising emissions, in 2014 the CO_2 emissions in the power sector fell sharply due to less demand and more renewables

Greenhouse gas emissions of the power sector 1990 – 2014

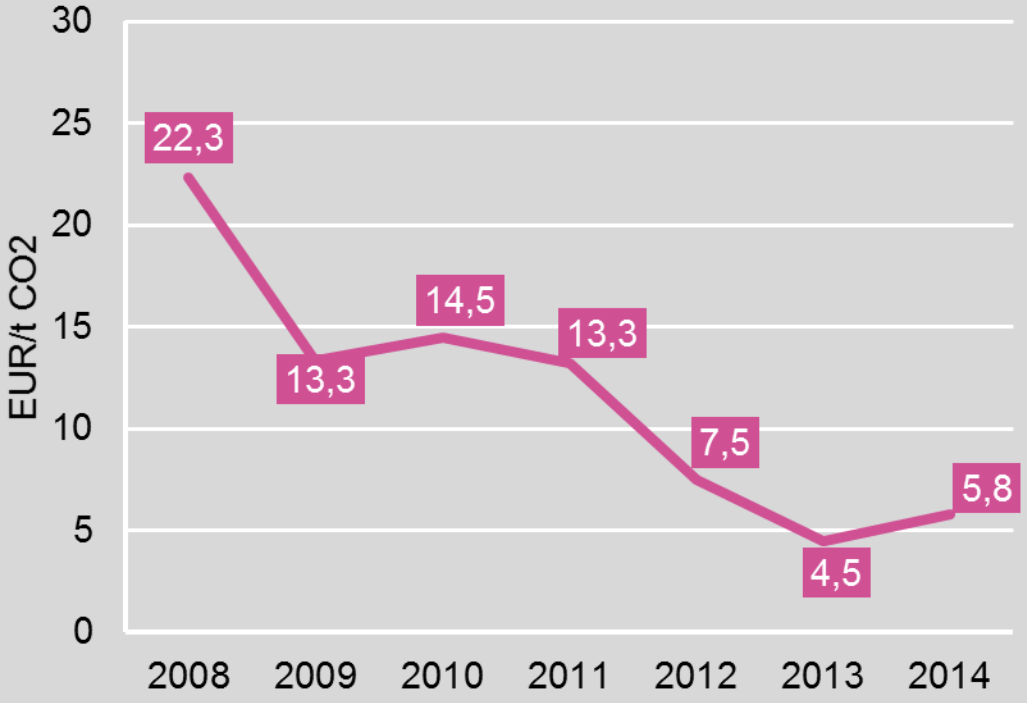


UBA (2014), own calculations

* prognosis

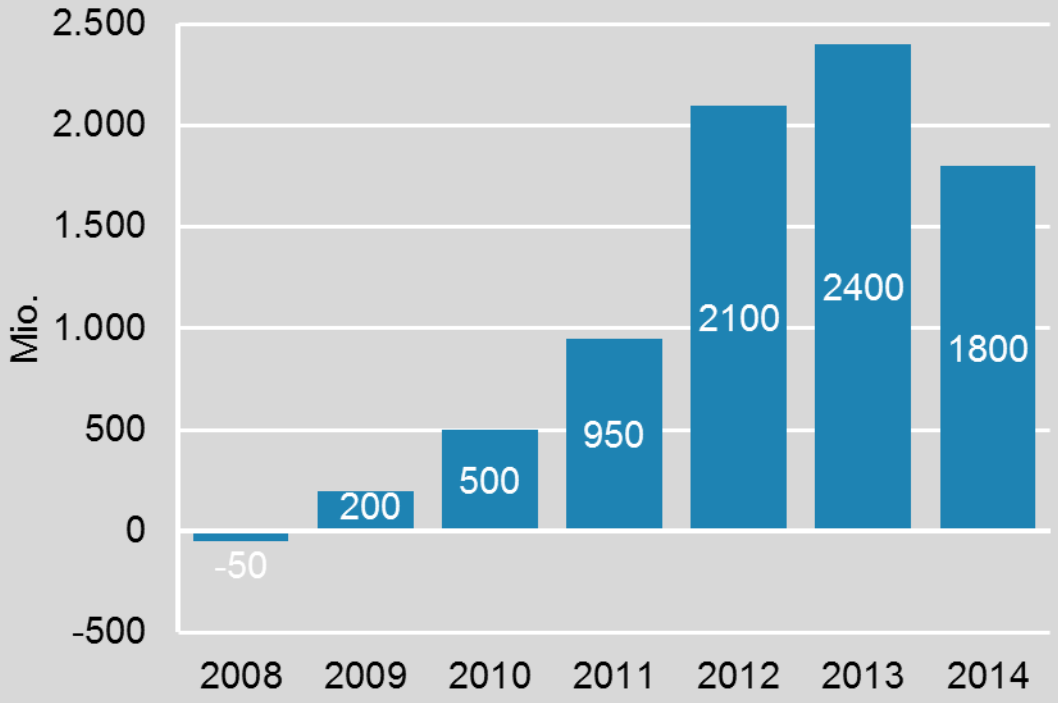
The key problem: The EU Emissions Trading system is facing huge overallocation, leading – unless fixed – to persistent low CO_2 prices

Price development of CO_2-certificates in EUR/t CO_2



ICE, BMWi (2014)

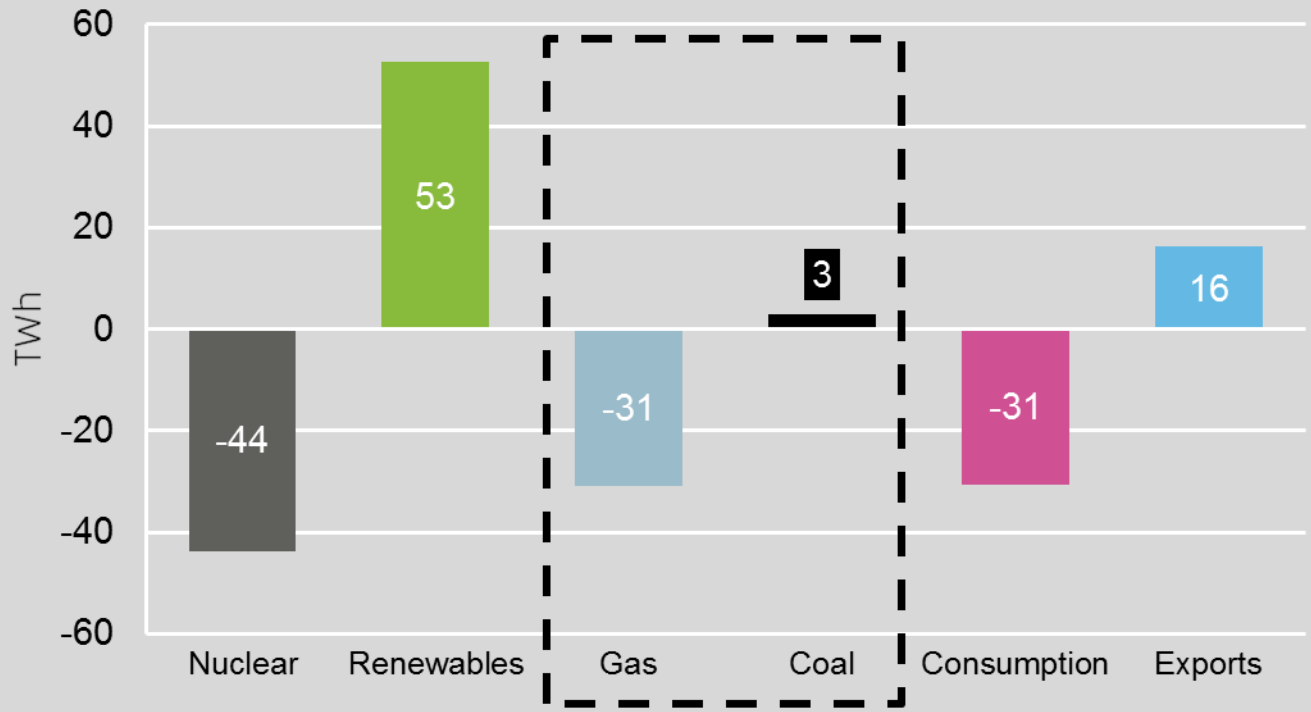
Cummulated overallocation of CO_2-certificates in Mio.



EC, DIW (2014)

As a consequence, coal use stays constant while gas in Germany and (via exports) in neighbouring countries is crowded out

Change of electricity generation, consumption and export surplus 2010 -2014 in TWh

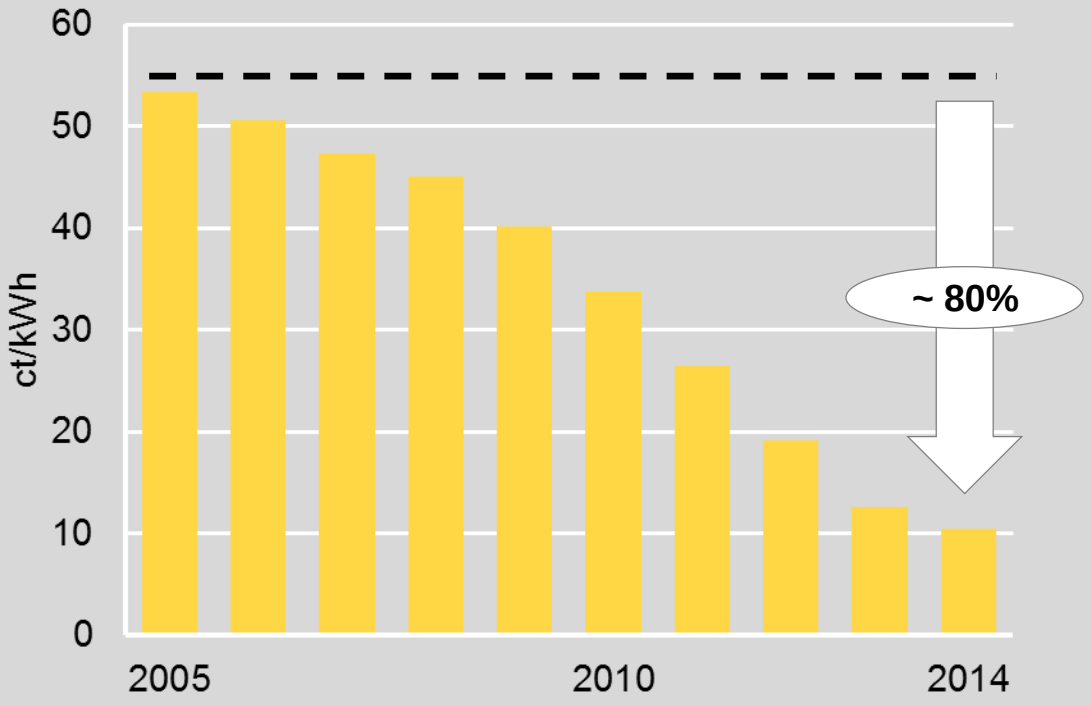


AG Energiebilanzen (2014)

A word on:
Household electricity prices

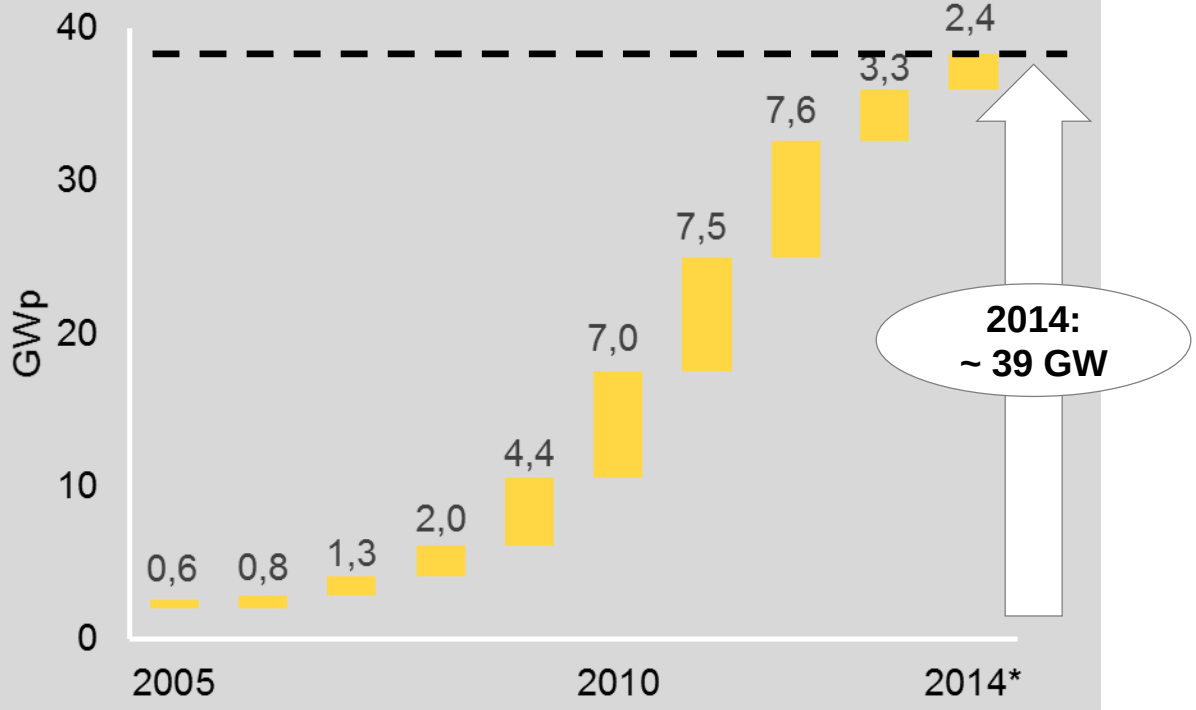
Germany took a lot of solar power plants into the system at times when they were still expensive

Average feed-in-tariff for solar PV panels 2005 - 2014



ZSW/BMWi (2014)

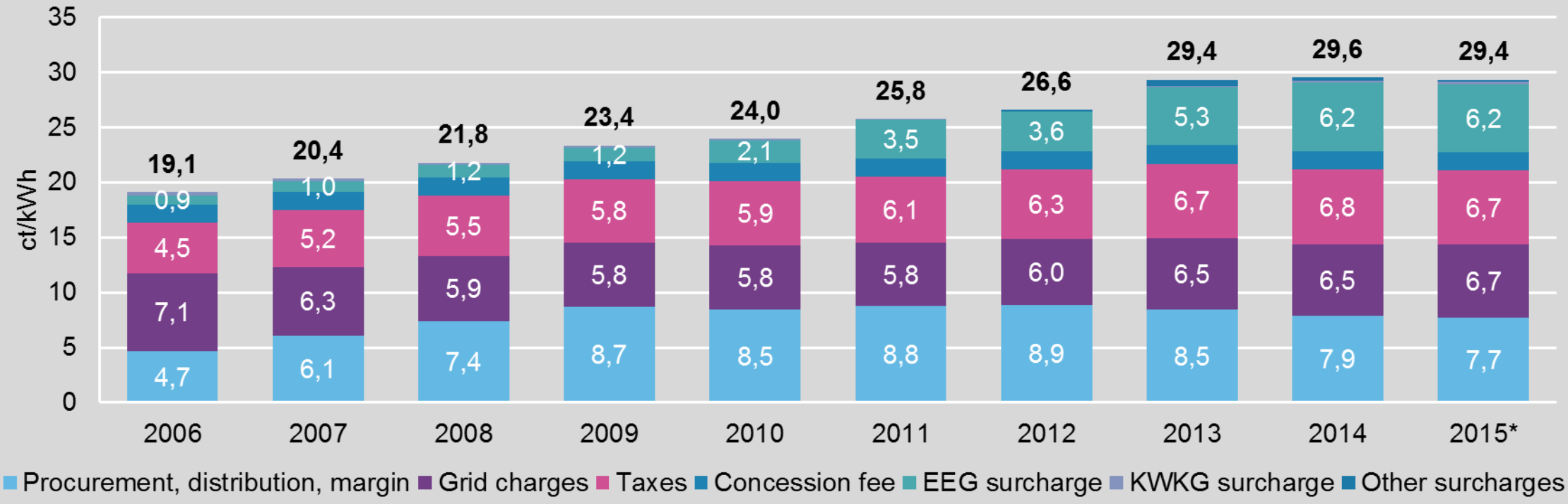
Annual installed solar capacities 2005 - 2014



BMWi (2014) *prognosis

This has driven household electricity prices in recent years. The price increase has come to an end in 2014…

Composition of household electricity prices 2006-2015 (3.500 kWh/a)

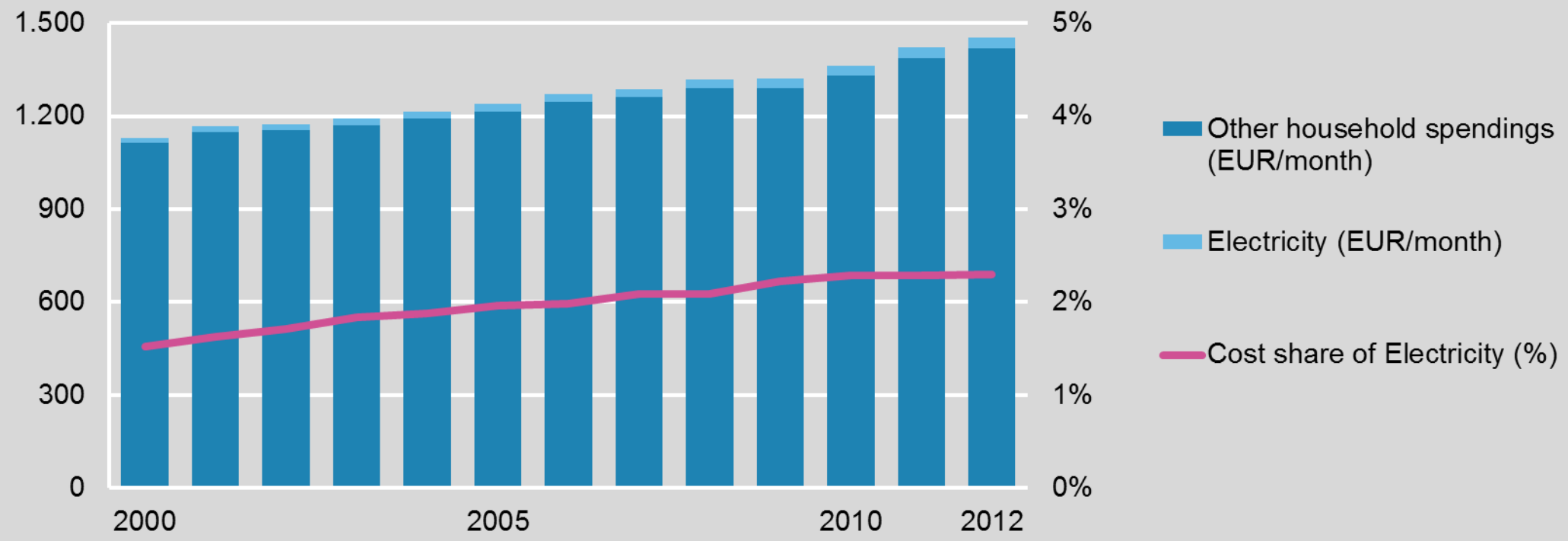


BDEW 2014, BNetzA 2014, own calculations;

*Prognosis for 2015

…with average household expenditures on electricity having varied between 1.6% and 2.4% in the past 20 years.

Share of electricity in average household spending



Destatis (2014)

Because of lower consumption, annual power bills of households in Germany are still in the same region as in other OECD countries.

Average household electricity bills in EUR/year

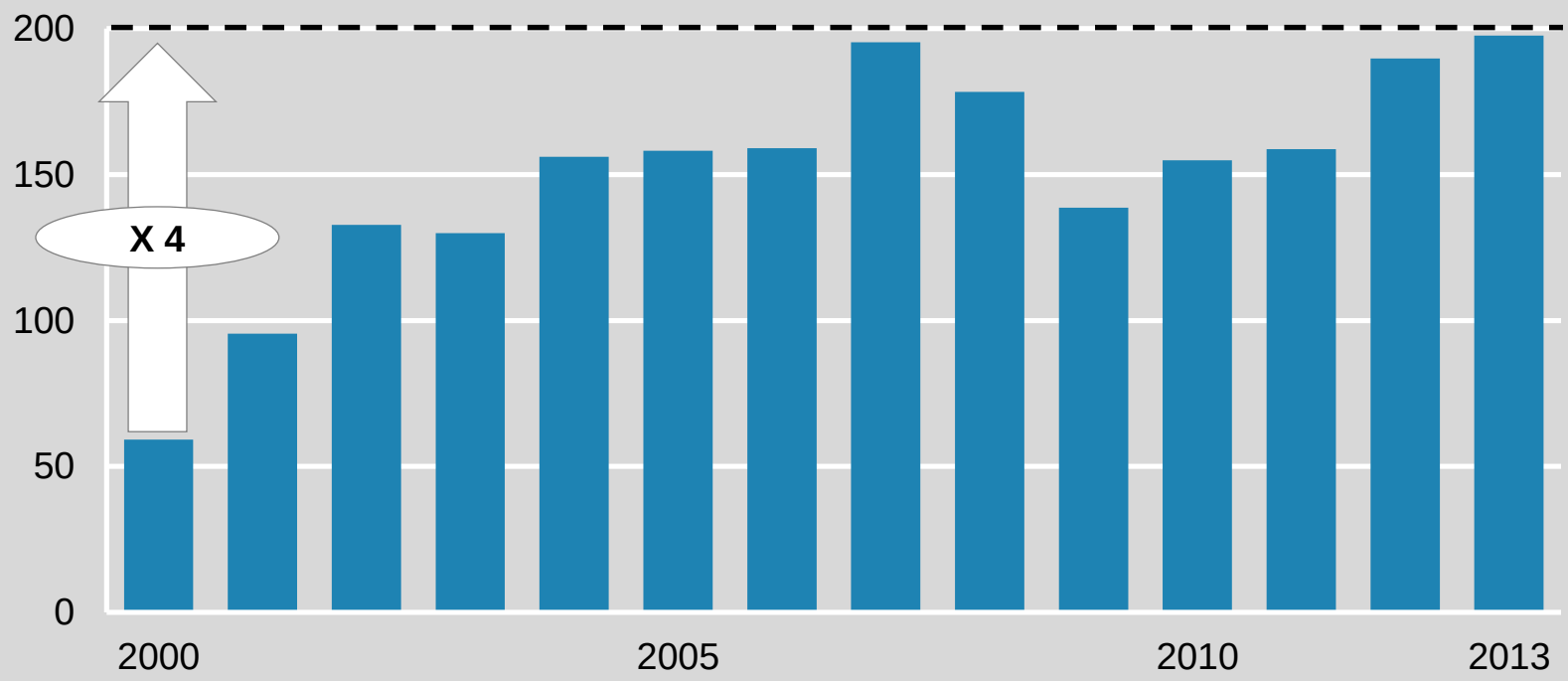
	Consumption (kWh)	Price (Ct/kWh)	Bill (EUR)
Denmark	4,000	30	1,200
US	11,800	9	1,060
Germany	3,500	30	1,050
Japan	5,600	18	1,010
Spain	4,400	23	1,010
Canada	10,800	8	850
UK	4,200	19	800
France	5,000	16	800
Italy	2,700	25	680

World Energy Council, EIA, Eurostat, Energy Intenlligence, New Energy, own calculations

A word on:
Industry electricity prices

The *Energiewende* does not seem to harm Germany's economic competitiveness

Export surplus in Bln. EUR



Destatis

For industry as a whole, energy costs account in average for about 2% of total production value…

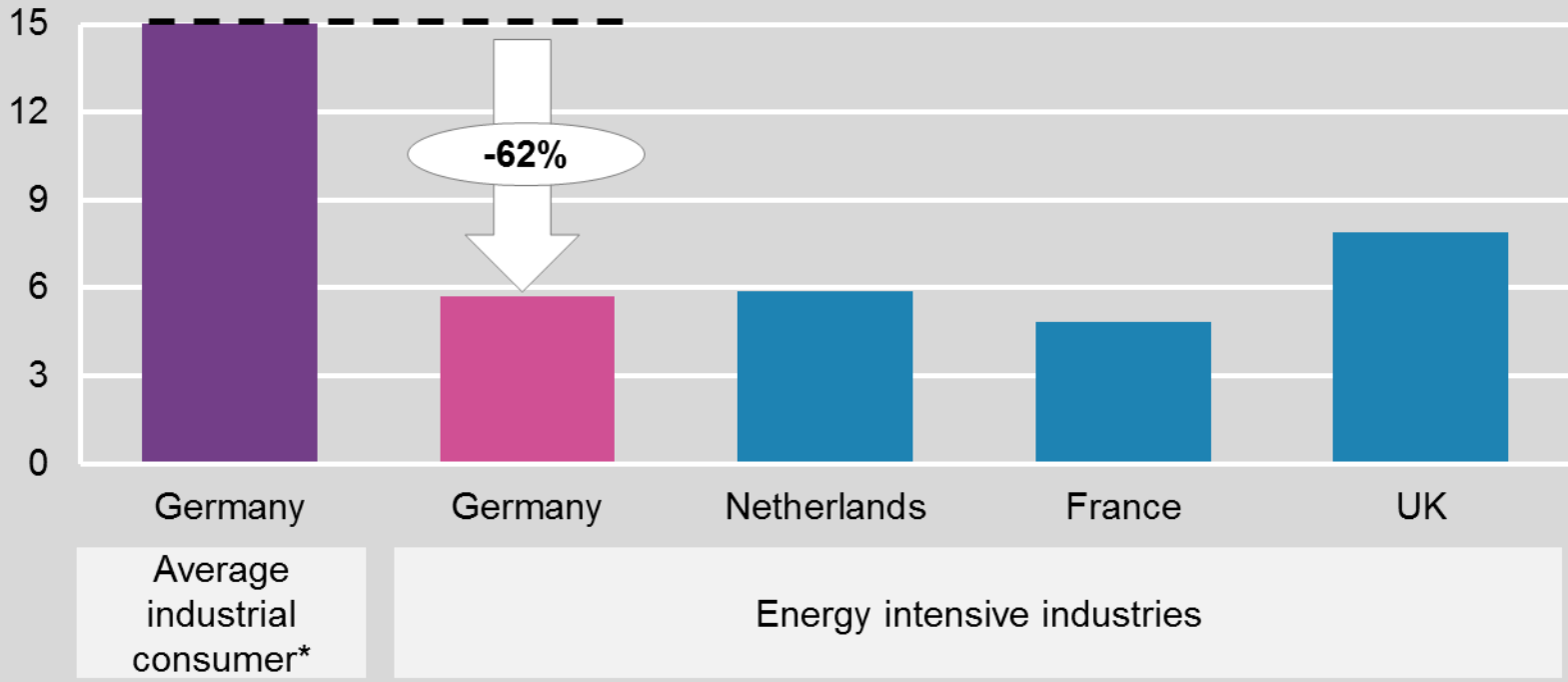
Gross production value* of the German manifacturing industry in Bln. EUR

Destatis

*incl. energy intensive sectors

…and energy intensive industries are largely exempt from taxes and levies to safeguard their competitiveness

Average electricity prices for energy intensive industrial consumers in 2013 in ct/kWh



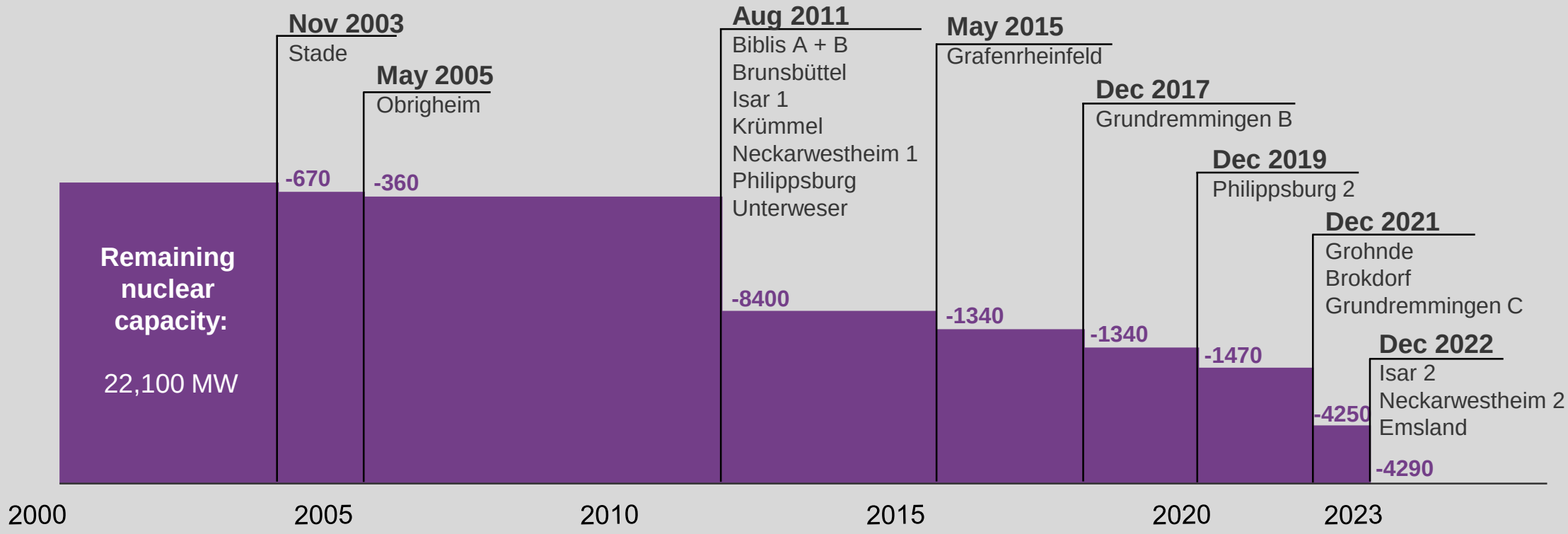
BMWi (2014)

*Assuming annual consumption of <20 MWh and partially exemptions from levies

Backup II

Nuclear phase out is stretched over two decades

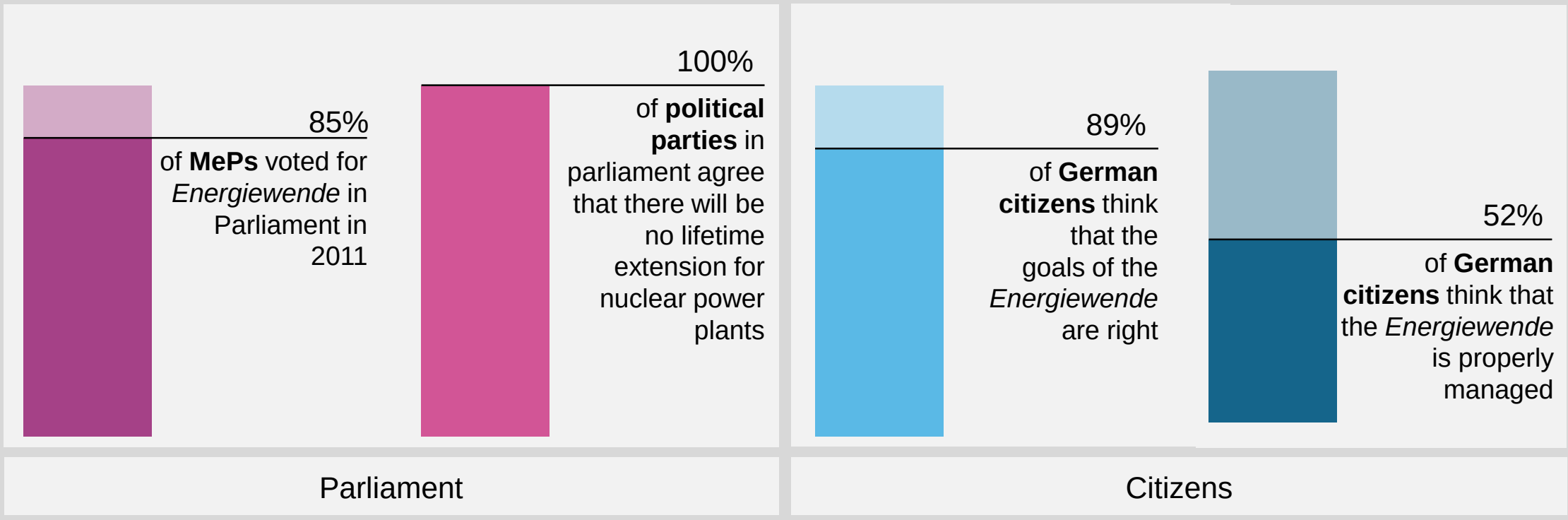
Planned phase-out of nuclear power plant units until 2022



BMWi, energytransition.org

There is a broad political consensus on the goals of the *Energiewende* – and discussions are mainly targeting its implementation

Political decisions and public opinion on *Energiewende*



BDEW, Forsa

LCOE – Cost assumptions

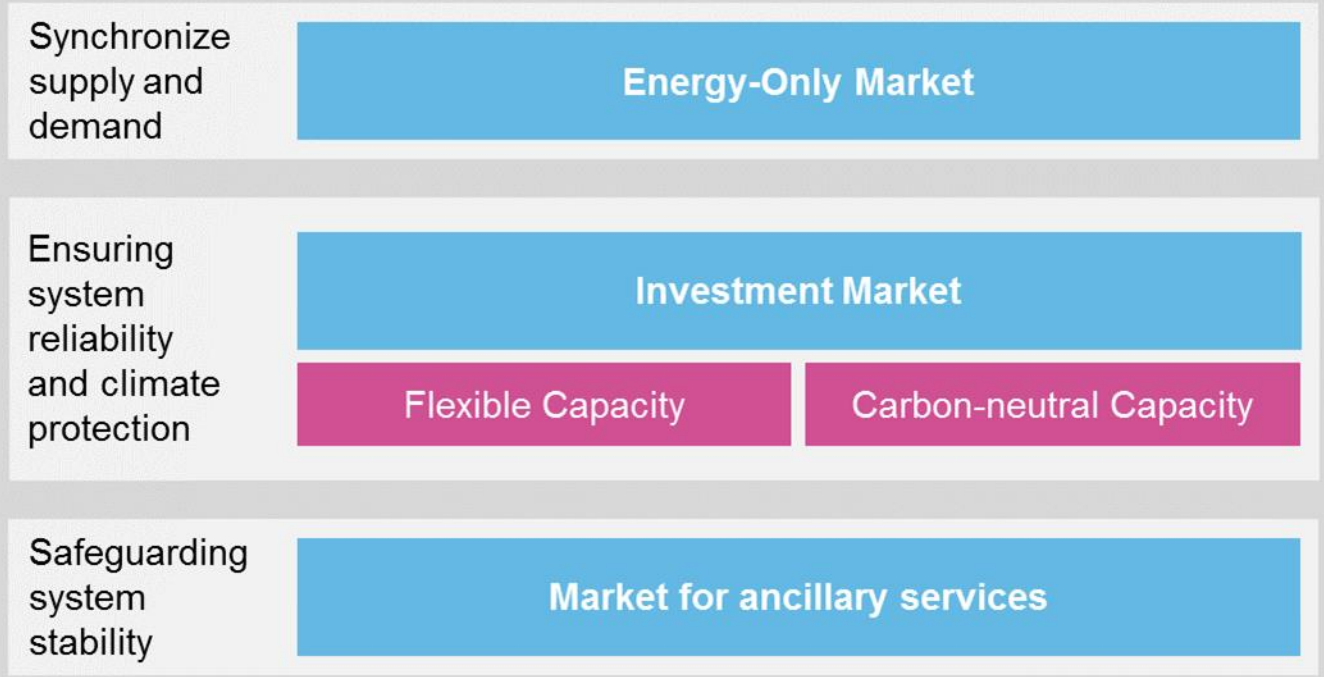
Range of levelized cost of electricity (LCOE) in 2015 in EUR/MWh - assumptions

	Invest (min./max.)	WACC (%)	Lifetime	Full load hours (min./max.)	CO2 certificats (min./max.)	Efficiency (min./max.)
	EUR/kW	%	a	h	EUR	%
Wind	1250/1500	7%	20	2000/2500		
PV	800/900	7%	30	1000		
Lignite	1850	12%	50	3000/6000	10/20	35%/45%
CCGT	900	12%	30	2000/4000	10/20	60%
Coal	1500/2250	12%	50	3000/6000	10/20	46%/50%
Nuclear	6000	12%	60	6000/7500		33%

Agora Energiewende

A new market design complying the *Energiewende* is necessary

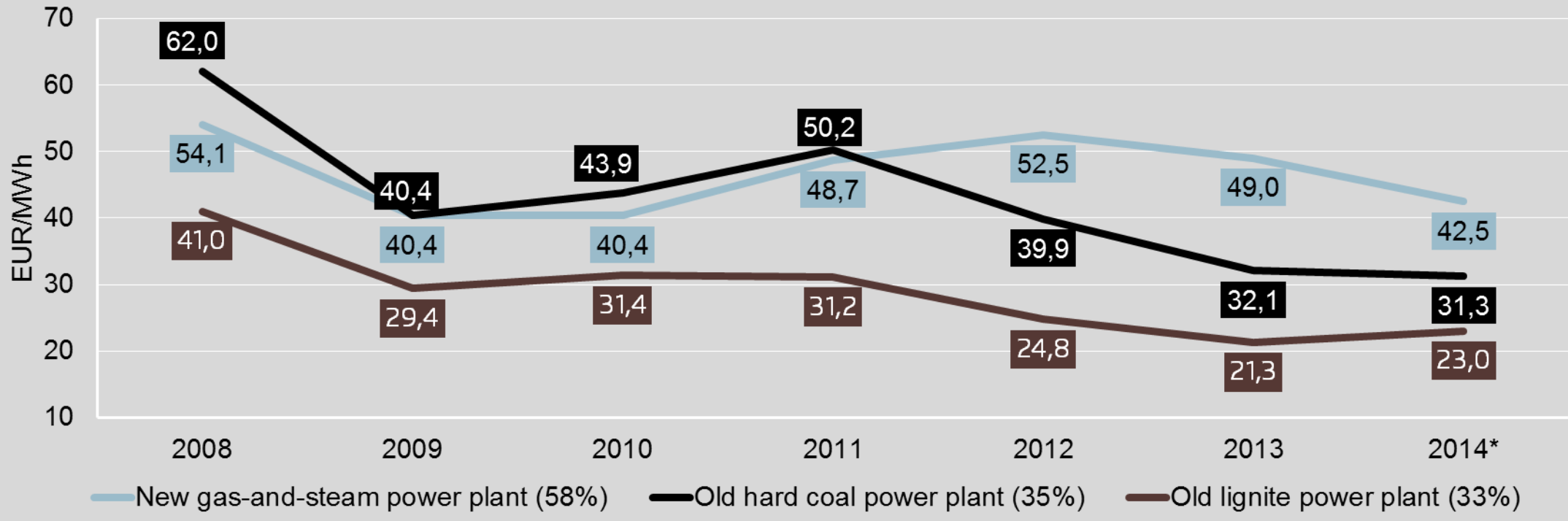
Illustrative structure of a future market design



Agora Energiewende

Diverging fuel prices of coal and gas increased the price spread of coal and gas power plants

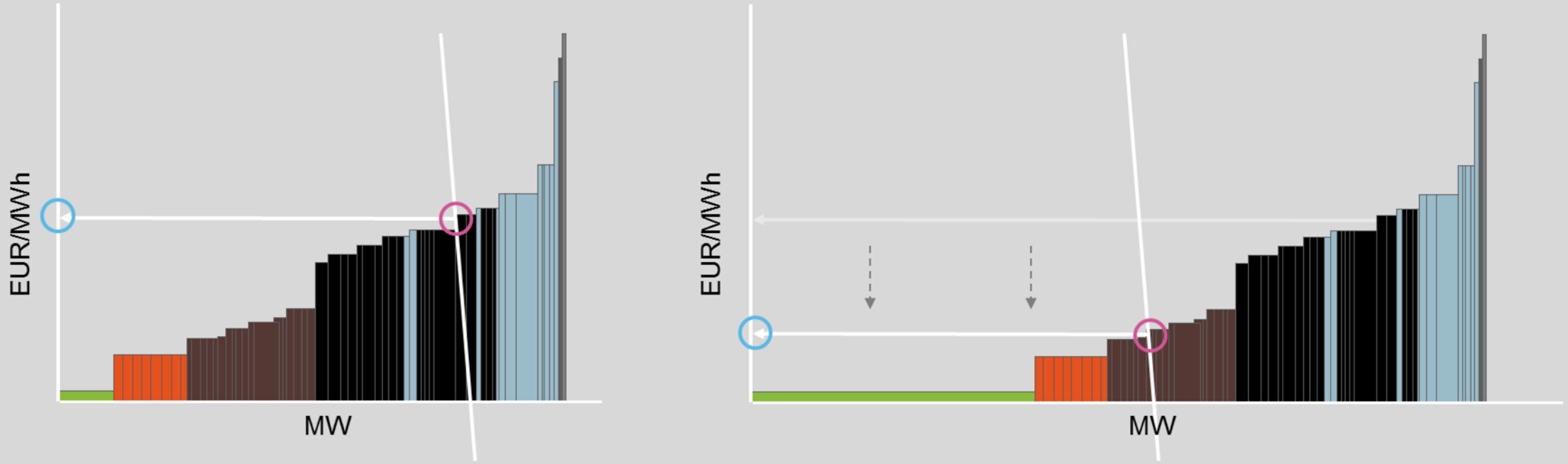
Marginal generation cost development of illustrative power plants in EUR/MWh



BAFA, BMWi, EEX, own calculations

Increasing shares of renewables led to sinking wholesale prices at the exchange

Illustration of the Merit-Order-Effect



Agora Energiewende