

The Energy Transition in the Power Sector: State of Affairs in 2017

*A review of the major developments of
2017, including an outlook for 2018*

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Podewils**

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Key Aspects of the 2017 Power Market



Overview of Key Findings

1

The expansion of renewables continues its record pace, with green power covering 36 per cent of Germany's electricity demand. The growth has been primarily driven by added wind capacity and windy conditions. 2017 was the first year that the share of wind energy in the power mix exceeded that of hard coal and nuclear power, both of which fell to their lowest levels since 1990. With renewable shares in the heating and transport sectors stagnating, however, Germany will reach its 2020 target share for renewables in total energy consumption only if renewable expansion in the power sector remains at this high level.

2

Energy use rose again in 2017, as in the previous years. Primary energy and electricity use both increased by around 0.8 per cent. Advances in energy efficiency, in other words, have not been strong enough to offset or even outweigh economic growth and a rising population. As a result, it will be nearly impossible for Germany to reach its 2020 energy efficiency targets (a 20 per cent reduction in primary energy use and a 10 per cent reduction in electricity use relative to 2008 levels).

3

Greenhouse gas emission levels have been flat for the third year in a row. While emissions in the power sector fell slightly as coal-fired electricity declined, increased use of petroleum and natural gas in the transport, building, and industry sectors has led to additional emissions. If Germany stays at its current pace (started in 2000), it will only be possible to achieve emission reductions of 30 per cent (in relation to 1990) by 2020 – a long way short of the government's goal of minus 40 per cent.

4

Electricity prices have risen slightly, while renewables have grown more affordable. In 2017, power exchange prices rose somewhat because of higher fuel prices. As a result, residential electricity prices in 2018 are likely to exceed 30 cents per kilowatt hour for the first time. By contrast, renewable energy auctions showed how cheap wind and solar have become: guaranteed kilowatt-hour prices fell below 5 cents for solar, 4 cents for wind onshore, and 2 cents for wind offshore.

10 Aspects of the 2017 Power Market

- **1. Renewable energy:** Thanks mostly to windy conditions and a significant number of new offshore and onshore wind turbines, renewables in Germany increased by a record-breaking 28.7 terawatt hours in 2017, covering 36.1 per cent of the country's electricity demand. By contrast, the stagnating growth of renewables in the transport and heating sectors kept its overall share in primary energy consumption to 13.1 per cent, up only slightly from the previous year.
 - **2. Conventional energy:** Amid power plants closures and upticks in import prices the share of hard coal in primary energy consumption fell to 11 per cent, its lowest level since 1990. Nuclear energy, in line with Germany's planned phase-out, dropped as well. That said, demand for petroleum and natural gas rose, while lignite consumption remained mainly unchanged.
 - **3. Primary energy and electricity consumption:** Economic growth, a rising population, and cooler temperatures produced 0.8-per cent rises in primary energy consumption and electricity demand. With these results, Germany's 2020 energy efficiency targets – a 20 per cent reduction in primary energy and a 10 per cent reduction in electricity use – seem to have drifted out of reach.
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10 Aspects of the 2017 Power Market

- **4. Climate change mitigation:** Despite the increased levels of renewables, greenhouse gas emissions remained constant at 27.6 per cent below 1990 levels – the slight drop in emissions from the power sector neutralized by a corresponding rise in the transport, industry and housing sectors. Germany's current CO_{2e} emission levels are still 155 million metric tons over its 2020 goal (i.e. a 40 per cent reduction against a 1990 baseline). If Germany stays at its current pace (started in 2000), emission reductions will reach only 30 per cent by 2020.
- **5. Electricity trading:** Germany had another record year for power exports as its export surplus rose from 56.1 terawatt hours in 2016 to 60.2 terawatt hours. Austria, France, the Netherlands, and Switzerland remain the largest importers of German electricity.
- **6. Electricity prices:** Increases in the cost of gas, coal and oil edged up prices on the power exchange. Futures for the year 2018 averaged 32.4 euros per megawatt hour, while next-day spot market prices hovered around 34.2 euros. As a result, German residential electricity in 2018 is projected to exceed 30 cents per kilowatt hour for the first time.

10 Aspects of the 2017 Power Market

- **7. Flexibility:** Price fluctuations on the spot market have become more pronounced amid rising shares of wind and solar power. 2017 saw negative prices during 146 hours – the most ever recorded in Germany – and many hours with prices over 100 euros per megawatt hour. Volatility on the intraday market was up as well. These trends have opened the market for new flexibility-based models such as load management and storage systems for electricity or heat.
- **8. Costs:** Wind and solar generation costs dropped considerably in 2017. The average auction prices for onshore wind, offshore wind, and solar continued to fall, amounting 3.82 cents, 1.94 cents, and 4.91 cents per kilowatt hour, respectively. However, total EEG costs will not begin to decline until 2023 due to the many legacy power plants still in operation.
- **9. Public opinion:** Generally, Germans view the clean-energy transition positively and support the phase-out of coal and nuclear power. But many also find the distribution of clean-energy costs to be unfair.

10 Aspects of the 2017 Power Market

- **10. Outlook for 2018:** In 2018, electricity companies plan to add no less than 4 gigawatts of wind capacity and 2 gigawatts of solar capacity. At the same time, nuclear power and lignite-fired electricity are likely to fall. The Gundremmingen B nuclear power plant was shut down on end of 2017 and 1.1 gigawatts of lignite capacity are currently slated for transfer to emergency reserve in October 2018. Planned closures of hard-coal- and gas-fired plants totaling 1.8 gigawatts will be offset by a similar amount of added capacity in these sectors.

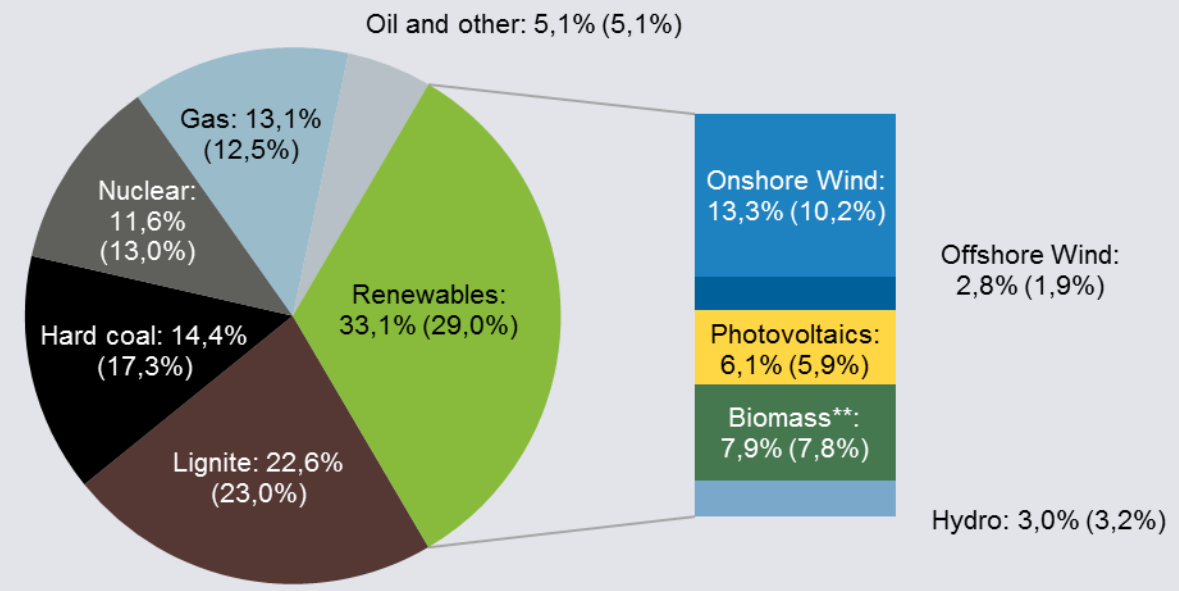
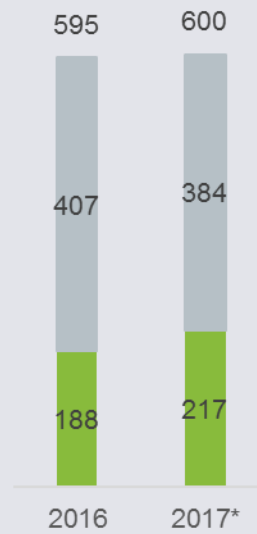
Power Generation in 2017

The background of the slide is a photograph of a wind farm. In the foreground, there are green grasses. In the middle ground, several white wind turbines are visible against a bright blue sky with scattered white clouds. The text 'Power Generation in 2017' is overlaid on the left side of the image.

The power mix in 2017: Renewables well in the lead; hard coal falls significantly, now behind wind energy

2017 power mix (2016 values in brackets)

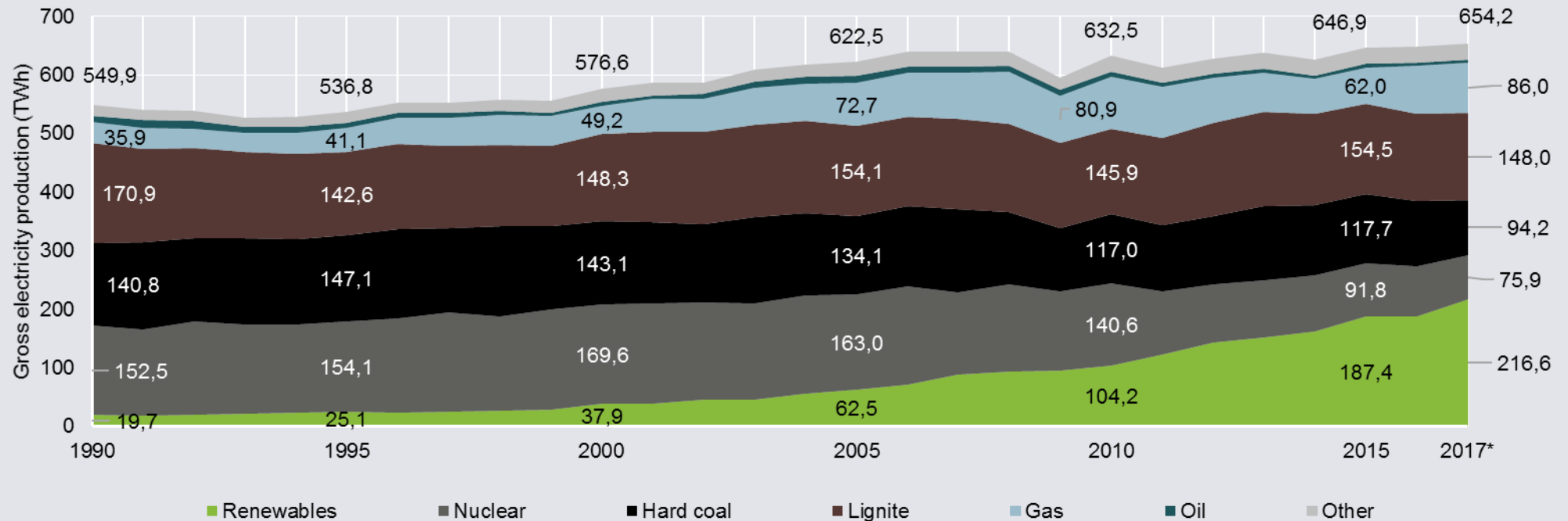
Gross national electricity consumption (TWh)



AG Energiebilanzen 2017a; *preliminary data; **includes biodegradable household waste

Power production in 2017: Renewables hit record high, hard coal and nuclear at record low

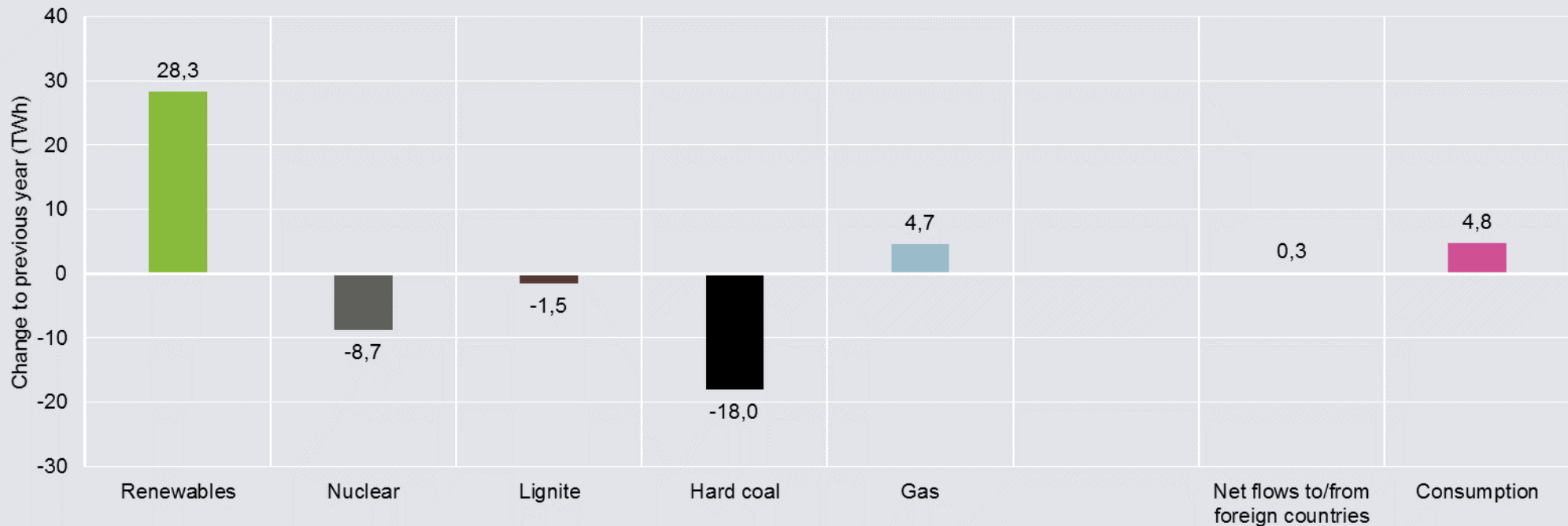
Gross power production, 1990–2017



AG Energiebilanzen 2017a; *preliminary data

Changes from 2016 to 2017: Record growth in renewables, sharp drop in hard coal and the continued decline in nuclear power

Changes in electricity volumes, 2016–2017



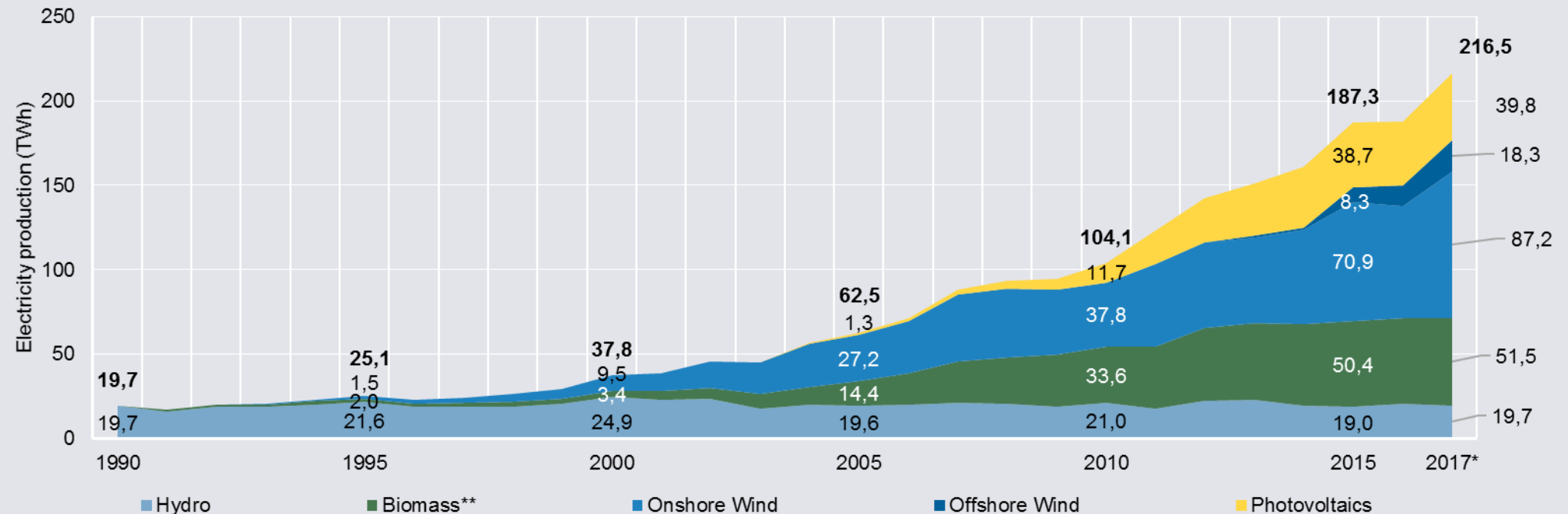
AG Energiebilanzen 2017a; preliminary data

Renewables in 2017



Renewables in 2017: Good year for wind and strong growth in capacity take renewables over 200 TWh mark for the first time

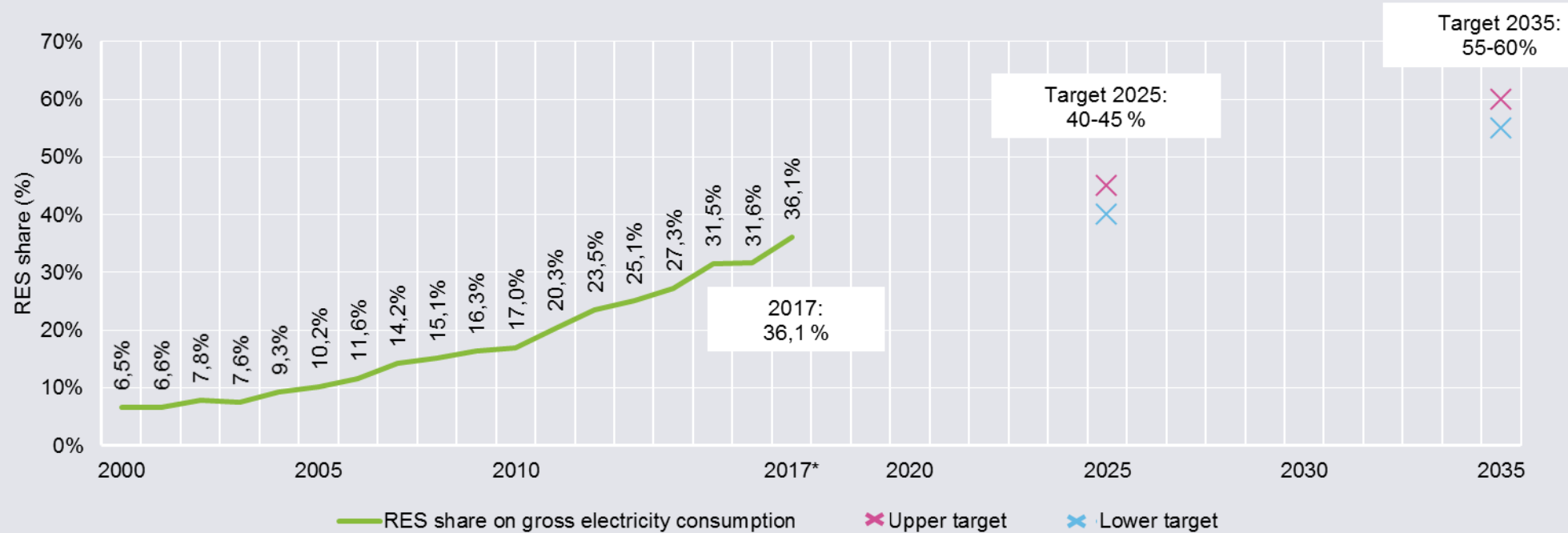
Power production from renewables, 1990–2017



AG Energiebilanzen 2017a; *preliminary data; **includes biodegradable household waste

Renewables cover 36 per cent of electricity use; Germany on track to reach 2025 target by 2020

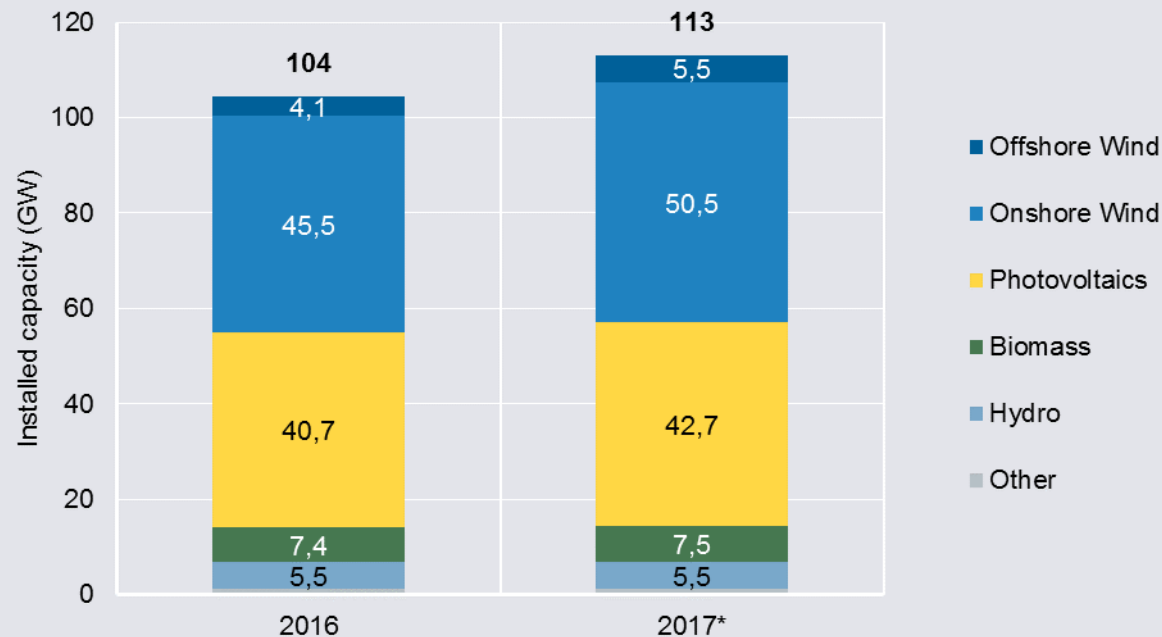
Share of renewables in gross power consumption, 2000–2017, together with 2025 and 2035 targets



AG Energiebilanzen 2017a; *preliminary data

Renewable capacity in 2017: Record expansion in wind energy

Renewable capacity in 2016 and 2017



Increases in 2017 (estimated)

- Wind onshore: 5 gigawatts
- Wind offshore: 1.4 gigawatts
- Solar: 2 gigawatts
- Biomass: 170 megawatts

Expansion targets

- Wind onshore: 2.8 gigawatts per year from 2017 to 2019; 2.9 gigawatts per year thereafter
- Wind offshore: 500 megawatts per year in 2021 and 2022; 700 megawatts per year from 2023 to 2025; 840 megawatts per year from 2026 to 2030
- Solar: 2.5 gigawatts per year
- Biomass: 150 MW from 2017 to 2019; 200 MW from 2020 to 2022.

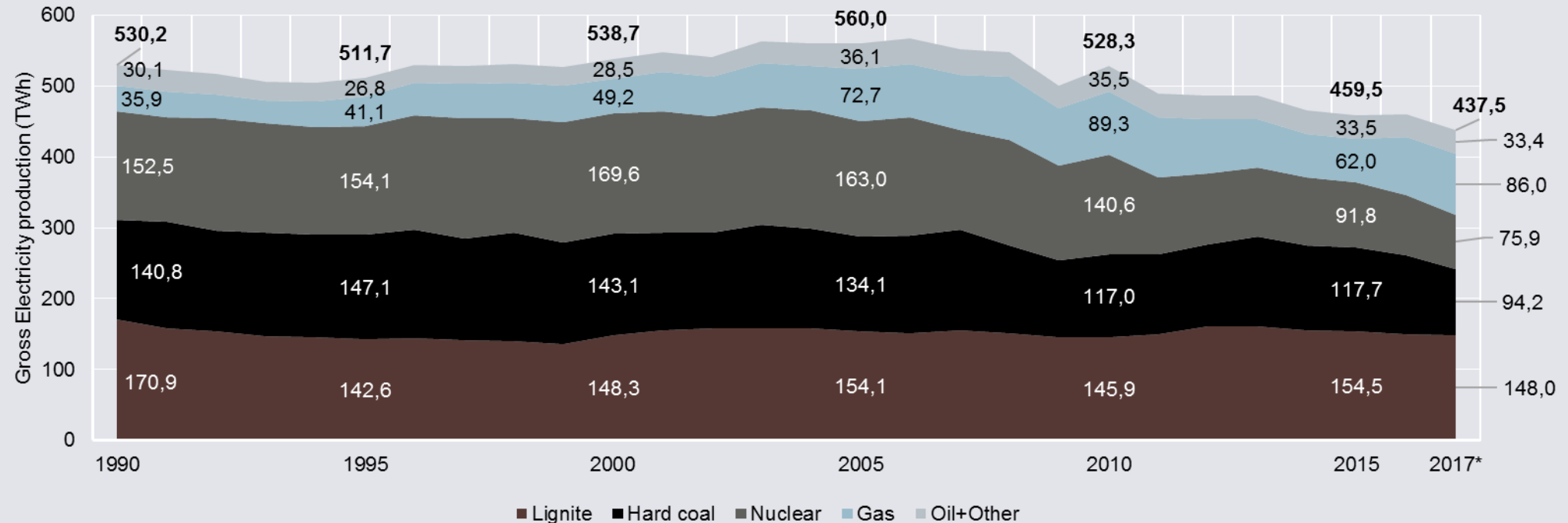
BNetzA 2017a; *own calculations based on BNetzA 2017a (7.11.2017), BNetzA 2017b, BWE 2017, FA Wind 2017, IWR 2017b, Offshore-Windindustrie 2018

Conventional Energy in 2017

A photograph of a wind farm with several white wind turbines in a field of tall green grass under a blue sky with scattered white clouds. The image is split into two vertical panels by a thin blue line.

Conventional power production in 2017: Hard coal and nuclear power fall to lowest levels since 1990; gas rises slightly and lignite remains constant

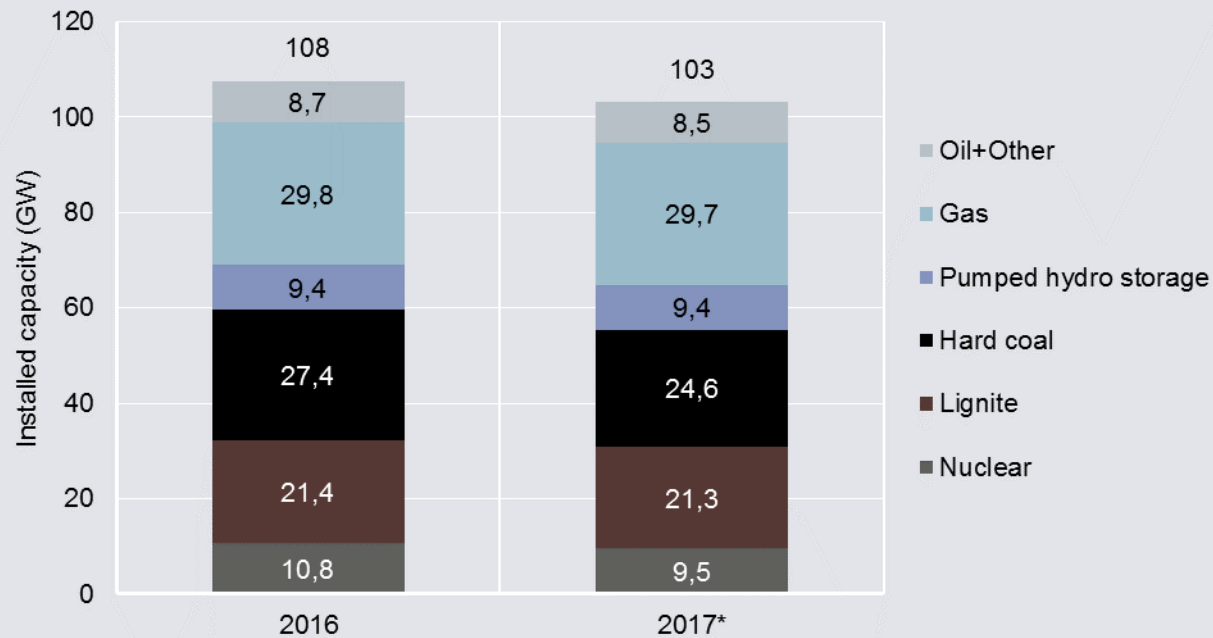
Gross power production from conventional fuel energy sources, 1990–2017



AG Energiebilanzen 2017a; *preliminary data

Conventional power production in 2017: Even after closures of hard coal and nuclear plants, power enough to guarantee supply security

Conventional capacity in 2016 and 2017



Conventional power production on 1.1.2017:

→ 108 gigawatts

Closures in 2017:

→ Hard coal: 2.8 gigawatts

→ Nuclear power: 1.3 gigawatts

Conventional power production on 31.12.2017:

→ 103 gigawatts

Maximum load in 2017:

→ 80.6 gigawatts (12.1.2017, 11am)

BNetzA 2017a; own calculations based on BNetzA 2017a (7.11.2017)

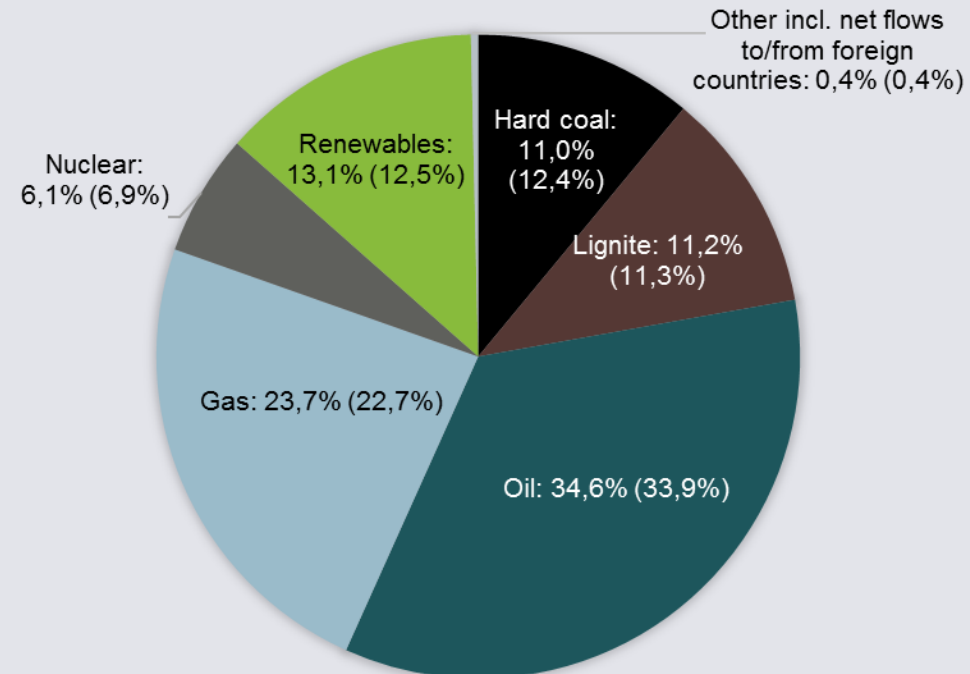
Energy and Electricity Consumption in 2017



Primary energy consumption in 2017: Renewables, petroleum, and natural gas increase; nuclear power and hard coal decline

Primary energy consumption mix in 2017 (values for 2016 in brackets)

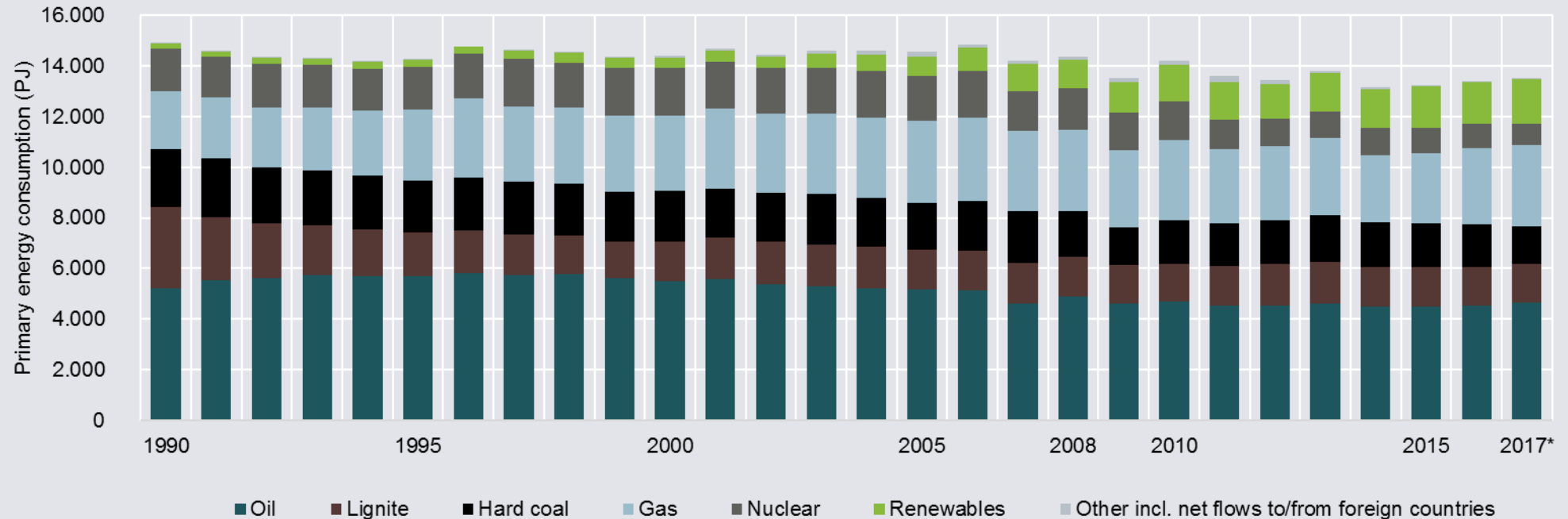
Primary energy consumption (PJ)



AG Energiebilanzen 2017b; *preliminary data

Primary energy consumption in Germany since 1990: For years now, very little changes in fossil fuel energy use – since 2014 even a rising trend

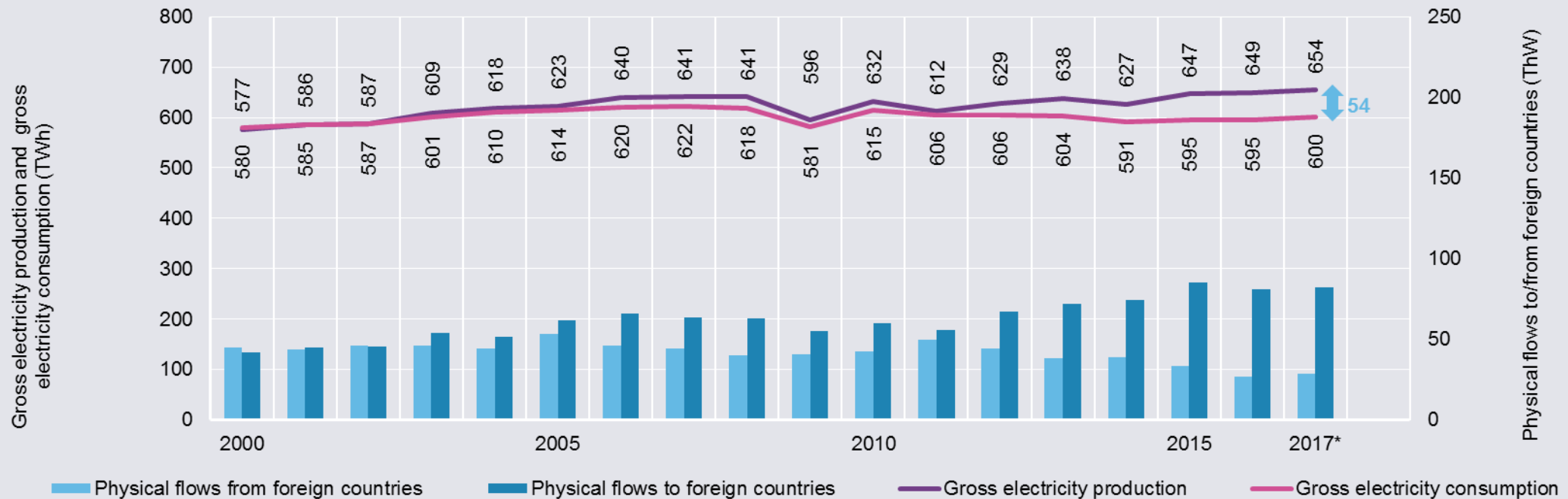
Primary energy consumption, 1990–2017



AG Energiebilanzen 2017b; *preliminary data

Growing export surplus since 2011: Germany produces more electricity than it consumes; in 2017, over 8 per cent of power went abroad

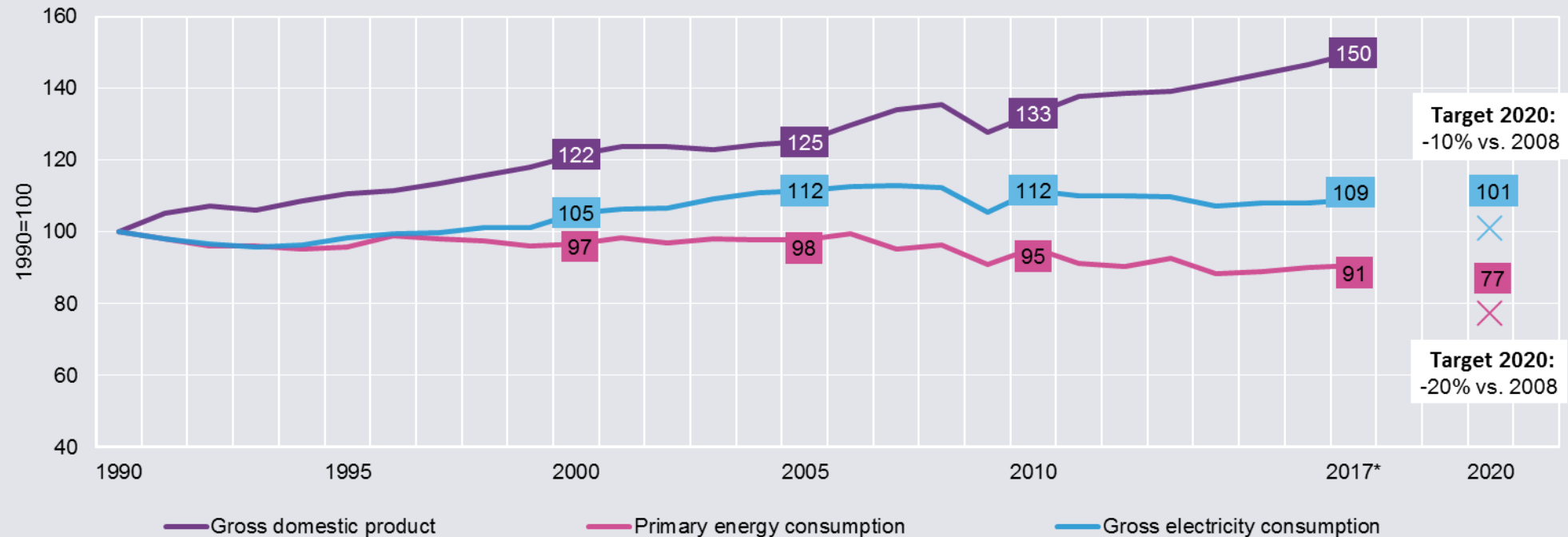
Power generation, power use, and load flows abroad, 2000–2017



AG Energiebilanzen 2017a; *preliminary data

Energy efficiency in 2017: Energy and electricity use begin to rise again as planned decoupling from economic growth remains only partial

Gross domestic product, primary energy consumption, and gross domestic electricity use, 1990–2017 (indexed, 1990=100)



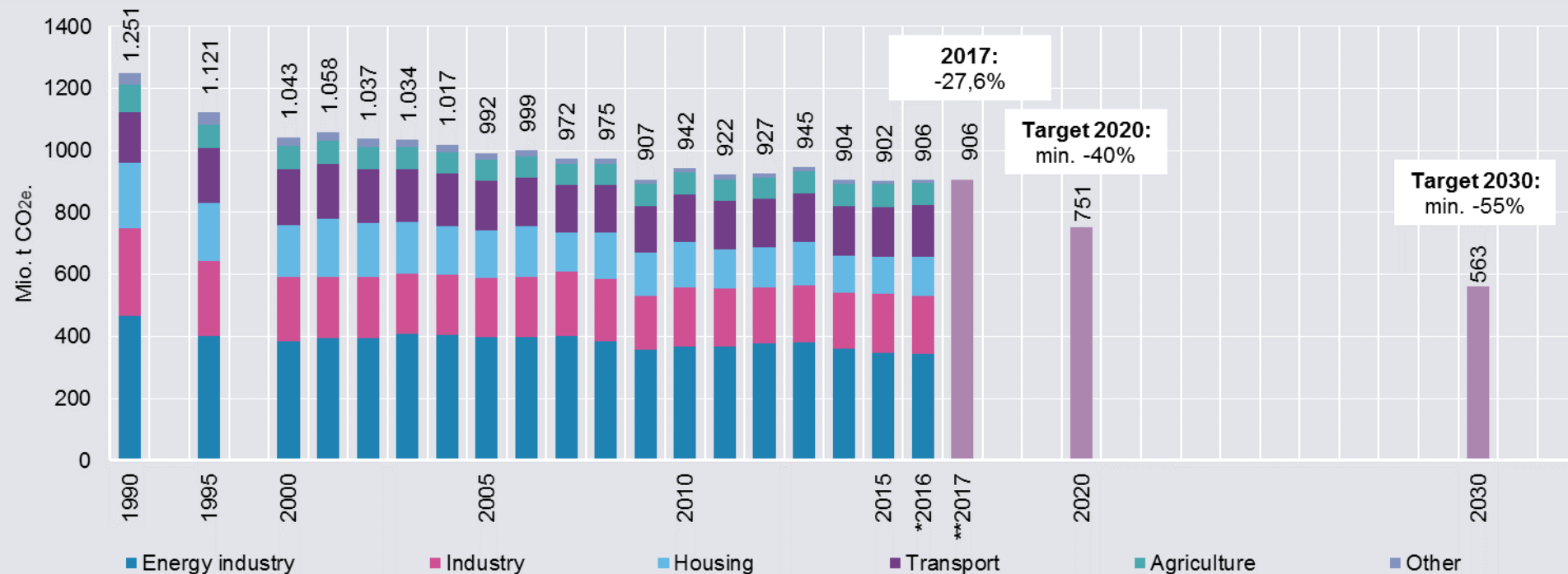
AG Energiebilanzen 2017a, Destatis 2017a; *preliminary data using own calculations

Greenhouse Gas Emissions in 2017



Greenhouse gas emissions 2017: As use of petroleum and natural grows, greenhouse gas emissions stagnate at a high level – the 40% reduction goal by 2020 is far away

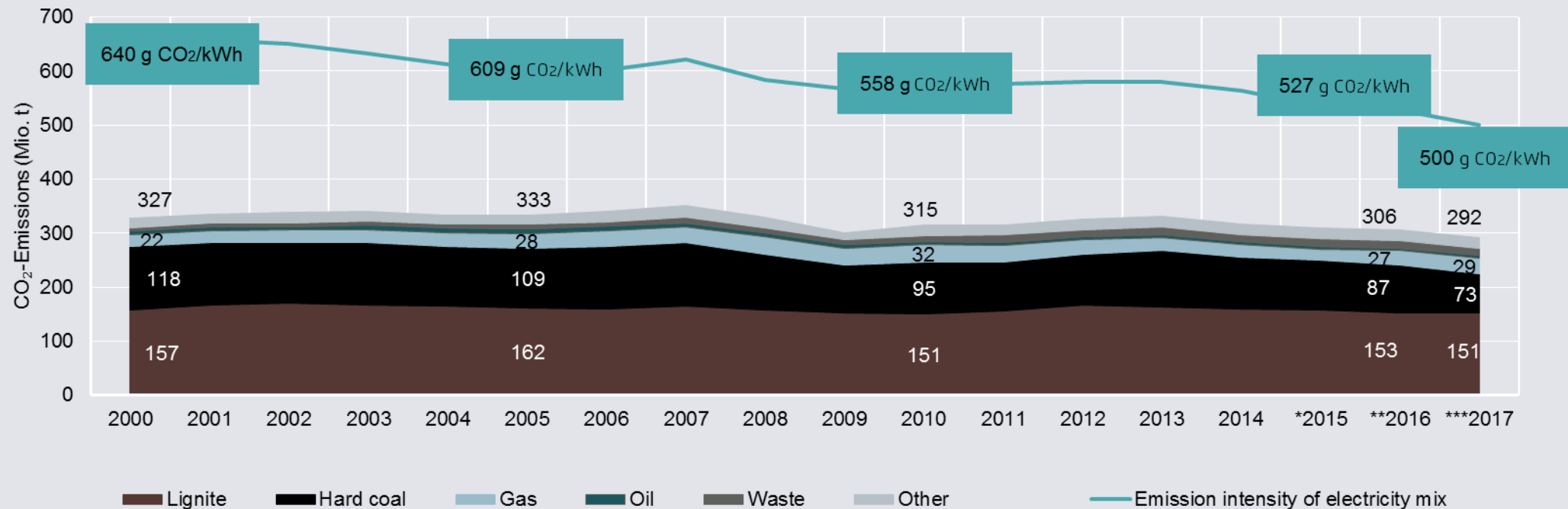
Greenhouse gas emissions by sector, 1990–2017, together with 2020 and 2030 targets



UBA 2017a; own calculations; *preliminary data; **own estimation

Greenhouse gas emissions in the power sector in 2017: With hard coal use in decline, CO₂ emissions are falling, albeit slowly

CO₂ emissions from power production, 1990–2017



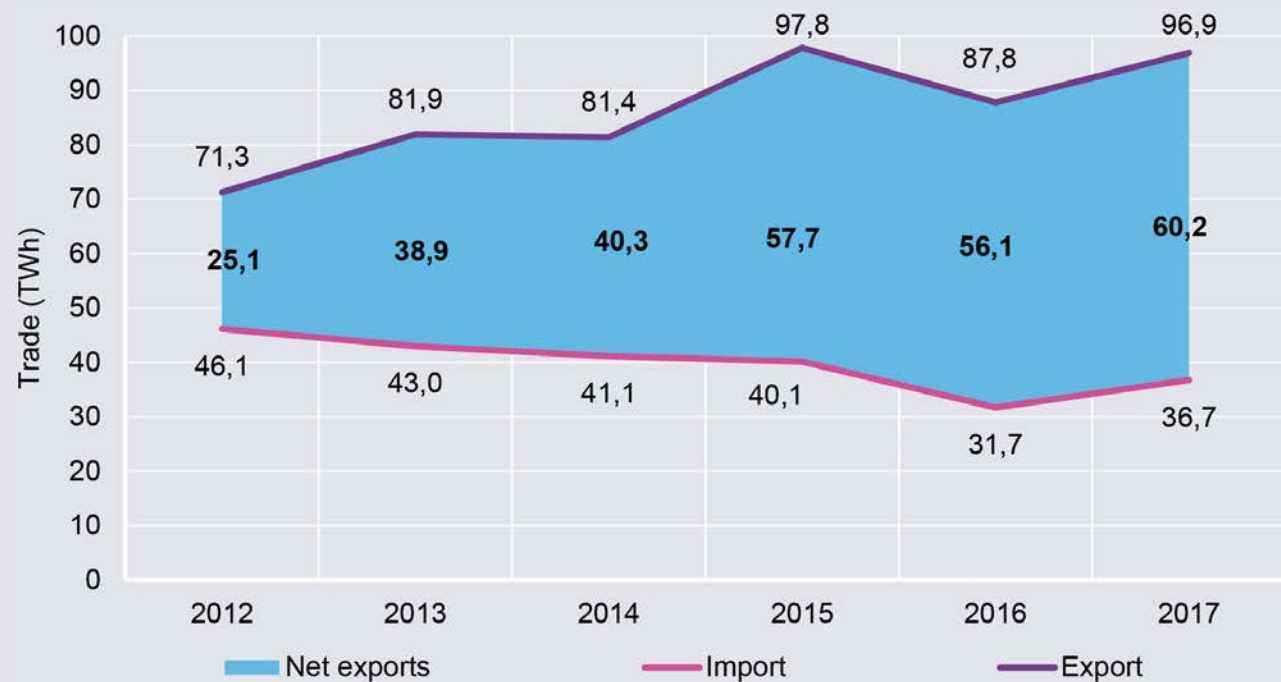
UBA 2017b (*preliminary data, **UBA estimation), ***own calculations

Electricity trading and prices in Europe in 2017



Germany is Europe's electricity export leader: Power totaling 10% of consumption sold abroad

Cross-border electricity trade in Germany, 2012–2017



Own calculations based on ENTSO-E 2018; commercial electricity trade flows are shown

- At 9 terawatt hours, electricity exports rose much more than electricity imports (5 terawatt hours)
- Austria, France, the Netherlands, and Switzerland remain the largest importers of German electricity.
- The largest exporters of electricity to Germany are Denmark and the Czech Republic.

Germany imports electricity from Sweden, Denmark, and the Czech Republic and exports it to France, the Netherlands, Switzerland, and Austria.

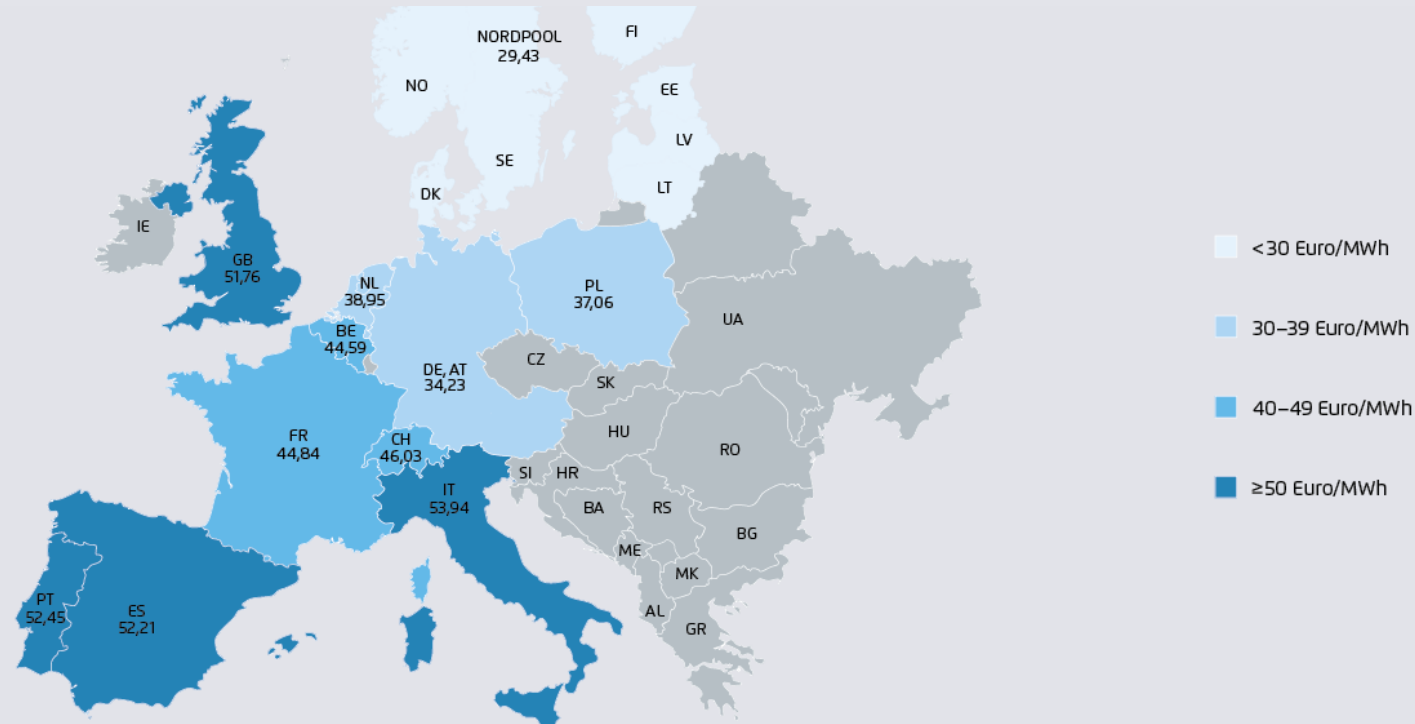
Comparison of foreign electricity trade with neighboring countries in 2016 and 2017

	2016			2017		
	Import from	Export to	Balance	Import from	Export to	Balance
Sweden	1,2	0,8	-0,4	2,2	0,3	-1,9
Austria	13,0	40,9	28,0	10,6	42,4	31,8
Switzerland	3,6	11,3	7,7	3,1	11,6	8,6
Czech Rep.	4,7	1,8	-2,9	7,7	5,1	-2,5
Denmark	2,8	4,5	1,7	6,3	3,9	-2,3
France	4,6	14,0	9,4	3,8	17,5	13,7
Netherlands	1,1	10,1	9,1	1,2	10,7	9,6
Poland	0,8	0,2	-0,6	1,9	0,8	-1,0
Luxembourg	0,0	4,2	4,2	0,1	4,5	4,3
Sum	31,7	87,8	56,1	36,7	96,9	60,2

Own calculations based on ENTSO-E 2018; commercial electricity trade flows are shown

Power exchange prices in 2017: Germany has Europe's second-lowest electricity prices after Scandinavia

Comparison of wholesale power prices in Europe



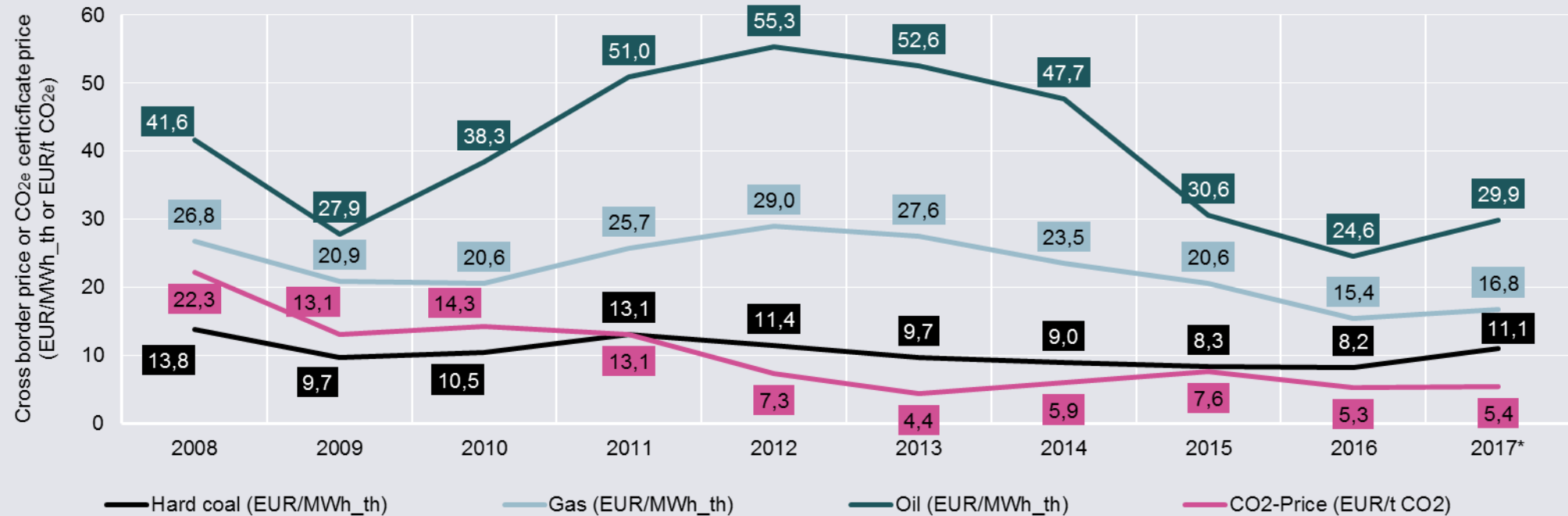
Own calculations based on EPEX-SPOT 2018, Nordpool 2018, Belpex 2018, OMEL 2018, Mercato Elettrico 2018, APX 2018, POLPX 2018

Electricity and Fuel Price Trends in Germany in 2017



2017 commodity prices: Coal, oil, natural gas, and CO₂ prices have increased slightly, but remain at a low level

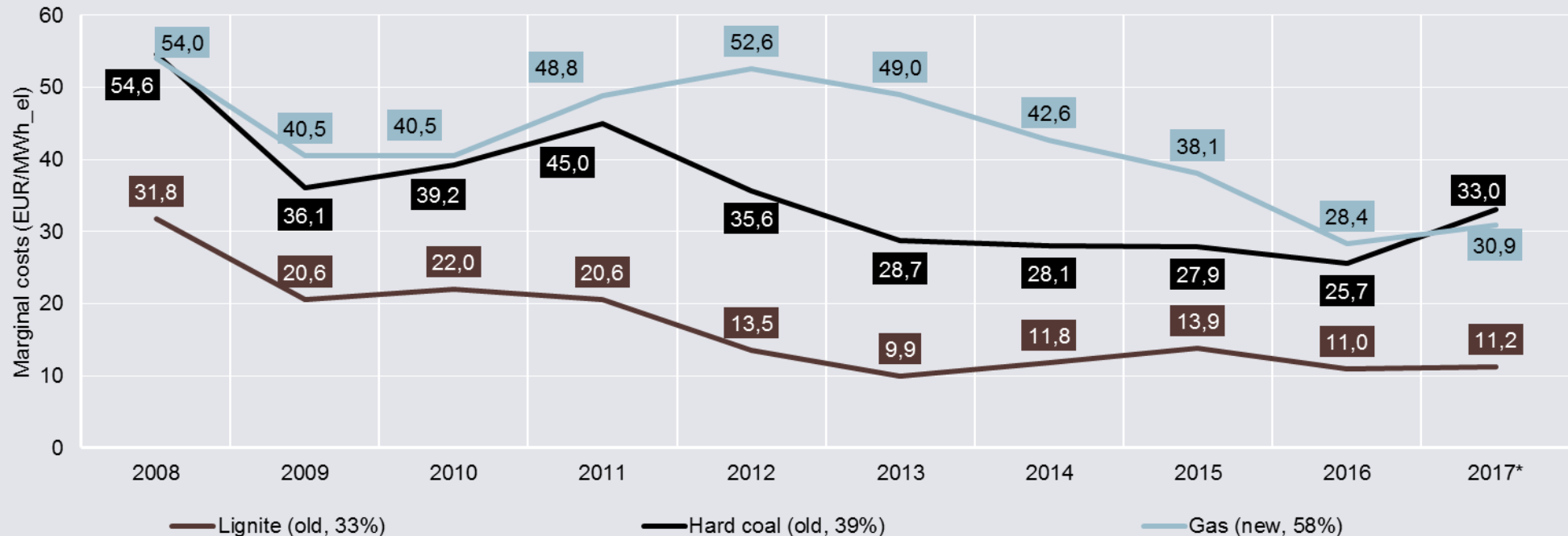
Import prices for natural gas, hard coal, and petroleum, as well as CO₂ certificate prices



BAFA 2017a, BAFA 2017b, BAFA 2017c, DEHSt 2017, authors' own calculations, *preliminary data

Electricity generation costs in 2017: New natural gas power plants are more competitive than old coal power plants for first time in 10 years

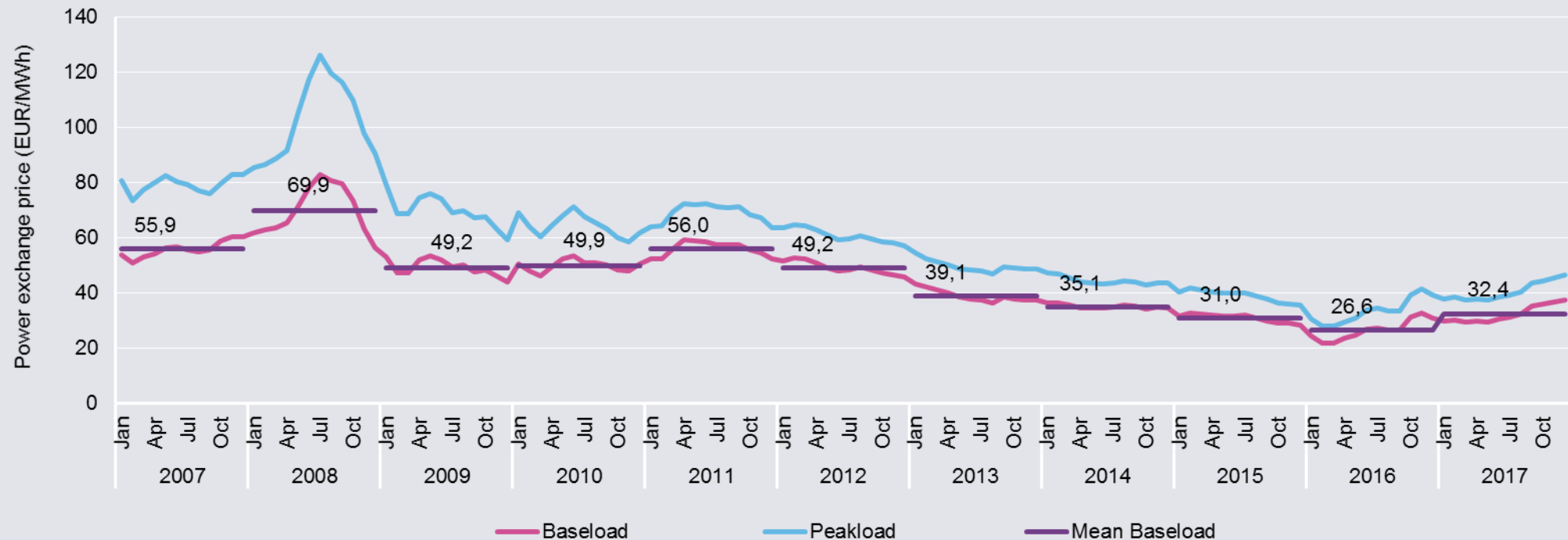
Marginal costs for new natural-gas power plants and old power plants fired with lignite and hard coal



BAFA 2017a, BAFA 2017b, DEHSt 2017/2006, Öko-Institut 2017a, *authors' own calculations, efficiency factor in brackets

Electricity prices in 2017: After a record low in 2016 electricity prices rise again slightly due to increased coal and gas prices

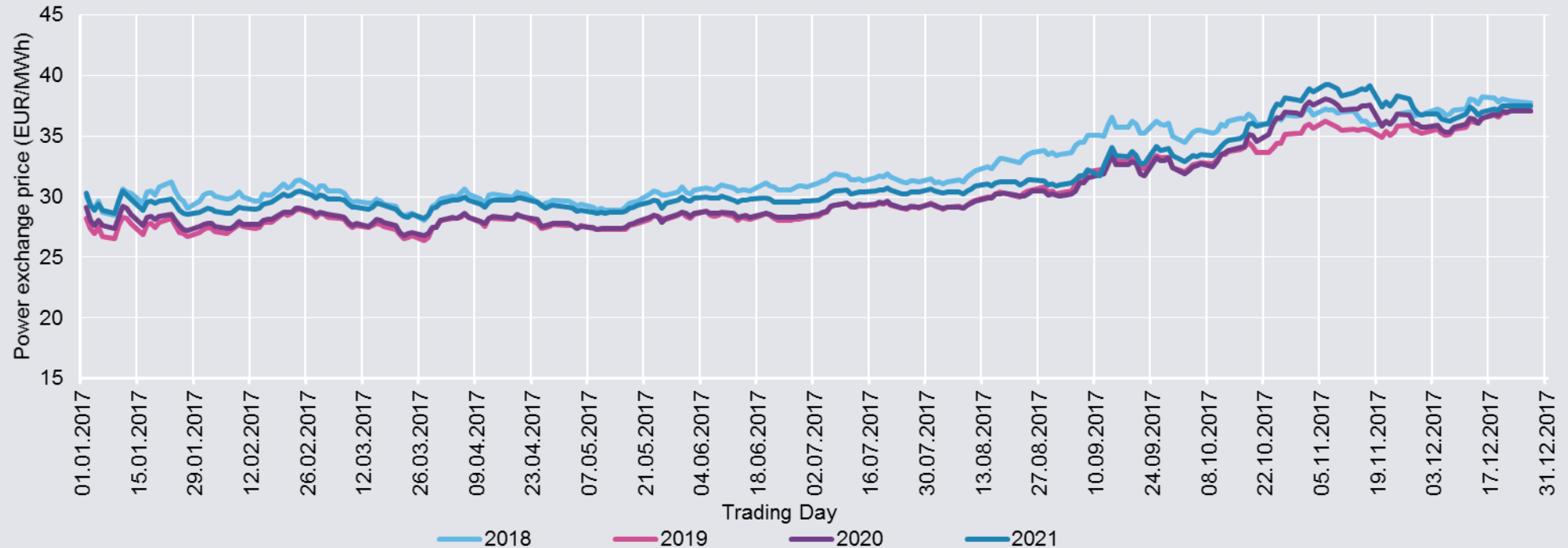
Rolling annual futures, 2007–2017



Authors' own calculations on the basis of EEX 2018

Future Electricity prices for 2018–2021: Electricity can be purchased years in advance for under 4 cents per kWh

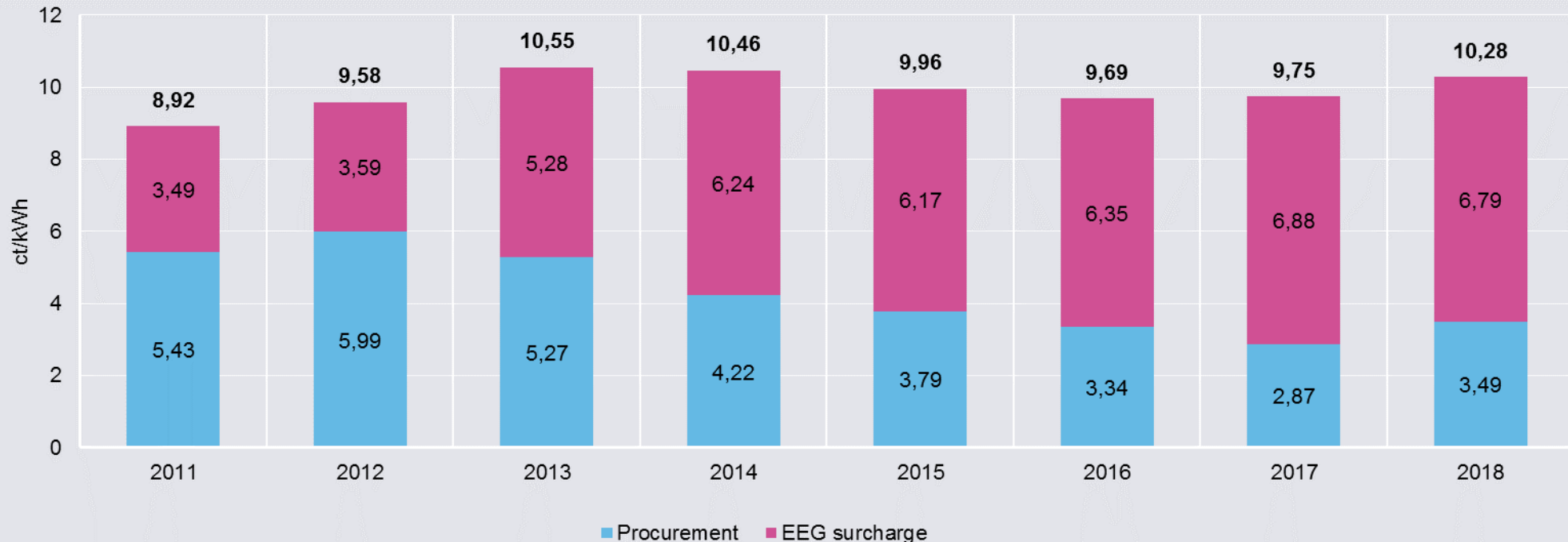
2017 future prices for power delivery in 2018–2021



EEX 2018

Electricity costs in 2017: Reduction in EEG levy overshadowed by increase in electricity procurement costs due to rising wholesale prices

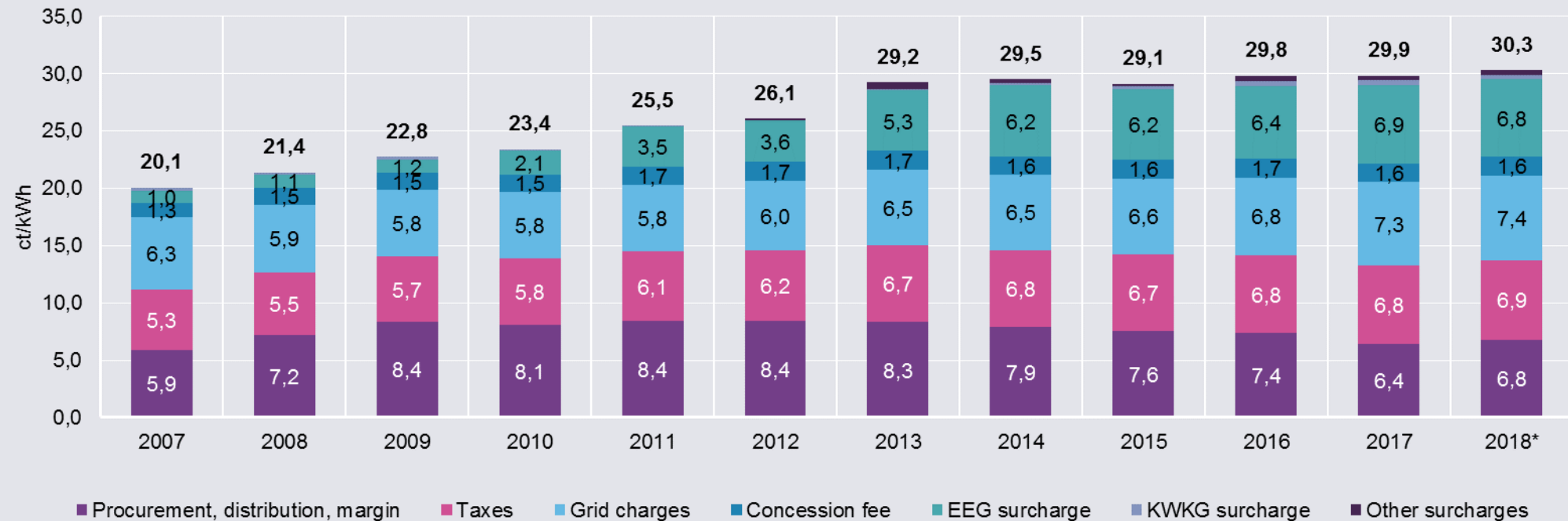
Electricity procurement costs and EEG levy, 2011–2017



EEX 2018, BNetzA 2017c, *70 per cent one-year future (base), 30 per cent one-year future (peak)

Electricity costs in 2018: Power rates for households in 2018 increase by 1.4 per cent to just over 30 cents per kWh

Household power rates, 2007–2018 for 4 person household (annual consumption of 3,500 kWh)



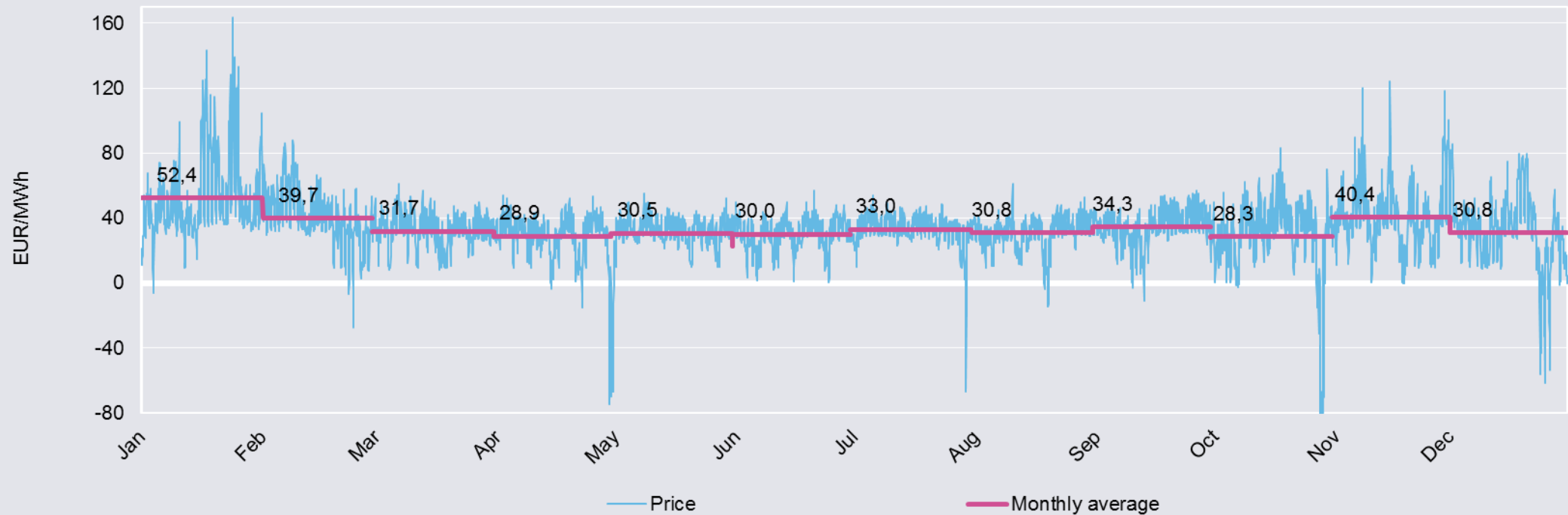
BNetzA 2017c, *authors' estimates based on the publication Übertragungsnetzbetreiber 2017a

Negative Electricity Prices and Power Market Flexibility in 2017



Hourly prices over the course of 2017: Power is cheaper when it is sunny (April–August) and windy (October, December), and more expensive when RES generation is low (January)

Hourly power prices in 2017



EPEX-SPOT 2018a

Negative electricity prices in 2017: More hours with negative electricity prices show increasing need for flexibility

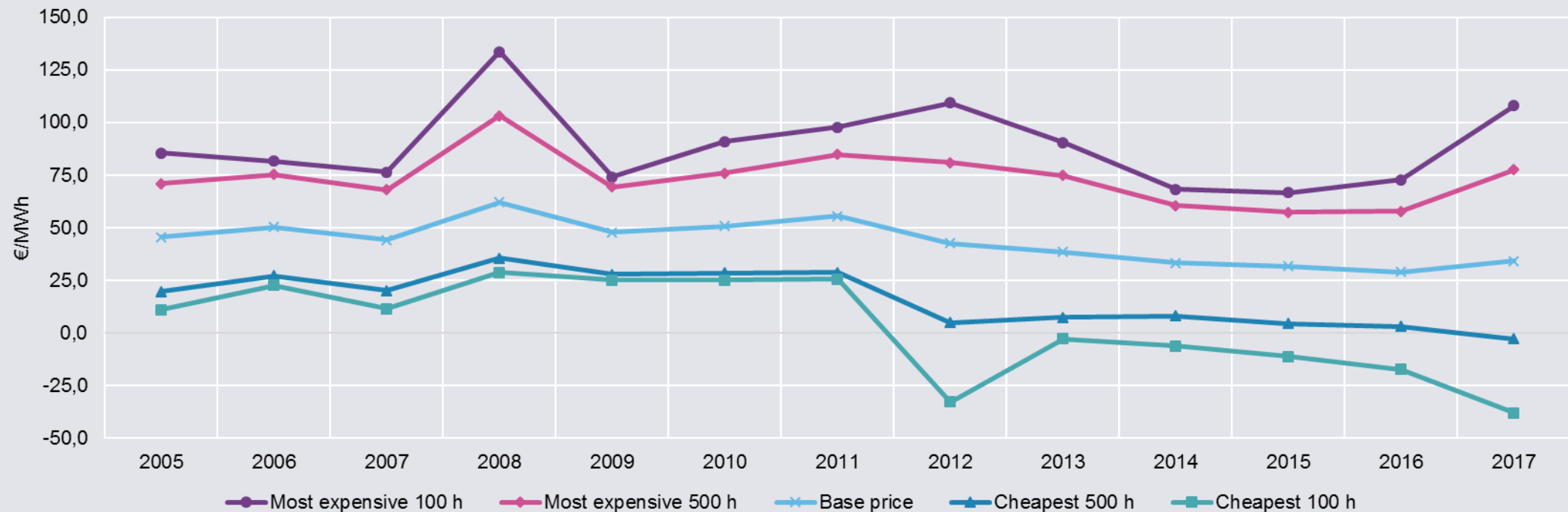
Number of hours with negative electricity prices in 2017



EPEX-SPOT 2018a

Power market flexibility in 2017: Wholesale market price volatility has increased

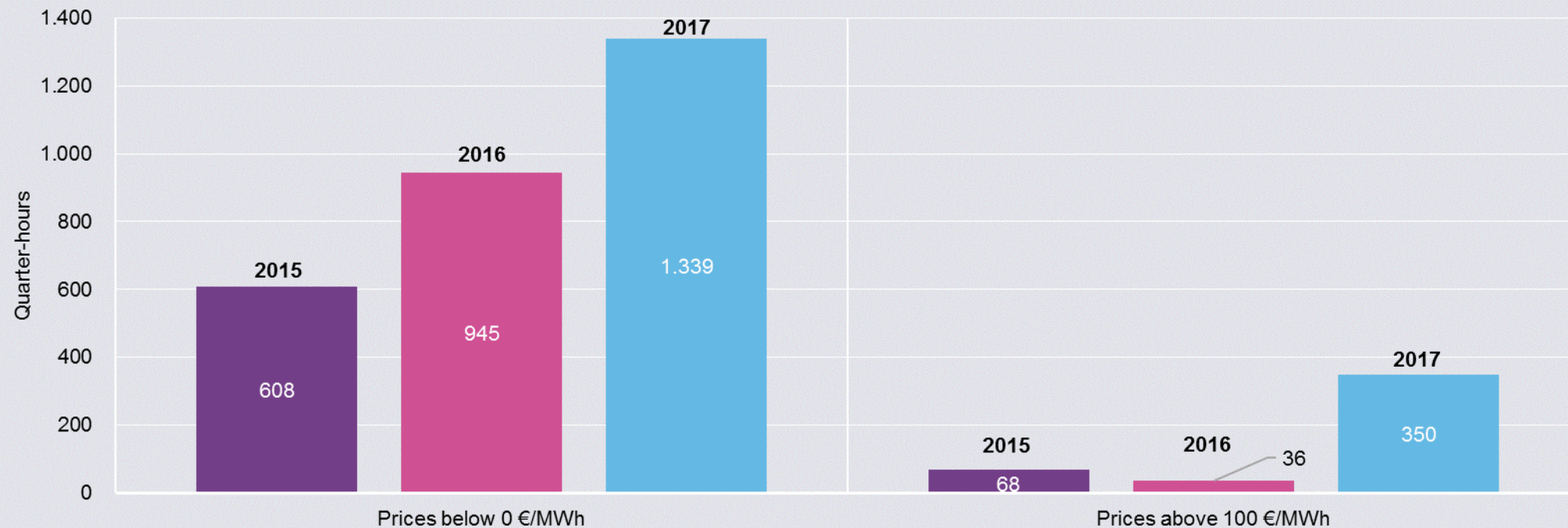
Cheapest and most expensive hours on wholesale markets in 2017



EPEX-SPOT 2018a

Power market flexibility in 2017: Volatility also high in intraday trading, highlighting opportunity for new business models

Number of quarter hour increments with prices less than 0 or more than 100 EUR/MWh



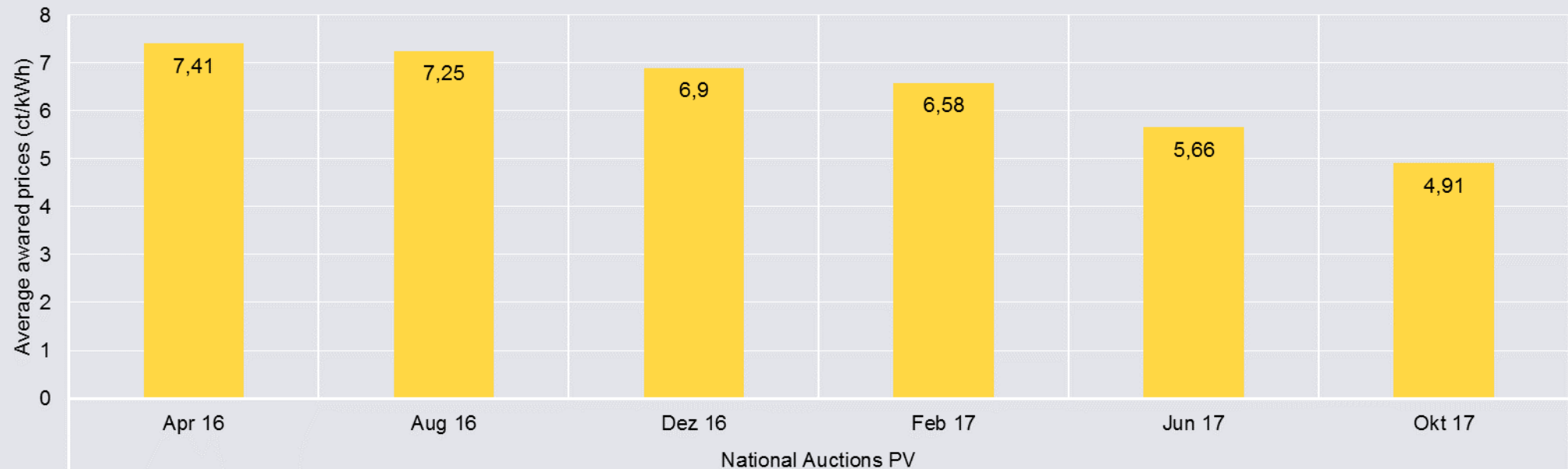
EPEX-SPOT 2018b

RES Auctions and EEG Costs in 2017



Renewable energy auctions in 2017: Solar power is becoming ever cheaper, and now only requires renumeration of less than 5 cents per kWh

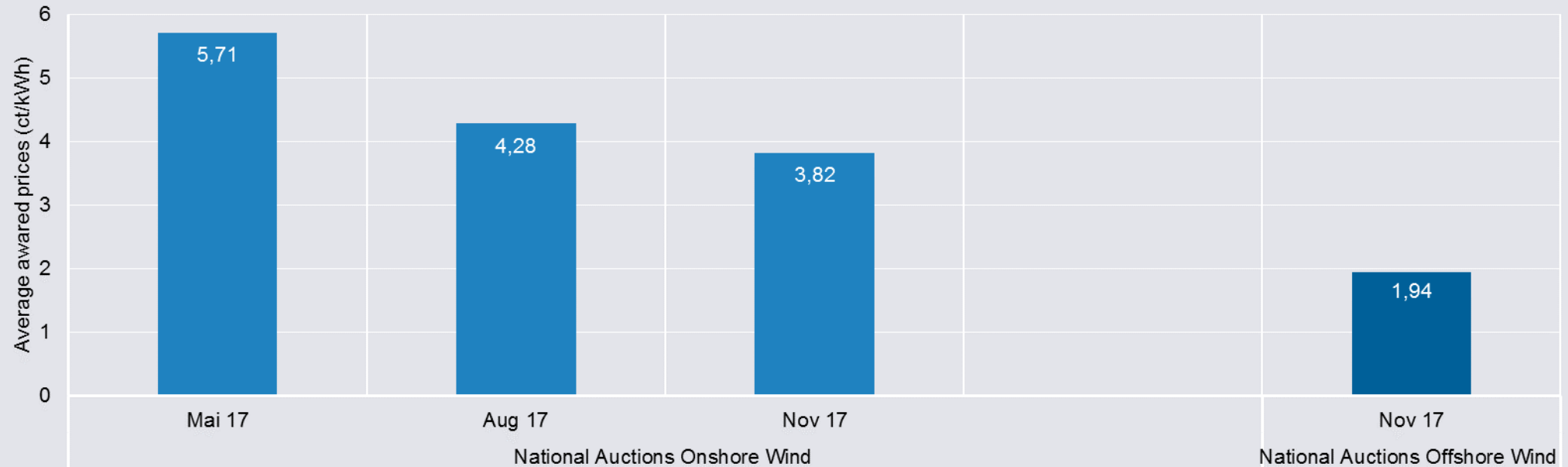
Average auction results for PV systems, 2016–2017



BNetzA 2017d

Renewable energy auctions in 2017: RES auction remuneration for wind now at or even below wholesale power prices

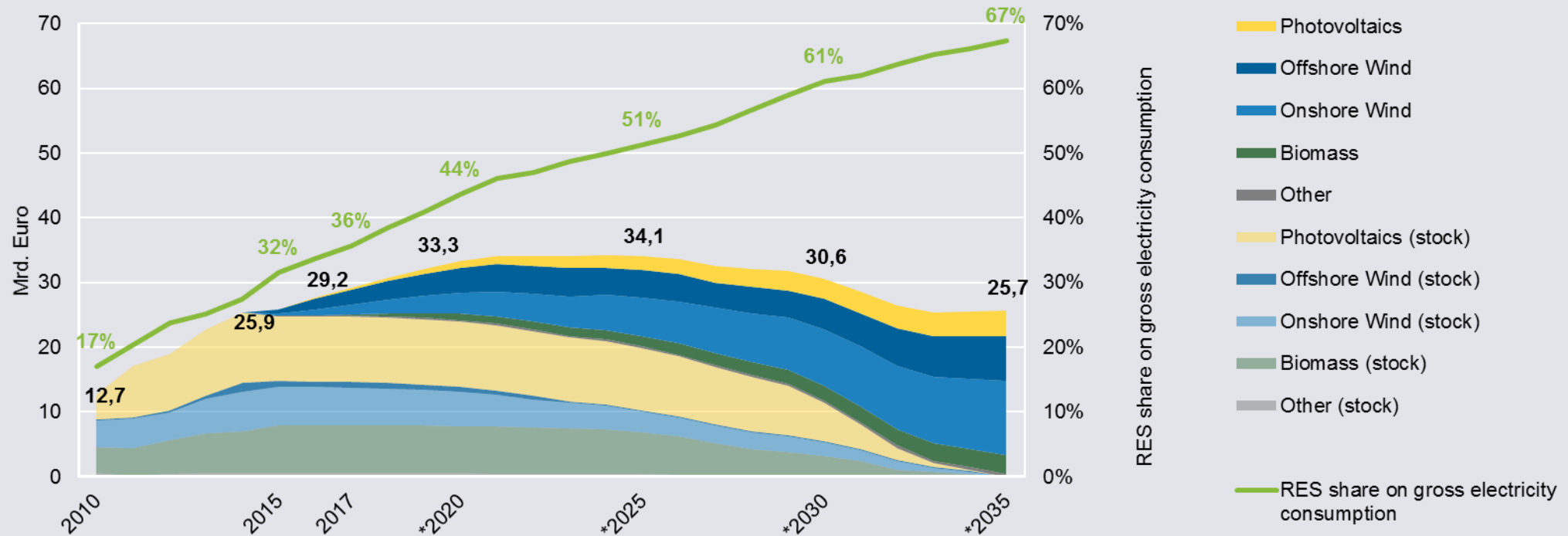
Average auction results for wind power, 2016–2017



BNetzA 2017e,f, *including grid connection costs (1.5 ct/kWh)

Renewable energy costs: Cost levels will soon peak, as new and less expensive plants will increasingly replace older and more expensive systems from 2021 onward

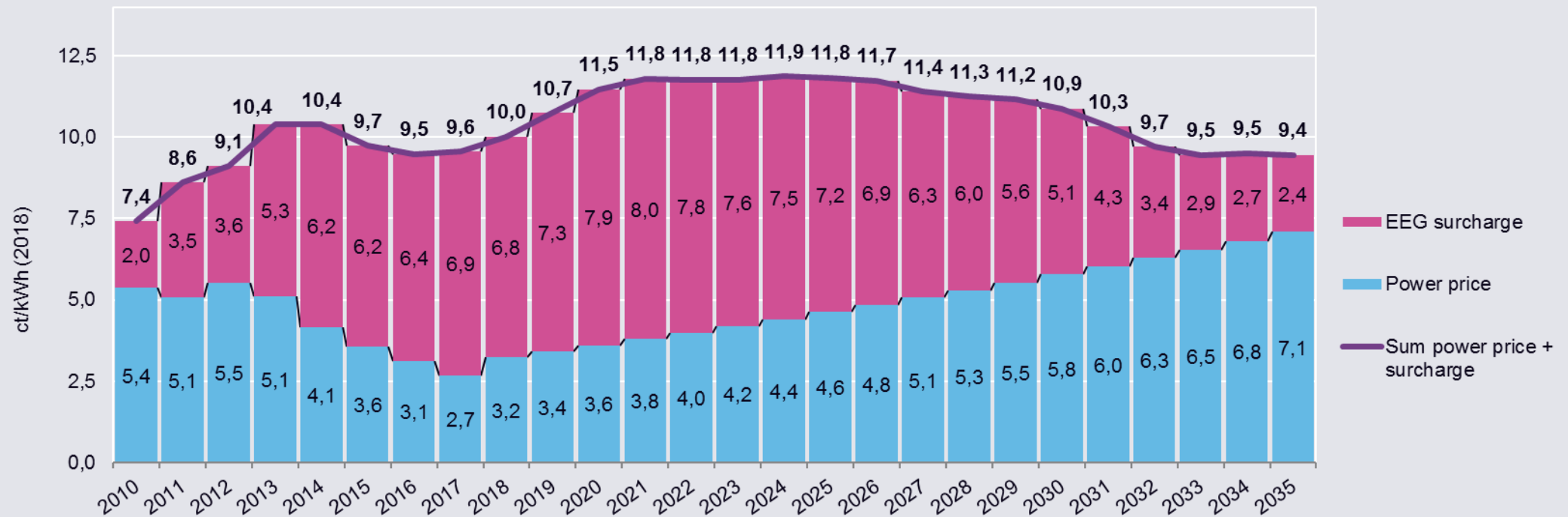
Guaranteed remuneration for RES power plants, 2010–2035



*Authors' projections based on the publication Öko-Institut 2017b

The sum of the wholesale price plus EEG levy will stabilize after 2020 at approx. 12 cents per kWh while the share of renewables continues to rise

Electricity price (rolling annual future price for base load) and EEG levy, 2010–2035



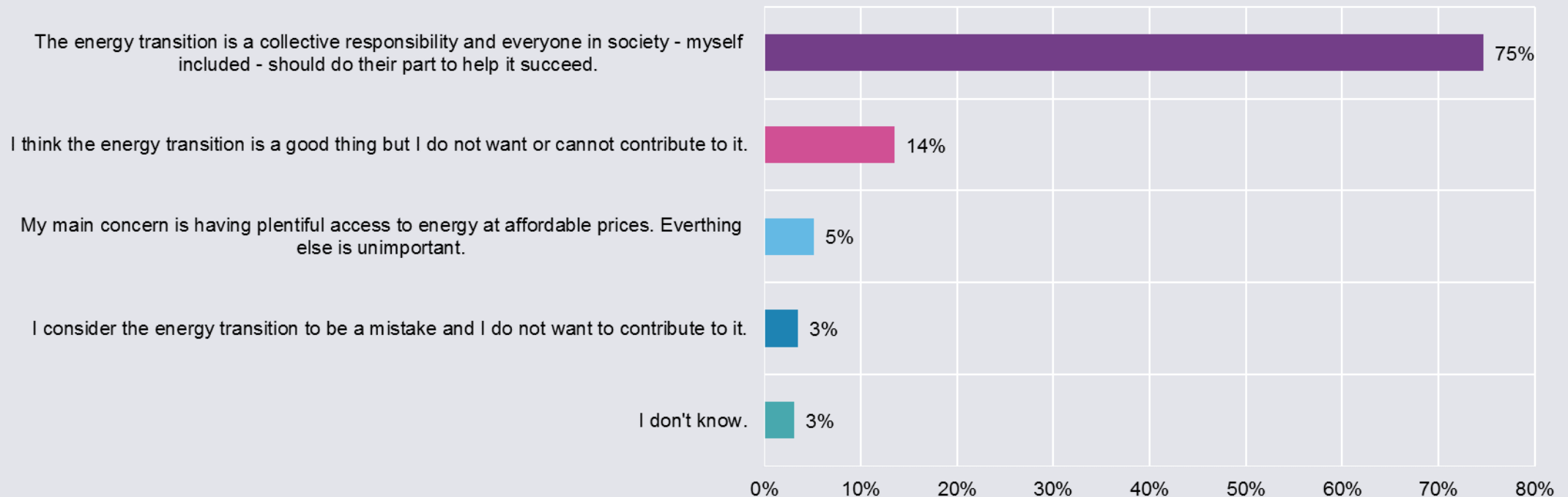
Authors' projections based on Öko-Institut 2017b

Public Opinion on Energy Transition in 2017



Surveyed opinion on energy transition in 2017: 90 per cent consider the energy transition to be important

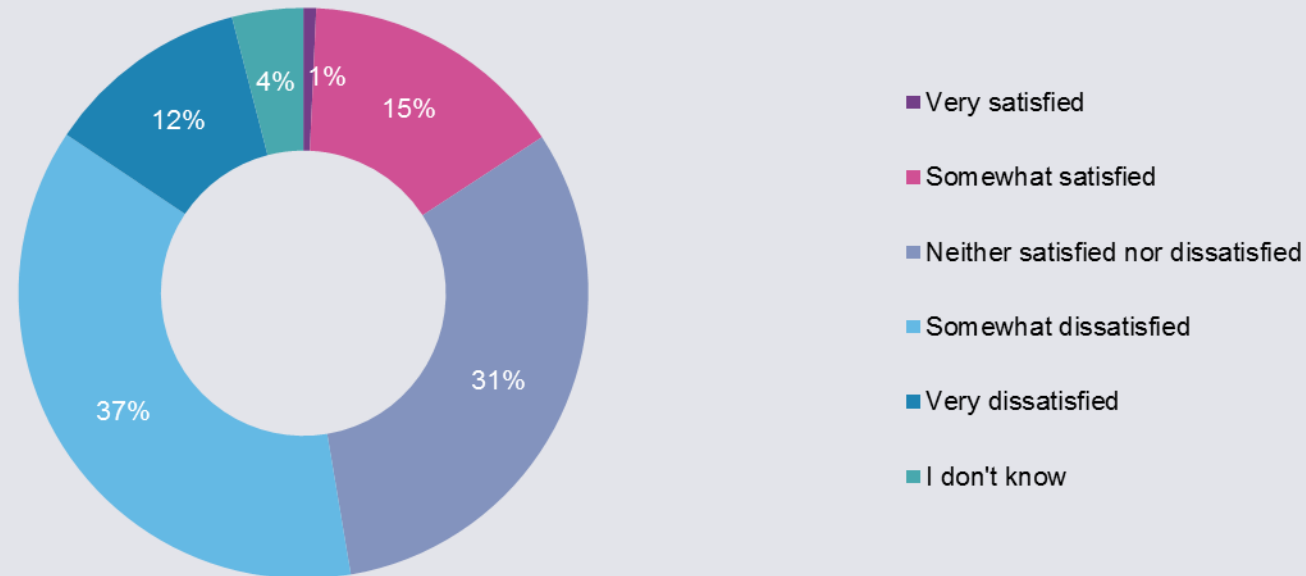
Views on the energy transition (N=7,313).



IASS/dynamis 2017

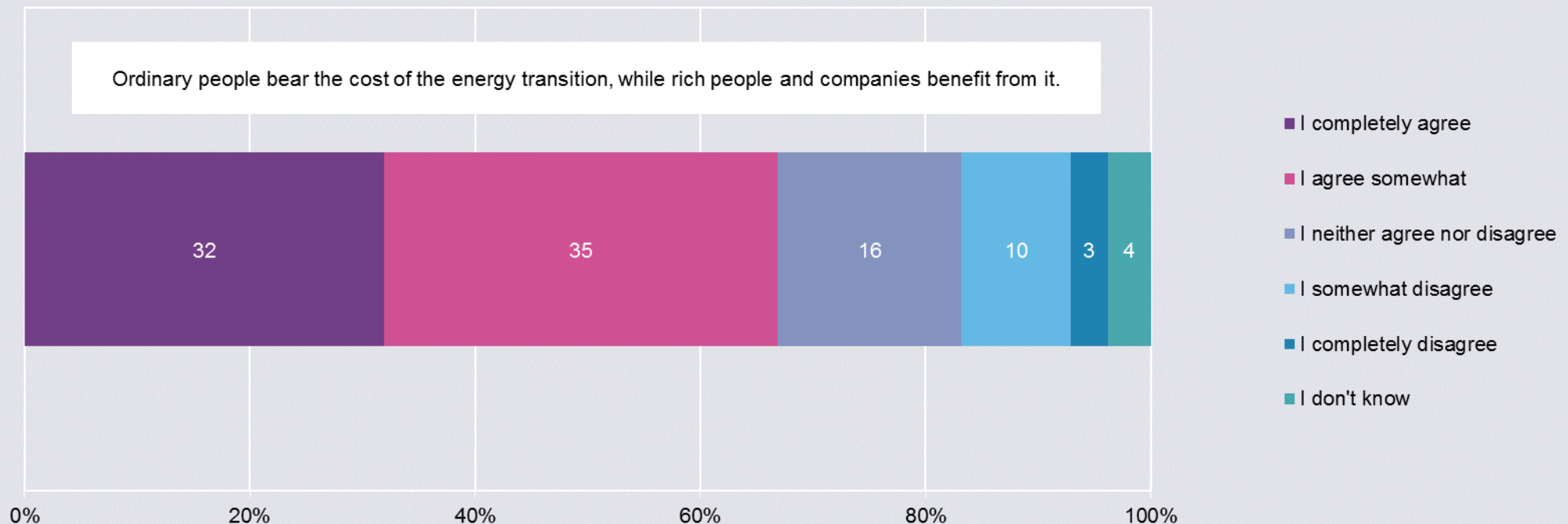
Public opinion on energy transition in 2017: The majority criticize the manner of political implementation

Satisfaction of the populace with the energy transition policy of the federal government (N=7,321)



Public opinion on energy transition in 2017: Two-thirds consider the allocation of cost burdens to be unfair

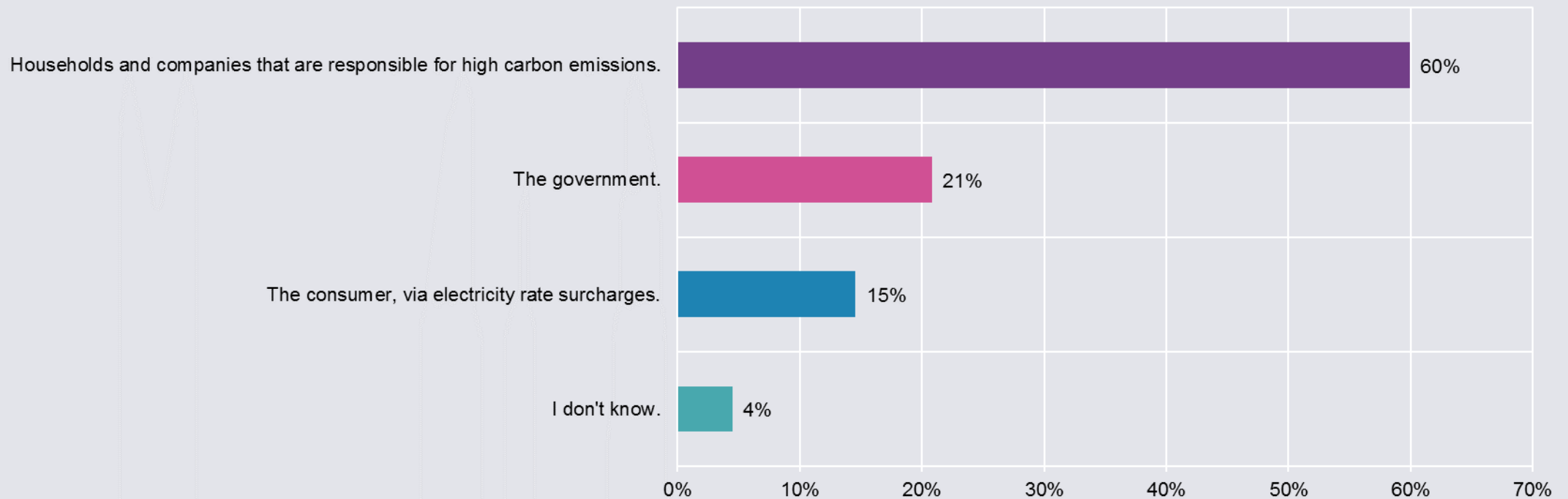
Effects of the energy transition on the costs of the power system (N=7,431)



IASS/dynamis 2017

Public opinion on energy transition in 2017: High support for “user pays” principle raises questions about allocation of costs

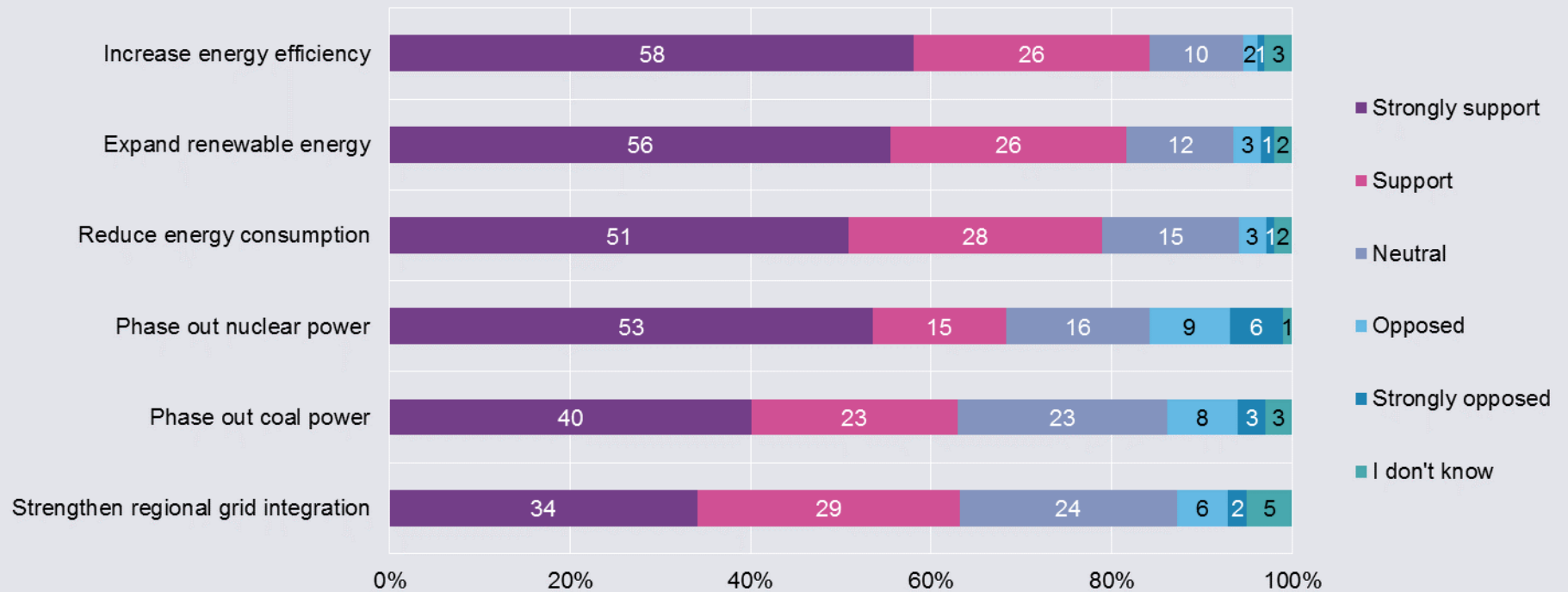
Actors who should bear the cost of financing the energy transition (N=7,431)



IASS/dynamis 2017

Public opinion on energy transition in 2017: Strong support for energy efficiency, renewables and the phasing out of coal and nuclear power

Support of the populace for selected energy policy goals (N=7,431)



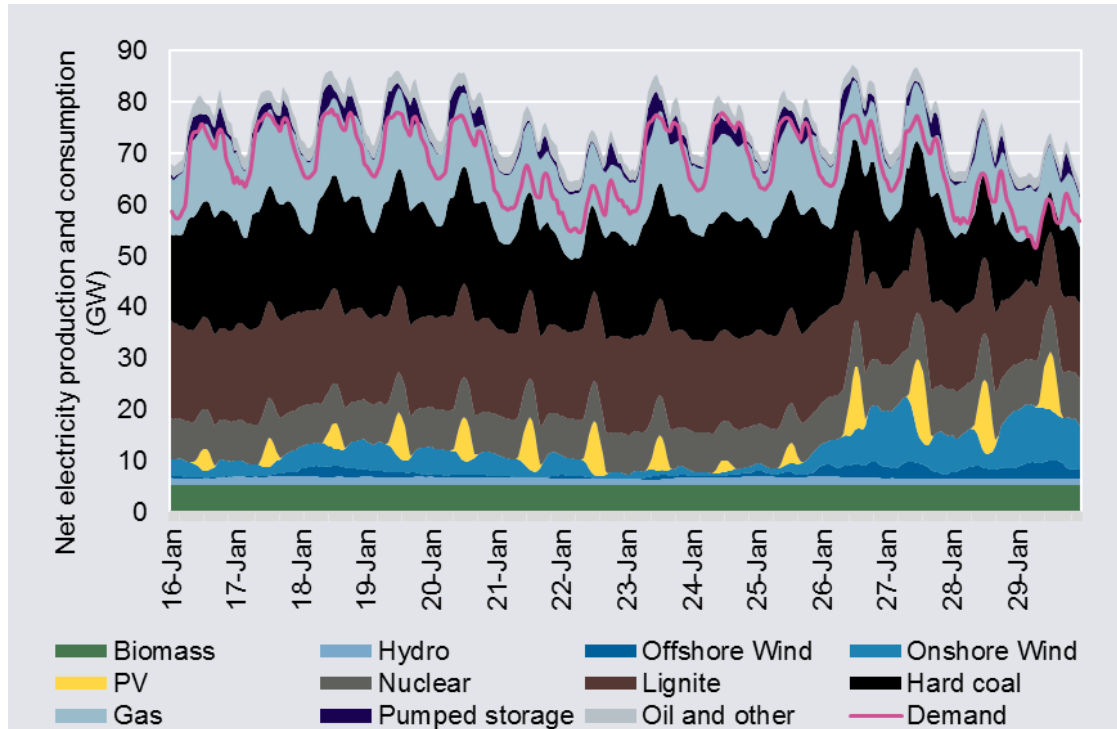
IASS/dynamis 2017

Notable Events in 2017



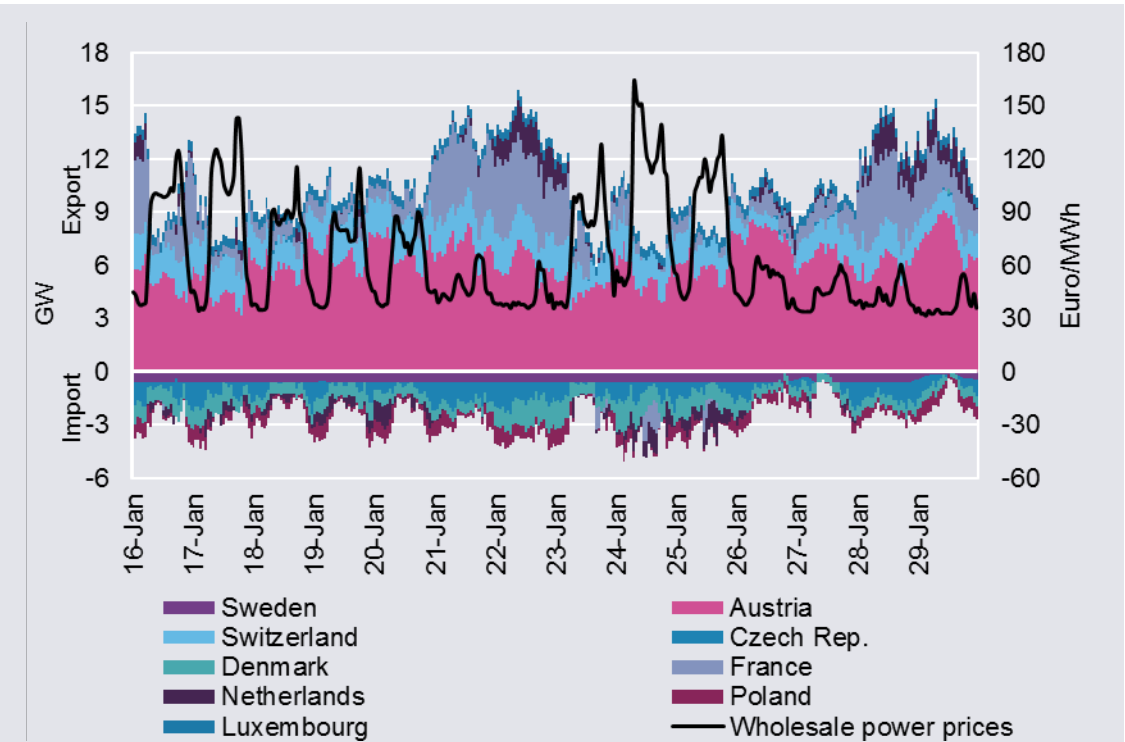
The “Dark Doldrums” (no solar, no wind) of January 2017: Renewables only made up 11 per cent of power generation; Germany nevertheless exported power

Net power generation and consumption by energy source, 16 to 29 Jan. 2017



Agora Energiewende 2017

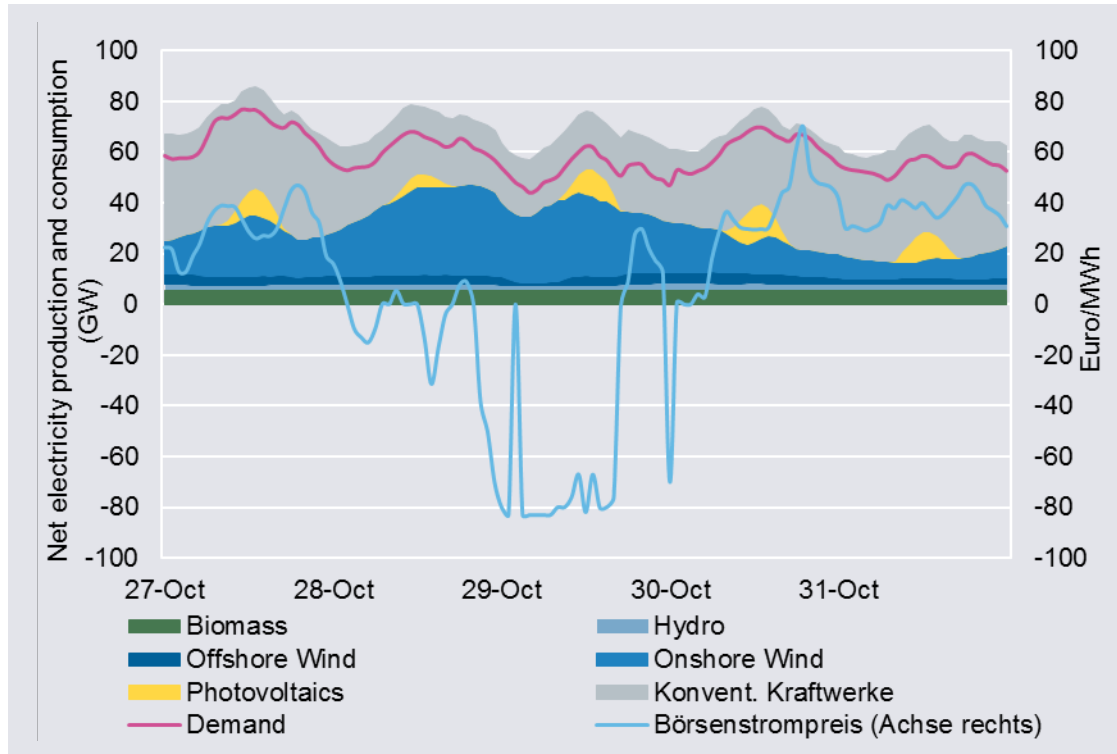
Power trading flows by country and wholesale market price, 16 to 29 Jan. 2017



Agora Energiewende 2017

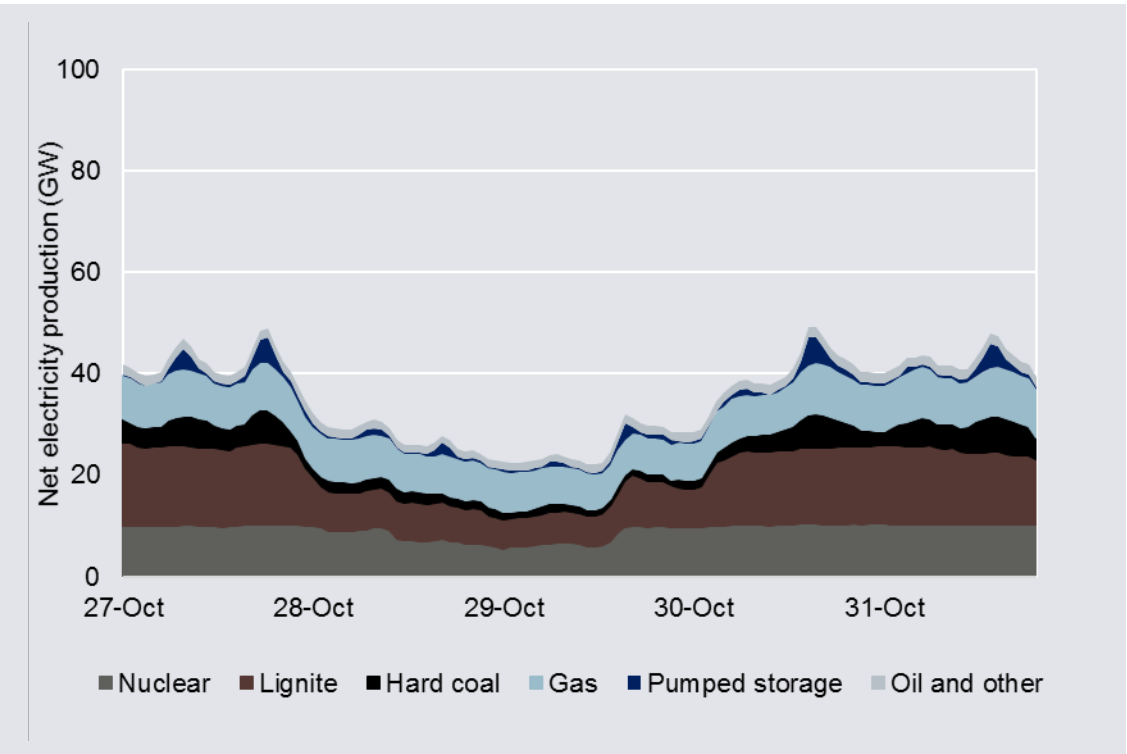
Cyclone Herwart in October 2017: Strong wind and continued operation of nuclear, coal, and natural-gas CHP plants led to negative electricity prices

Net power generation and consumption by energy source and wholesale market prices, 27 to 31 October 2017



Agora Energiewende 2017

Net power generation by conventional energy sources, 27 to 31 October 2017



Agora Energiewende 2017



Outlook for 2018

Outlook for Power Sector in 2018: Key Trends

Energy and power consumption:

- Primary energy and power consumption levels are likely to be flat or increase over the year, driven by the weak impact of energy efficiency policy, strong expected GDP growth (2.2 to 2.5 per cent), and increasing freight transport volumes.

Renewables:

- Wind energy expansion rates will remain robust; total deployment of over 4 GW (onshore and offshore) is realistic for the year.
- We expect a 2 to 3 GW expansion of PV in 2018 due to continued declines in equipment costs and increasing incentives for small-scale generation.

Conventional power plants:

- Nuclear power production will further decline after the shut down of nuclear power plant Gundremmingen B at the end of 2017
- 1.1 GW of lignite coal generation will be transferred to reserve capacities as of October
- Some 1.8 GW capacity is announced to be shut down in 2018 (1.2 GW hard coal, 500 MW natural gas, 100 MW oil), being counteracted by a capacity expansion of 1.05 GW hard coal; 0.6 GW natural gas.

Outlook for Power Sector in 2018: Energy Policy

Greenhouse Gas emissions:

- If current trends continue, Germany is very likely to miss fulfilment of its 2020 climate targets; the national reduction in carbon emissions is likely to be 30 rather than 40 per cent (relative to 1990 levels).
- To meet existing targets, the German government would need to implement an immediate action programme that seeks to reduce coal-based power generation, further expand renewables, and encourage replacement of boiler equipment.

National Energy and Climate Plan for 2030:

- Like all other EU member states, Germany will need to come up with a National Energy and Climate Plan for 2030 by the end of 2018. Hence, the question of which sector contributes how much to the climate targets 2030 will stay high on the agenda; including the question of a just transition for the coal mining regions in Germany.

Renewables and Efficiency Policy:

- There will be the need for a short-term revision of the renewable energy act, as otherwise a drastic decline in wind power installation in 2019 is to be expected. The reason is that auction winners in 2017 were mostly so called citizen-owned projects with realization periods of more than 4 years.
- Additional tax incentives for renovation in the building sector can be expected, as most parties in the new parliament subscribe to this idea. How ambitious they are and when to take into effect, remains to be seen.

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Thank you for your attention.

Do you have questions or comments? Please contact me:

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