FRAUNHOFER INSTITUTE FOR SOLAR ENERGY SYSTEMS ISE

Power generation in Germany – assessment of 2017

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Freiburg, Germany, 08.05.2018

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Power generation in Germany – assessment of 2017

The **fourth** version of 08.05.2018 contains additional graphics on CO2 emissions.

The **third** version of 25.04.2018 contains a correction in the market value factors.

This **second** version from 29.03.2018 takes into account the monthly data of the Federal Statistical Office (Destatis) for electricity generation for the entire year 2017.

The **first version** of 02 January 2018 takes into account the monthly power generation data published by the German Statistical Office (Destatis) up to and including September 2017. The data for October, November and December were extrapolated from adjusted hourly values from the European Energy Exchange EEX in Leipzig and hourly data from the four German TSOs (50 Hertz, Amprion, Tennet, TransnetBW). The tolerance range is greater for extrapolated values.

The data at Energy Charts is updated by the hour:

www.energy-charts.de

Power generation in Germany – assessment of 2017

Difference between gross and net production

This report presents data on German **net electricity generation for public power supply**. The numbers thus represent the electricity mix that actually is consumed in the households or with which even electric vehicles are charged. Only the net electricity generation is traded on the German electricity exchange EEX and only net figures are measured for cross-border electricity flows.

In contrast, the **AG Energiebilanzen** uses the data of the total **gross electricity generation**. This also includes the electrical losses of the power plants, which are consumed directly in the power plant and are not fed into the public grid at all. In addition, the AG Energiebilanzen also takes into account the self-generation of electricity in industry, the so-called "factories in the processing industry as well as in mining and in the extraction of stones and earth". This self-generation is consumed directly in the factories and also not fed into the public grid.

Data on **net electricity generation** and total **gross electricity generation** differ significantly. This also results in significantly different shares of renewable energies.

Power generation in the year 2017
Renewable energy: solar and wind

In 2017, roughly 38.4 TWh of electricity from **photovoltaic arrays** was fed into the grid. Production thus is 0.4 TWh or 1% higher than in 2016. Despite the increase, electricity generation is still below the 2015 level, when 38.7 TWh were generated. The installed PV power at end of December was 43 GW. Approximately 2.3 GW PV were added in 2017. Solar power production peaked at 30 GW and 42.7% of total electricity generation on 27 May 2017at 13:00 o'clock. In June 2017, the monthly electricity production of PV systems (5.8 TWh) was higher than that of hard coal power plants (4.7 TWh).

Wind energy produced about 104 TWh in 2017 and was about 32% higher than the production of 78.6 TWh in 2016. Wind energy is thus for the first time the second largest power source after lignite, but ahead of hard coal and nuclear. In ten months, wind power production exceeded that of hard coal and nuclear. Quarter hourly production peaked at 40 GW on 28 October 2017.
Onshore wind farms produced 85 TWh in 2017, 20 TWh more than in 2016.
Offshore wind farms raised their production from 12 TWh in 2016 to 17.4 TWh in 2017. In the North Sea they produced 16 TWh compared to 10.7 TWh in 2016. The offshore wind farms in the Baltic Sea produced 1.4 TWh (1.3 TWh in 2015). At the end of 2017, 51 GW wind onshore and 5.3 GW wind offshore were installed.

Taken together, **solar and wind power generators** produced approx. 142 TWh in 2017. For the first time, they are thus ahead of brown coal, hard coal and nuclear.

1 TWh = 1 terawatt-hour = 1,000 gigawatts-hours (GWh) = 1 million megawatt-hours (MWh) = 1 billion kilowatt-hours (kWh)

Power generation in the year 2017

Renewable energy: hydropower and biomass

Approximately 20.5 TWh were produced from **hydropower**, a level roughly unchanged year-over-year. Production was lowest in January (1 TWh) and highest in May (2 TWh).

Roughly 47.5 TWh of electricity was generated from **biomass.** Production is at the level of the previous year.

In total, **renewable energy sources** – solar, wind, hydropower, and biomass – produced approximately 210 TWh of electricity in 2017. This is 15% higher than the previous year's level at 182 TWh. Renewables thus made up around 38% of public net power supply. The share in gross power supply – including power plants in the processing sector, the mining sector, quarries, and excavation – is around 35%.

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Power generation in the year 2017

Non-renewable generation

The net power production from **nuclear plants** came in at around 72.2 TWh, 10% below the 80 TWh net in the previous year. The reasons for the decline are mainly longer repair and maintenance work. As of December 31, 2017, the Gundremmingen B nuclear power plant was finally shut down.

Lignite power plants generated 134 TWh net, some 1 TWh or 0.7% less than in 2016. They were forced to curtail production in particular at times of peak wind power generation during wind storms. Lignite power stations are still inflexible in their response to high feed of renewable energies.

Net production from **hard coal** plants was posted at 81.7 TWh, 18 TWh (16%) lower than in 2016, when 99.8 TWh were produced.

Gas power plants for public power supply generated some 49.1 TWh, 2.6 TWh above the value of 2016. In addition to power plants for public power supply, there are also power generation facilities in the mining and manufacturing sector for self supply. These units produced additional 20 to 25 TWh for industrial use, which is not included in this publication.

1 TWh = 1 terawatt-hour = 1,000 gigawatts-hours (GWh) = 1 million megawatt-hours (MWh) = 1 billion kilowatt-hours (kWh)

Power generation in the year 2017

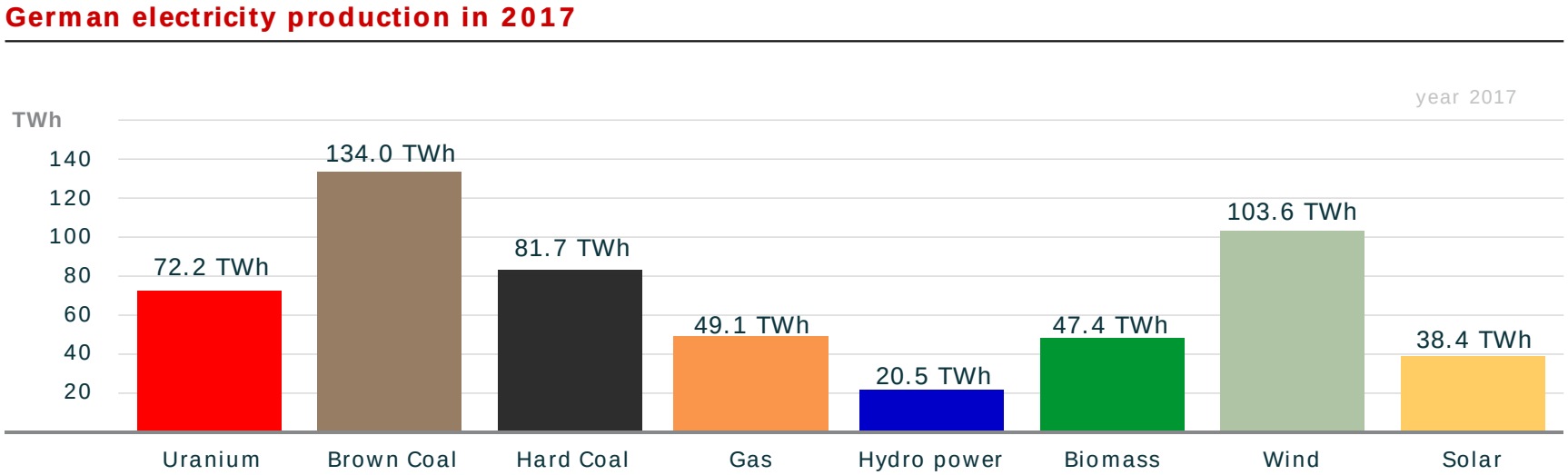
Export surplus

In 2017, the **export surplus** reached some 53 TWh. Since 2011, the export surplus is continuously rising. The largest share of exports, 16.6 TWh, went to Switzerland, which passed along most of the electricity to Italy. In second place came Austria, which also passes some of the electricity to it's neighbor countries. The Netherlands in third place, passed on most of this exports to Belgium and the UK. Poland on the fourth place passed on some of the electricity from eastern Germany to southern Germany via the Czech Republic.
Germany imported less electricity from France compared to the previous years, mainly since several French nuclear power plants were temporarily switched off for safety reasons. Germany acts as transit country for French electricity and passes it to neighboring countries. Electricity was exported at 8215 hours of the year (94%) and electricity was imported in 545 hours (6%).

In **power trading** 26.9 TWh were imported to a value of 1.03 billion euros. The export amounted to 79.8 TWh and a value of 2.84 billion euros. In balance, the resulting export surplus was 52.8 TWh and revenues worth 1.81 billion euros. Imported electricity cost an average of 38.31 Euro/MWh compared to 35.57 Euro/MWh for exports.
The average volume weighted **day-ahead price** of electricity has risen from 28.78 Euro / MWh in 2016 to 32.89 Euro / MWh and is adjusted for inflation at approximately the same level as of 2003 and 2004.

For additional information and graphics, visit: www.energy-charts.de
1 TWh = 1 terawatt-hour = 1,000 gigawatts-hours (GWh) = 1 million megawatt-hours (MWh) = 1 billion kilowatt-hours (kWh)

Net power generation for the public power supply
Year 2017



The graph shows net power generation from power plants for the public power supply. Electricity from power plants in the processing sector, mining, quarries, and excavation is not included.

Graphic: B. Burger, Fraunhofer ISE; data: DESTATIS and the EEX power exchange in Leipzig, with adjustments

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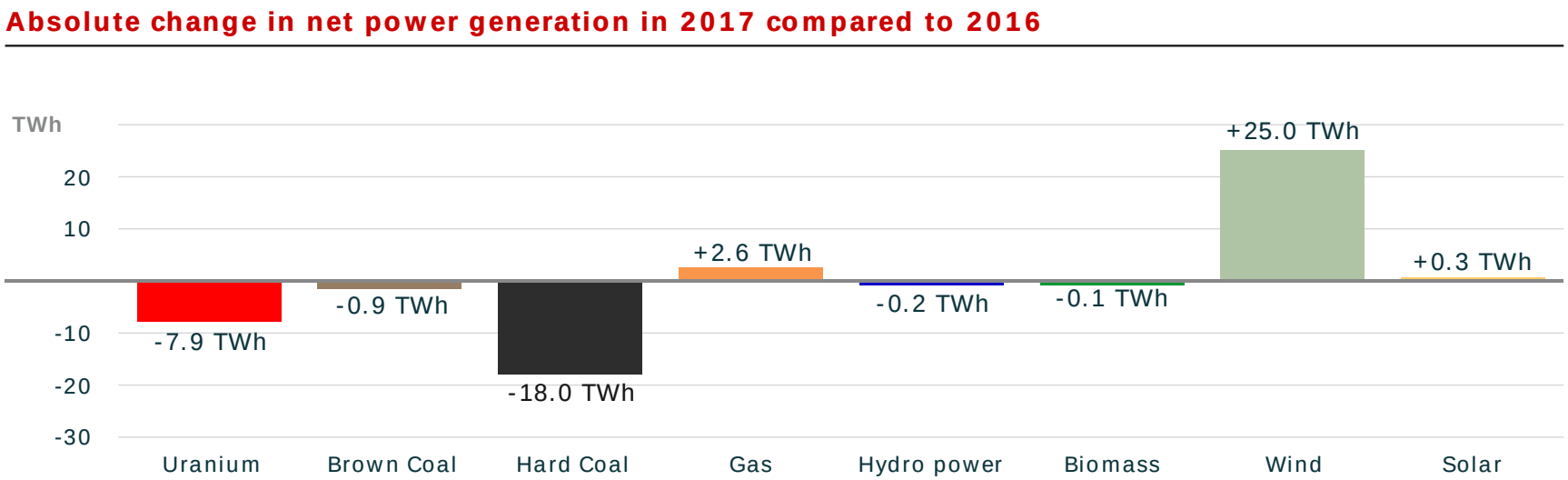
Absolute change in net power generation
Year 2017 compared to year 2016



Graphic: B. Burger, Fraunhofer ISE; data: DESTATIS and the EEX power exchange in Leipzig, with adjustments

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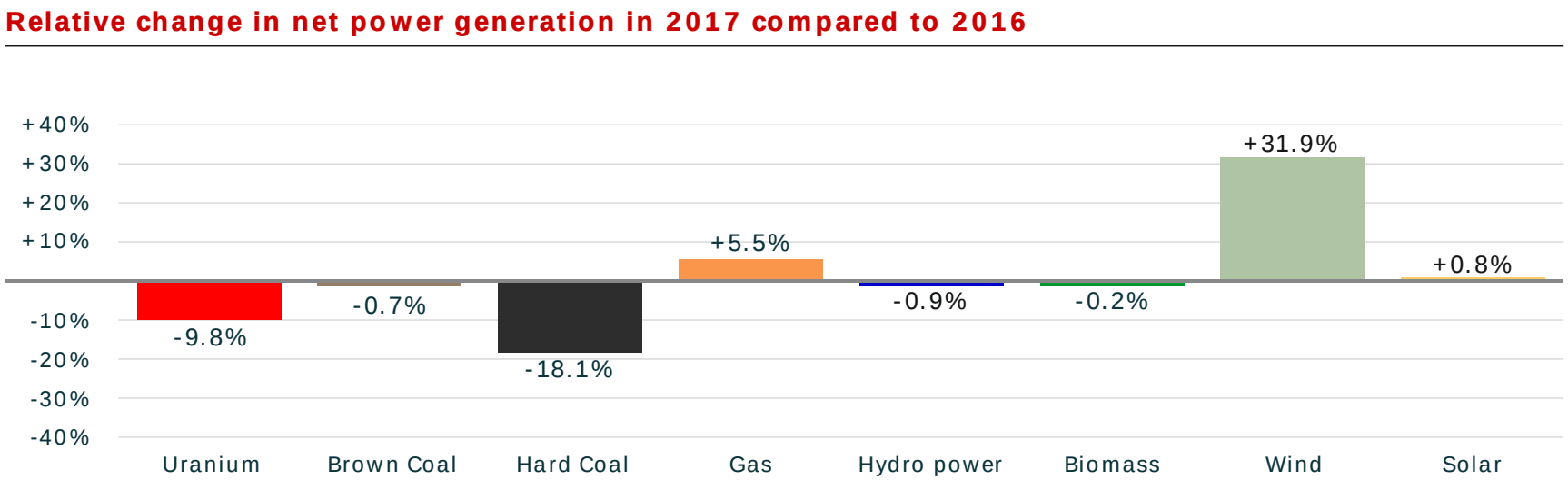
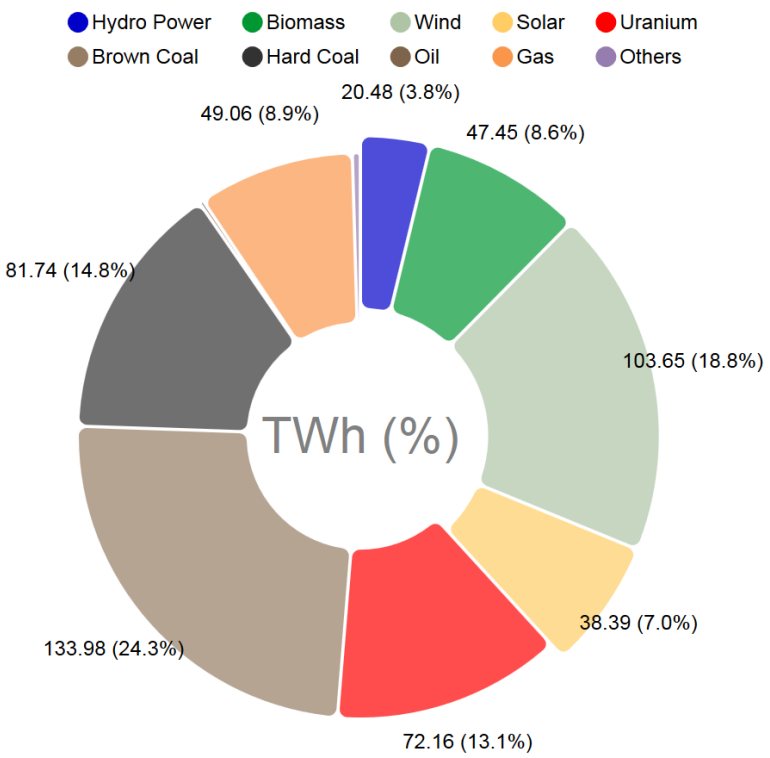
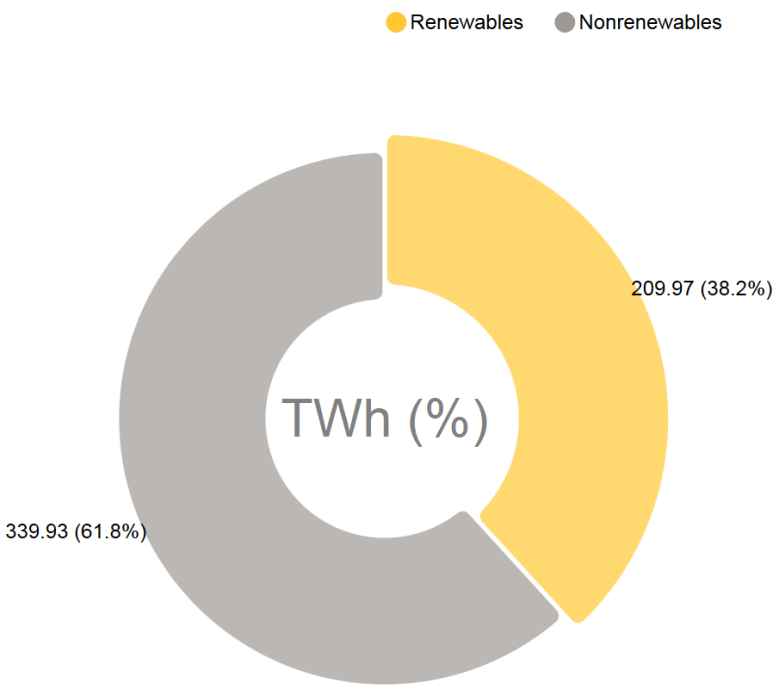
Relative change in net power generation
Year 2017 compared to year 2016



Graphic: B. Burger, Fraunhofer ISE; data: DESTATIS and the EEX power exchange in Leipzig, with adjustments

German net power generation for public power supply
Year 2017





Graphic: B. Burger, Fraunhofer ISE; data: DESTATIS and the EEX; source: www.energy-charts.de/energy_pie.htm

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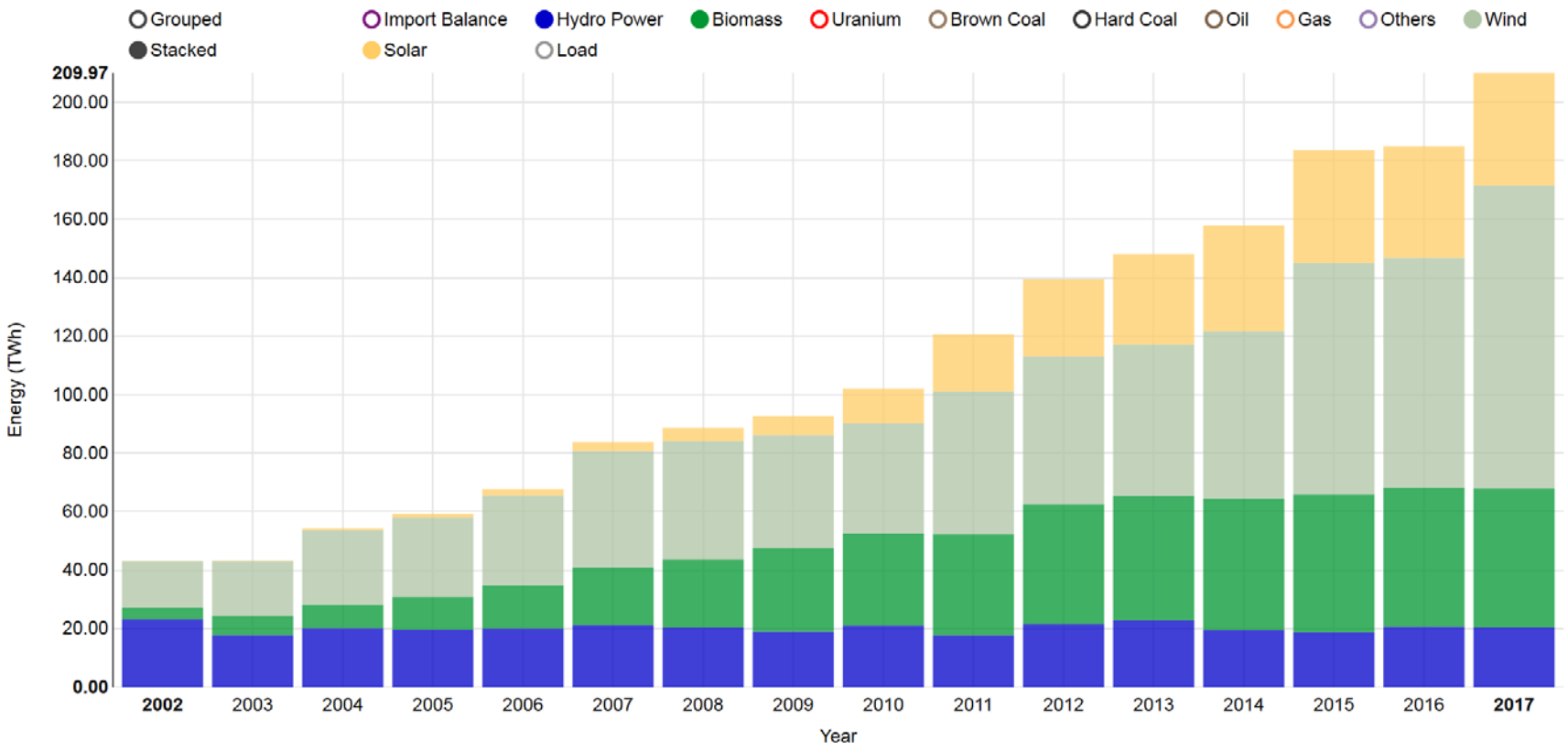
German net power generation from renewable sources

Year 2002 - 2017



Graphic: B. Burger, Fraunhofer ISE; data: DESTATIS and the EEX; source: https://www.energy-charts.de/energy.htm

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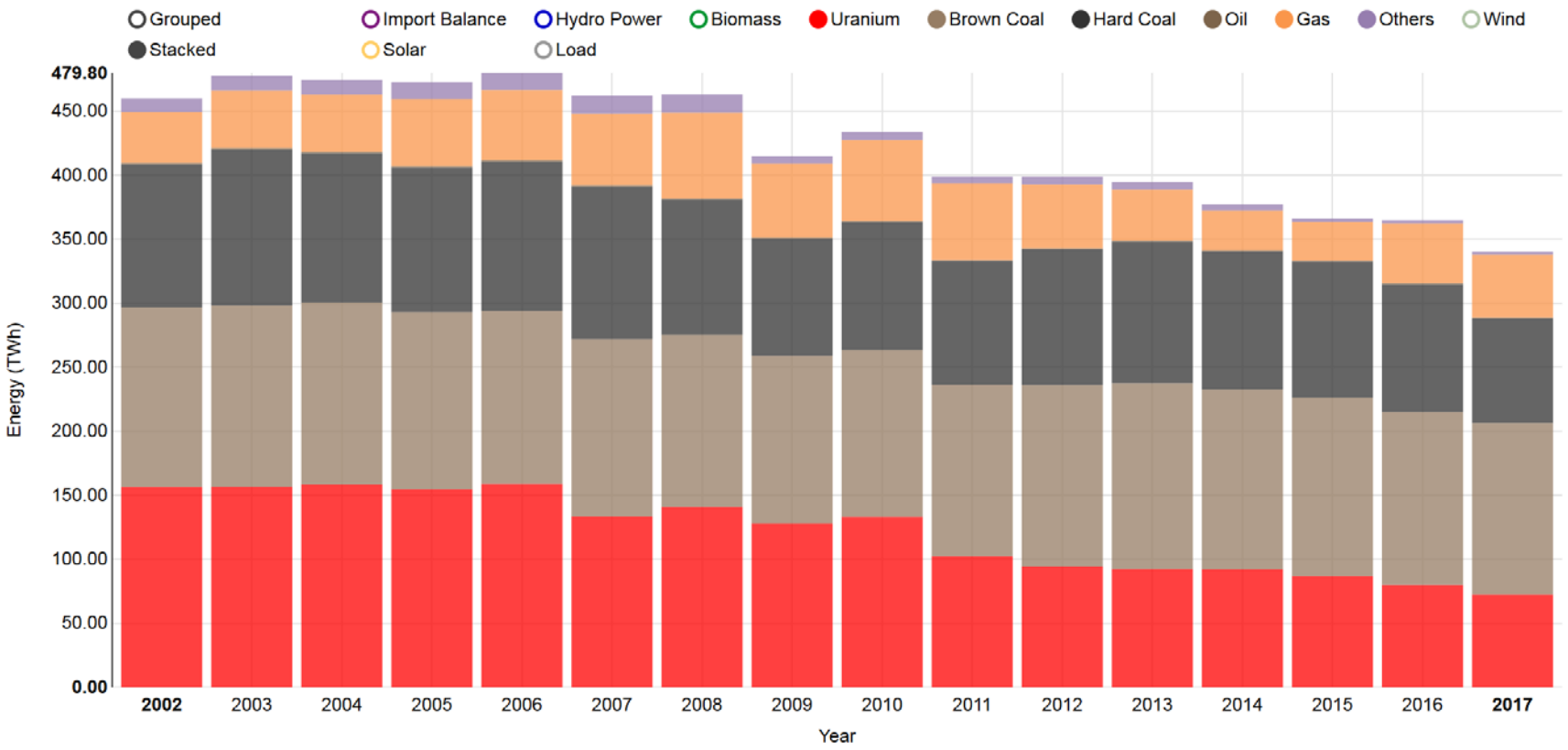
German net power generation from conventional sources

Year 2002 - 2017



Graphic: B. Burger, Fraunhofer ISE; data: DESTATIS and the EEX; source: https://www.energy-charts.de/energy.htm

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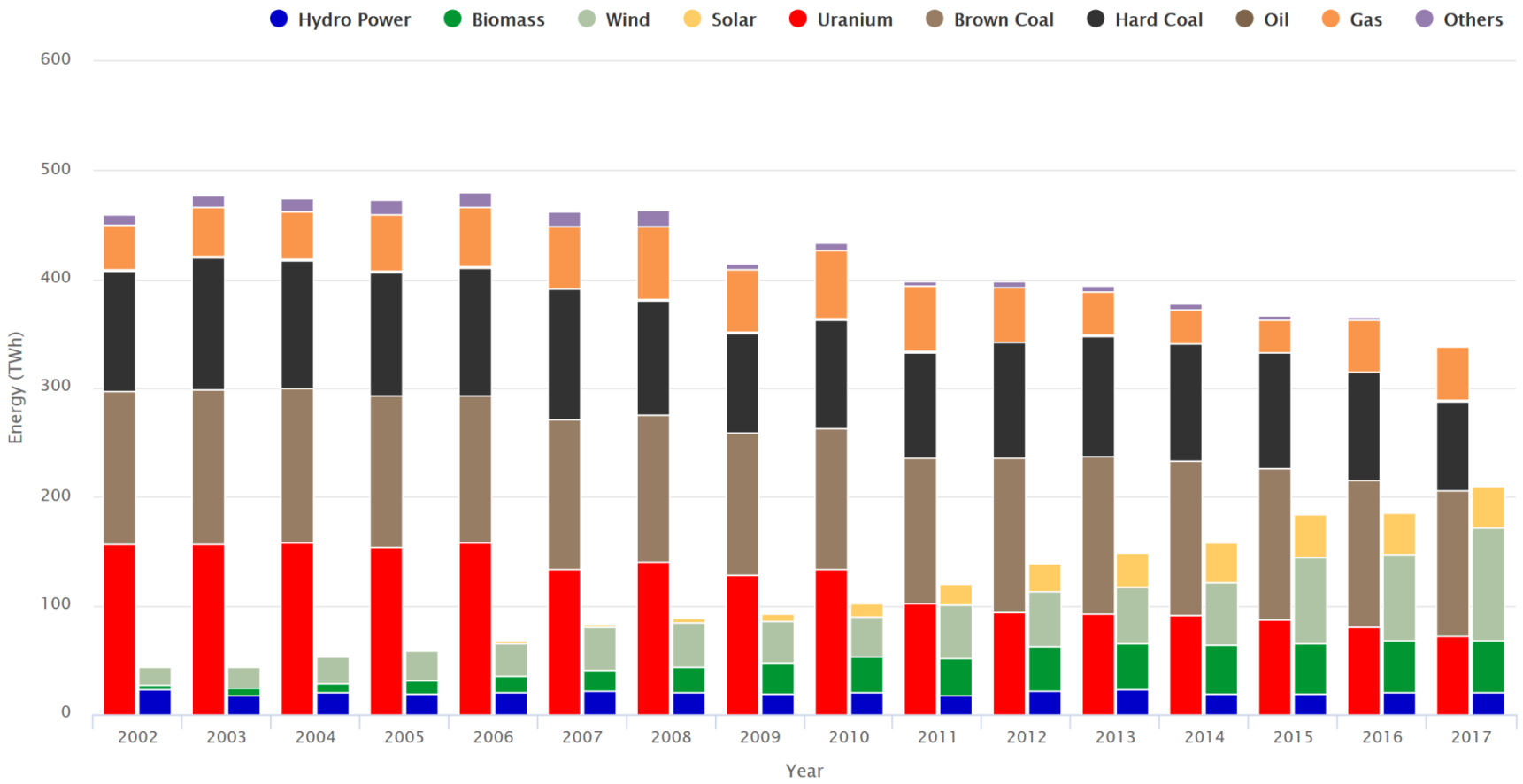
German net power generation from conventional and renewable sources

Year 2002 - 2017



Graphic: Oliver Blanck; source: https://www.energy-charts.de/energy.htm

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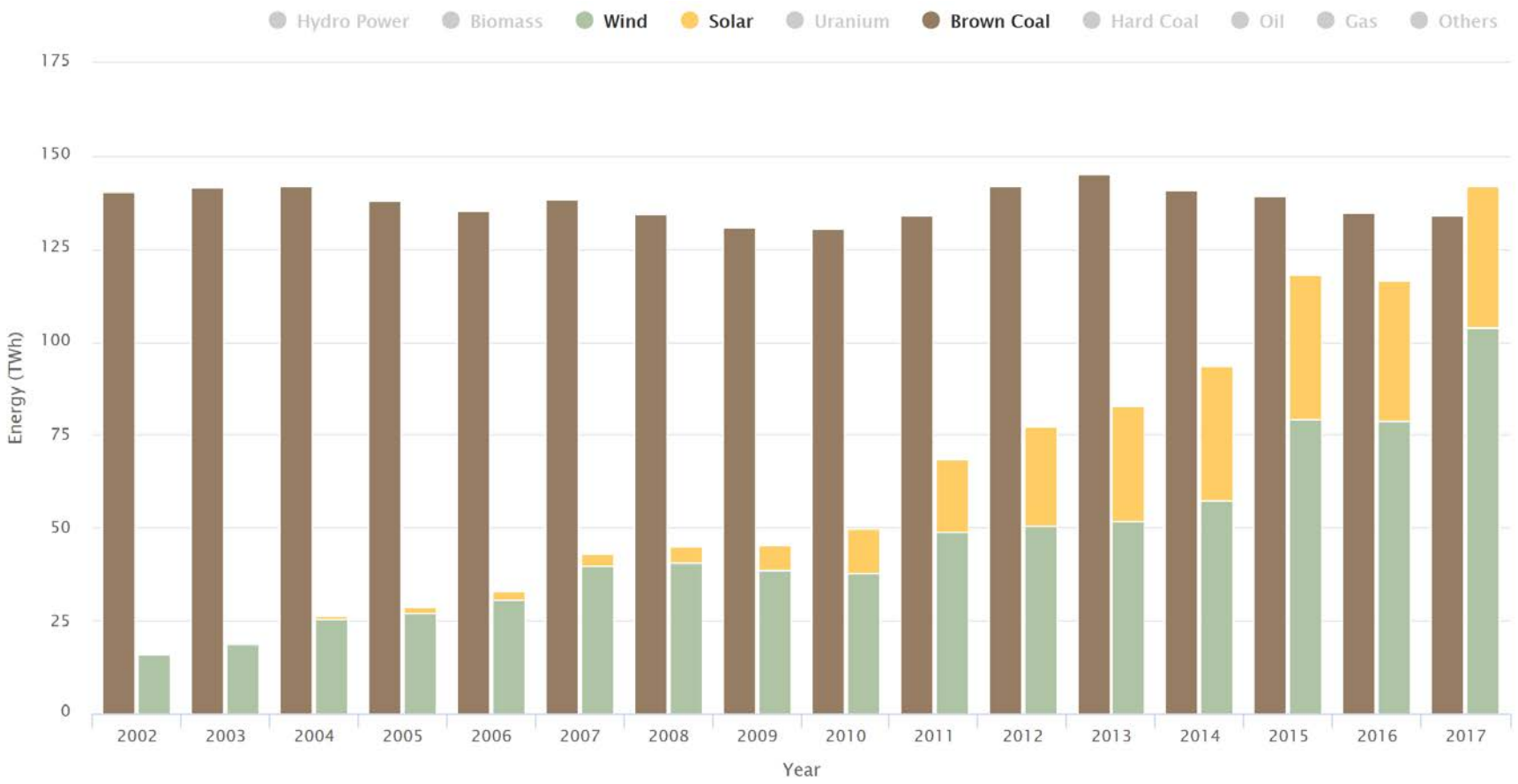
German net power generation from brown coal compared to solar plus wind

Year 2002 - 2017



Graphic: Bruno Burger; source: https://www.energy-charts.de/energy.htm

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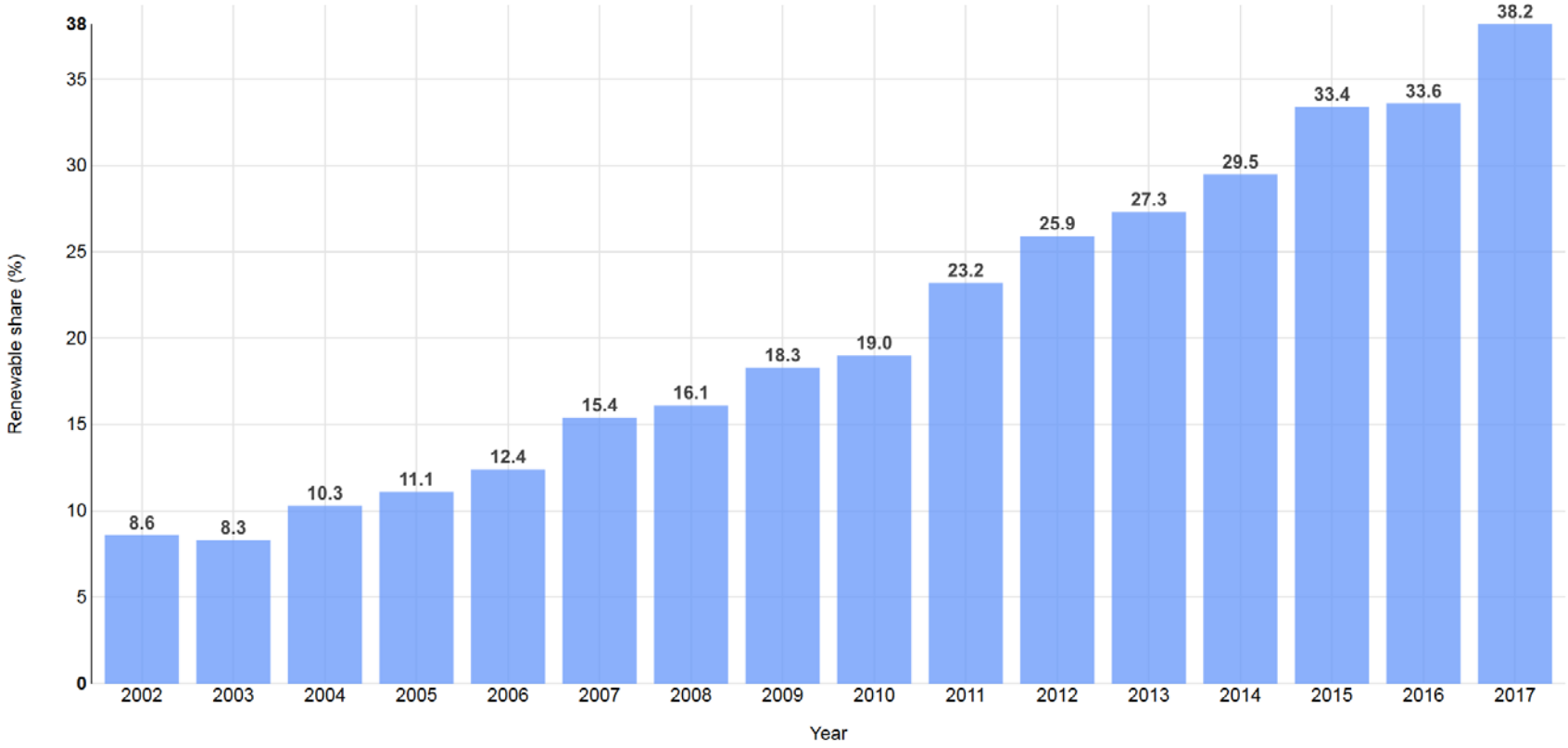
Renewable shares of net public power production

Year 2002 - 2017



This graph shows the share of renewable energies in net public power production. That's the power mix that actually comes out of the socket. Self-generation from power plants of industry for self-consumption is not included.

Graphic: B. Burger, Fraunhofer ISE; Source: https://www.energy-charts.de/ren_share.htm

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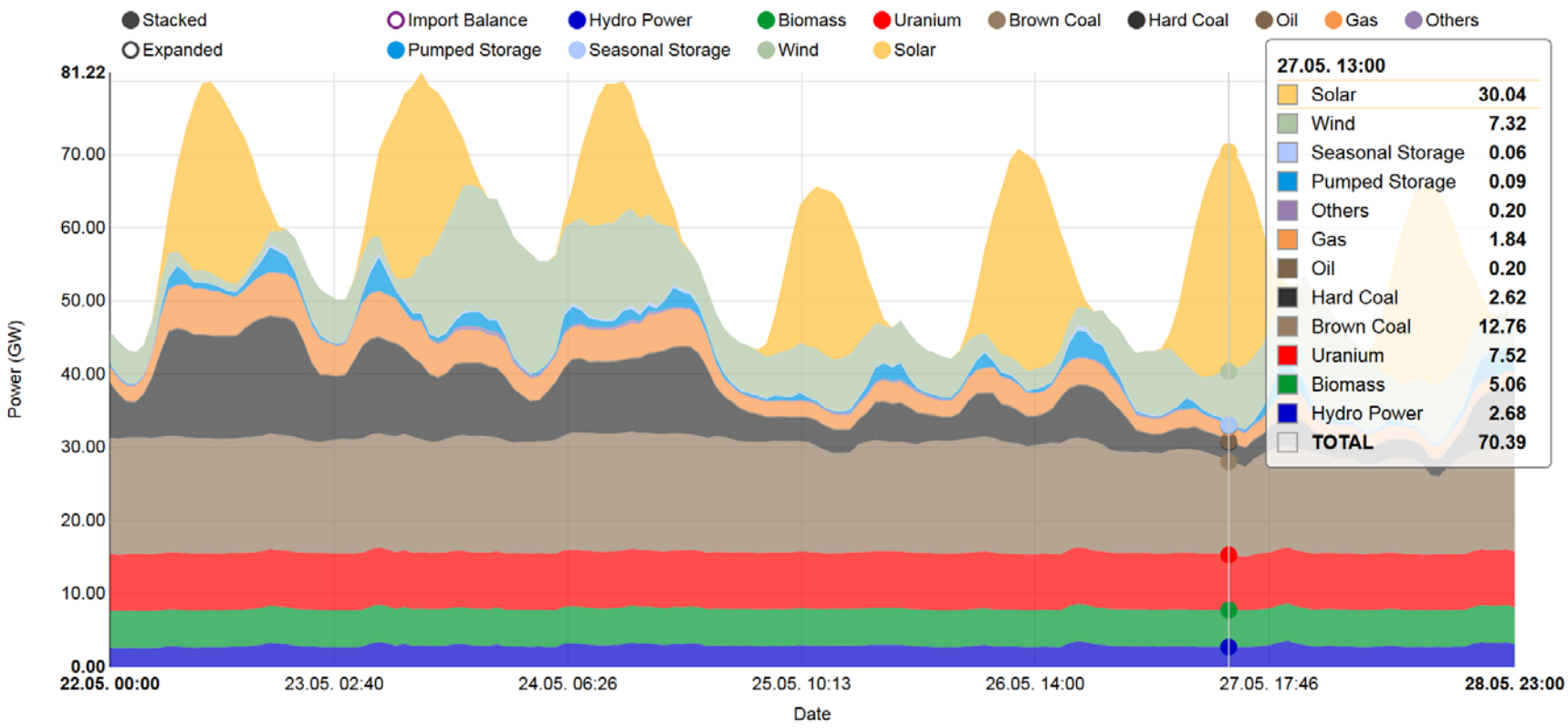
Highest power production from solar
Week 21 2017



Source: B. Burger, Fraunhofer ISE; Quelle: https://www.energy-charts.de/power.htm?source=all-sources

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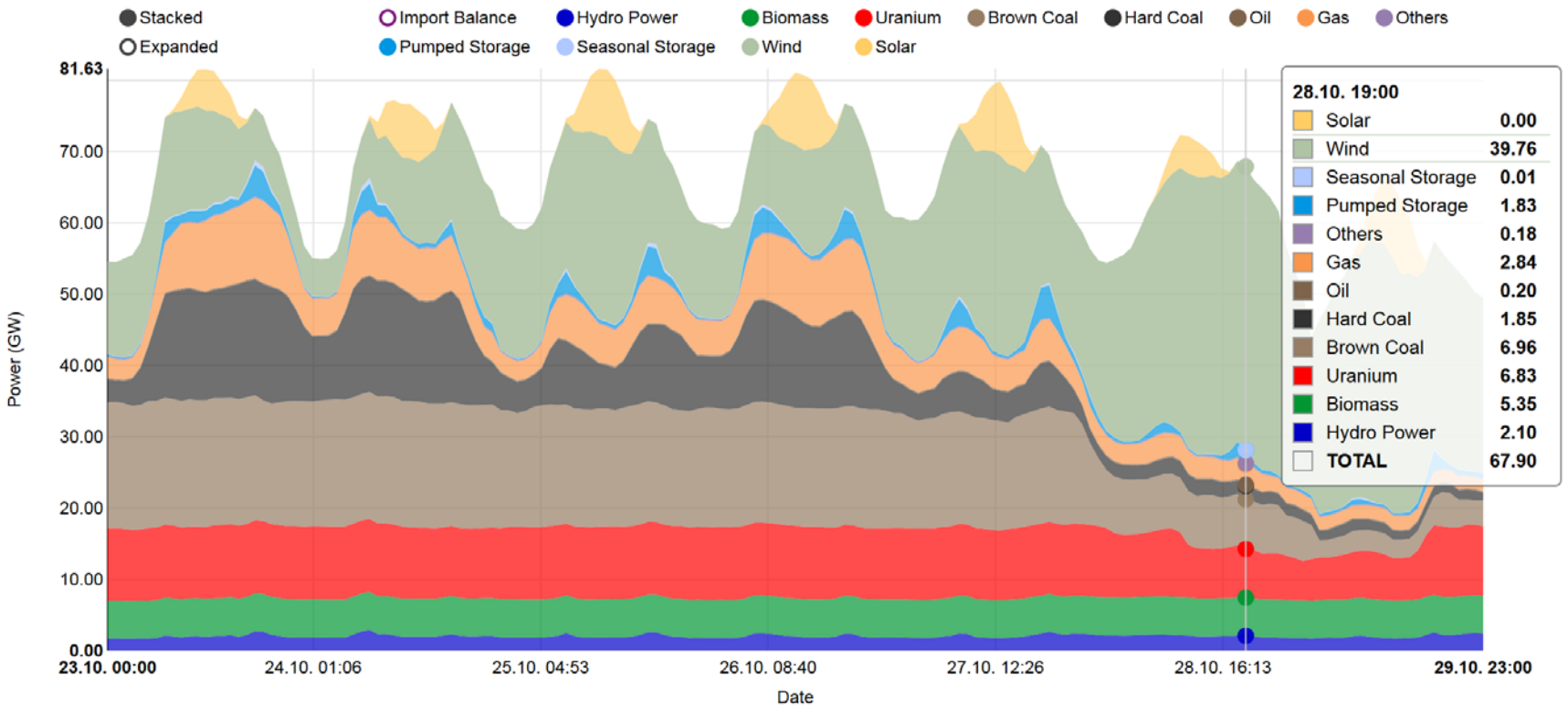
Highest power production from wind
Week 43 2017



Grafik: B. Burger, Fraunhofer ISE; Quelle: https://www.energy-charts.de/power.htm?source=all-sources

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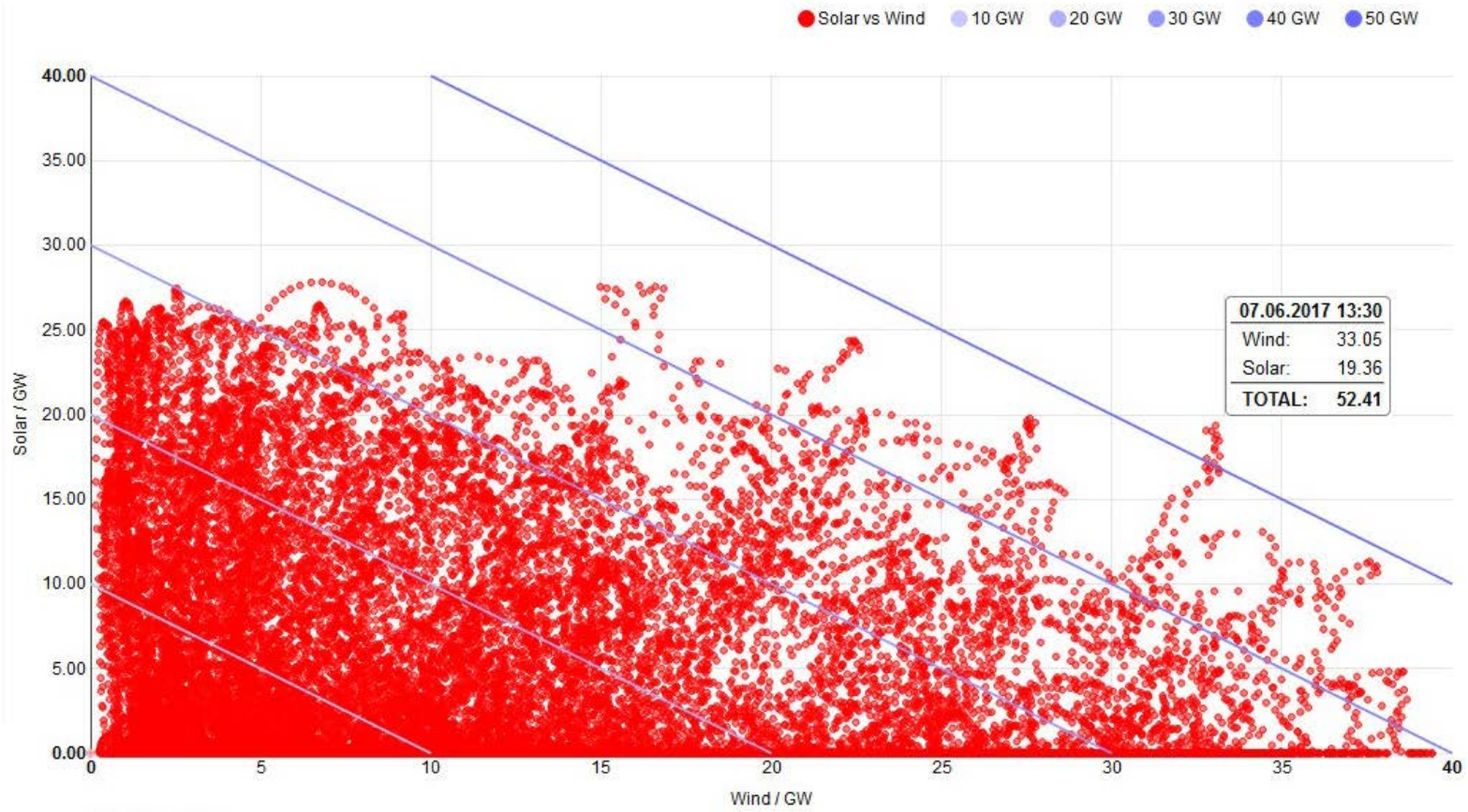
Scatter chart of solar vs. wind production

Quarter-hourly values of 2017



This graph shows 35 thousand quarter-hourly values of solar vs. wind production.

Graphic: B. Burger, Fraunhofer ISE; Source: https://www.energy-charts.de/scatter.htm

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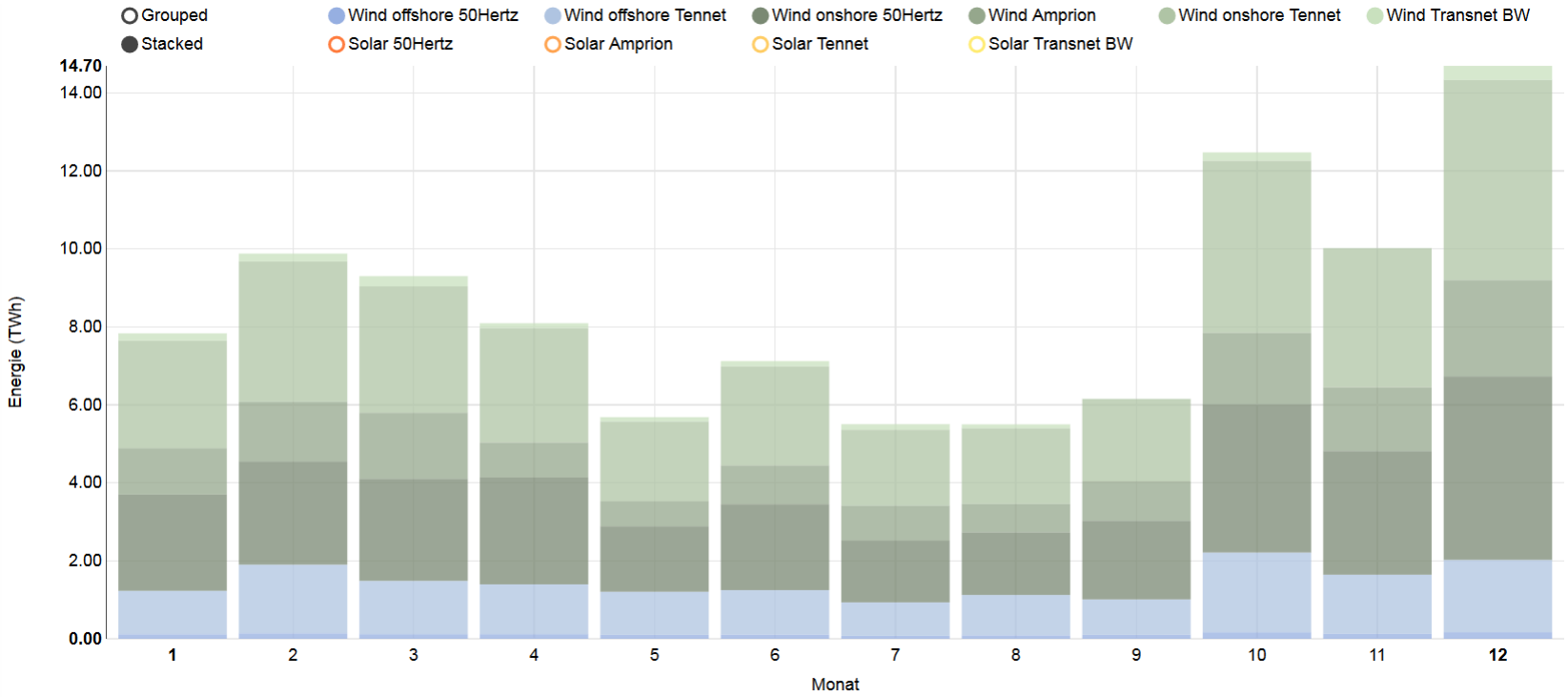
Monthly wind power production
Year 2017



Source: B. Burger, Fraunhofer ISE; Quelle: https://www.energy-charts.de/energy.htm?source=solar-wind

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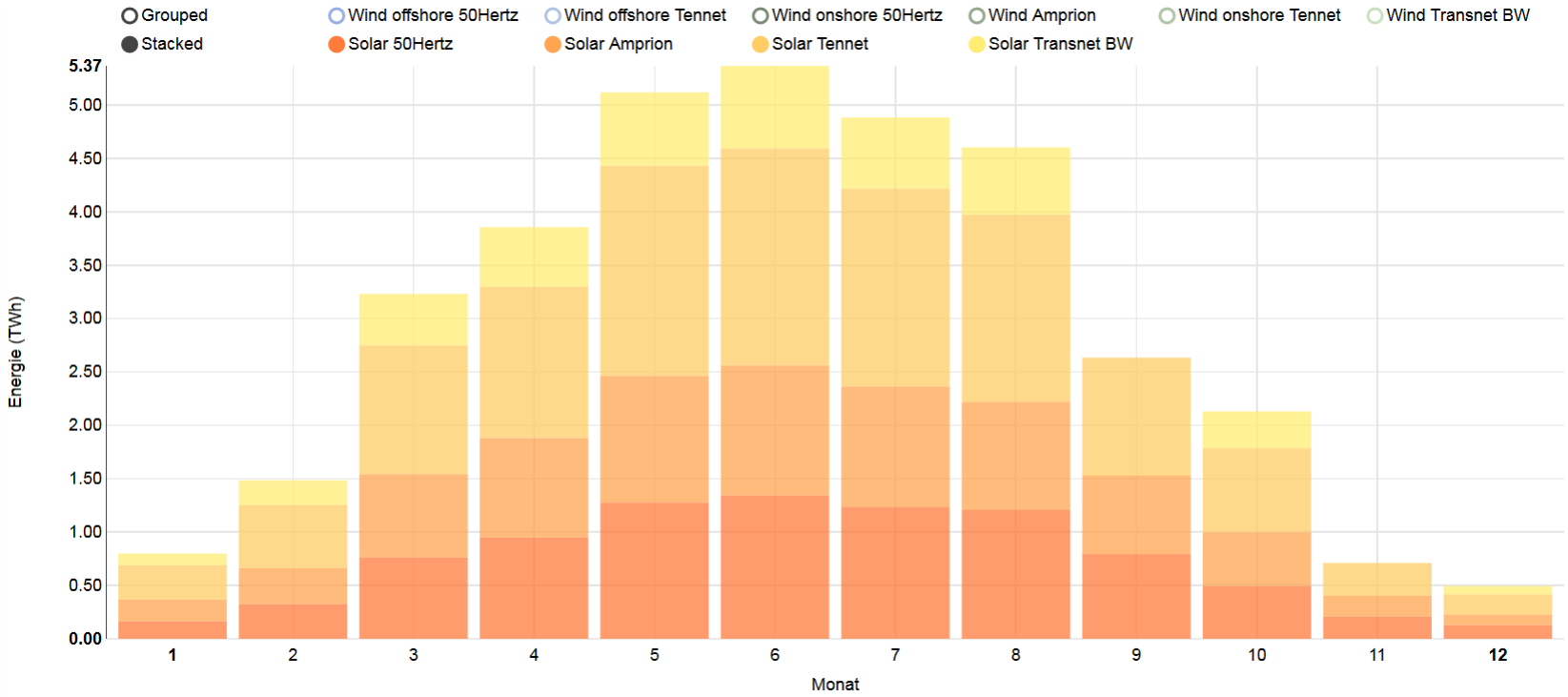
Monthly solar power production

Year 2017



Grafik: B. Burger, Fraunhofer ISE; Quelle: https://www.energy-charts.de/energy.htm?source=solar-wind

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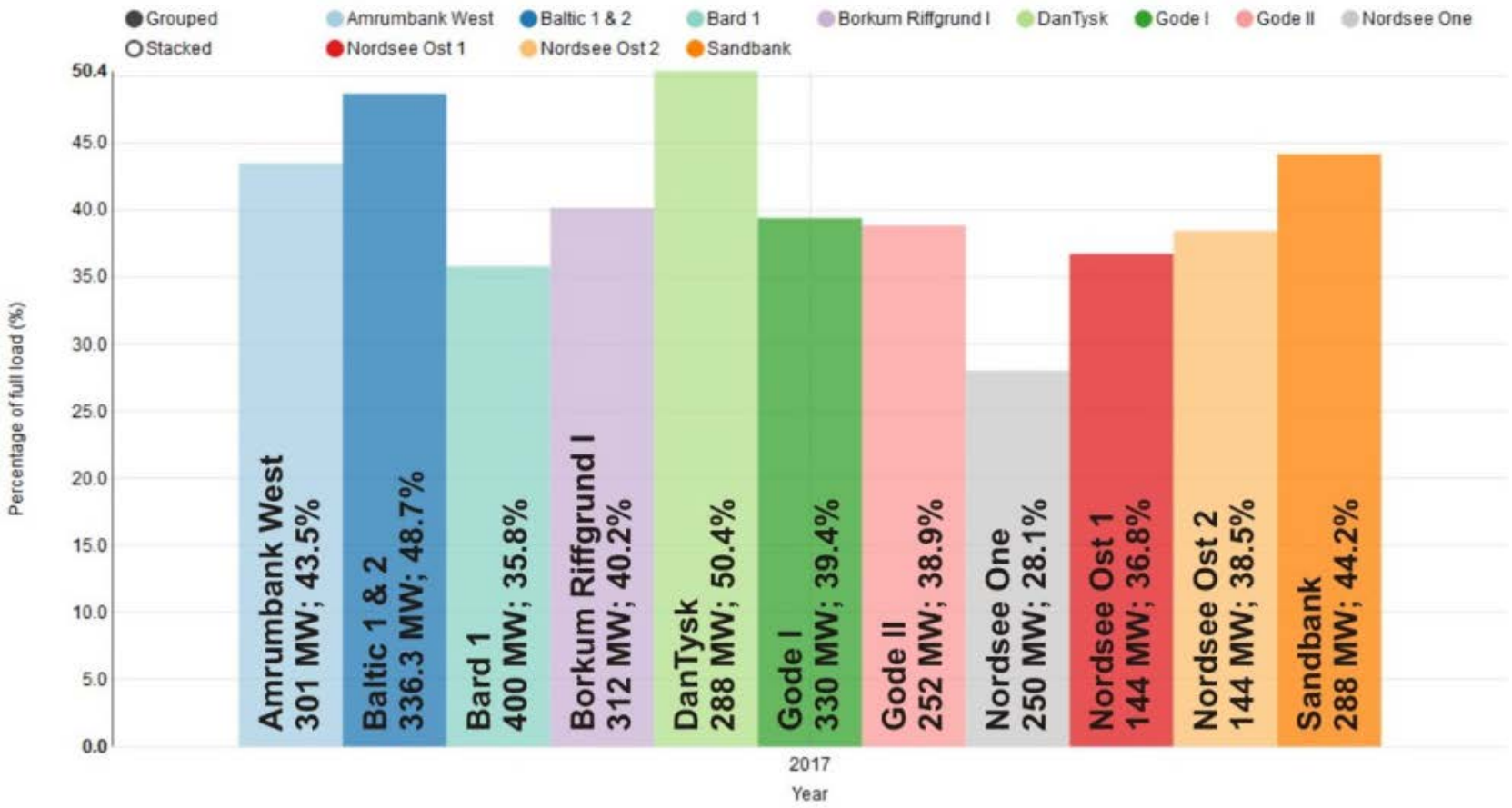
Annual percentage of full load of wind offshore
Year 2017



Graphic: B. Burger, Fraunhofer ISE; Source: https://www.energy-charts.de/energy.htm

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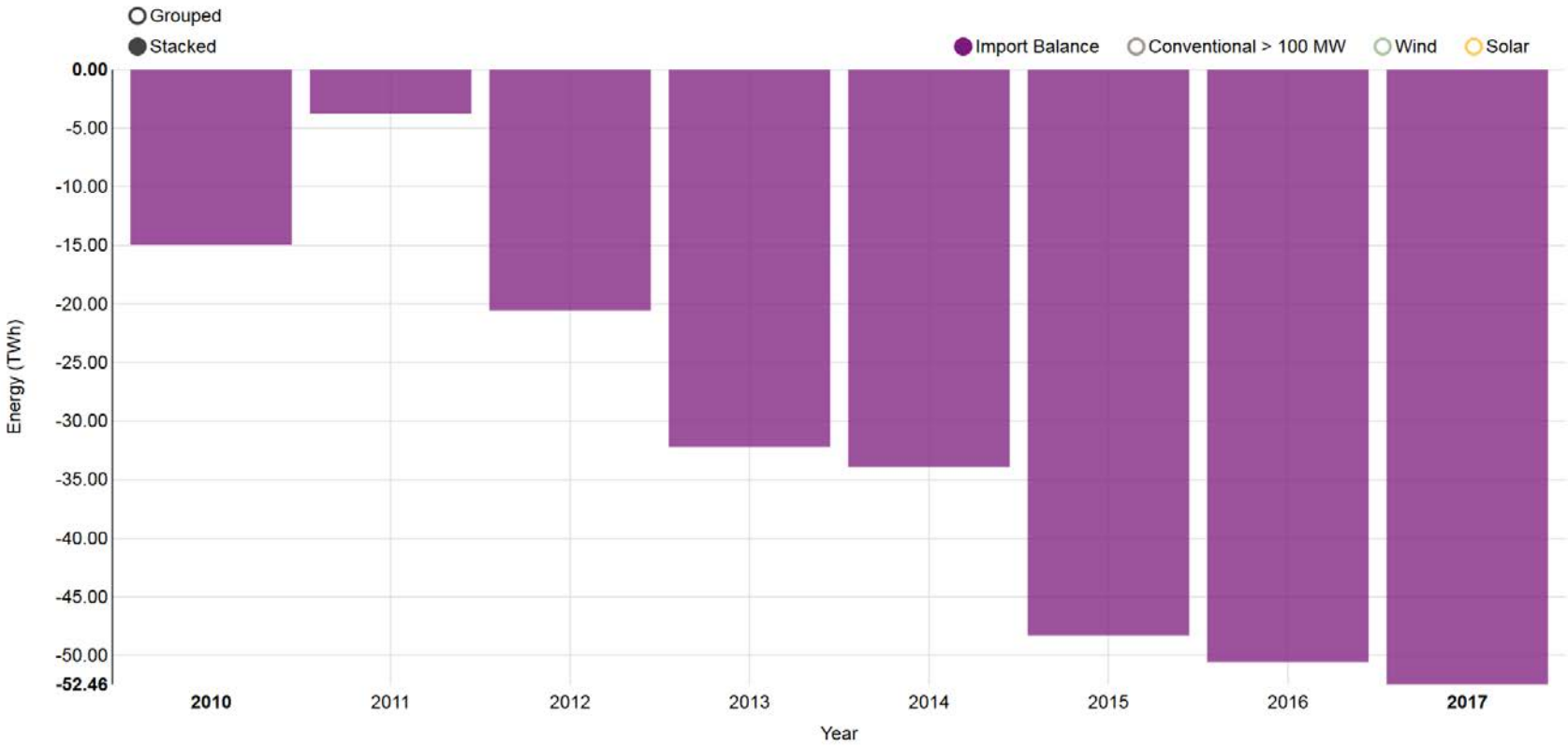
German power export surplus

Year 2010 - 2017



Physical flows. Positive values indicate import. Negative values indicate export.

Graphic: B. Burger, Fraunhofer ISE; data: TSOs and ENTSO-E; source: https://www.energy-charts.de/energy.htm

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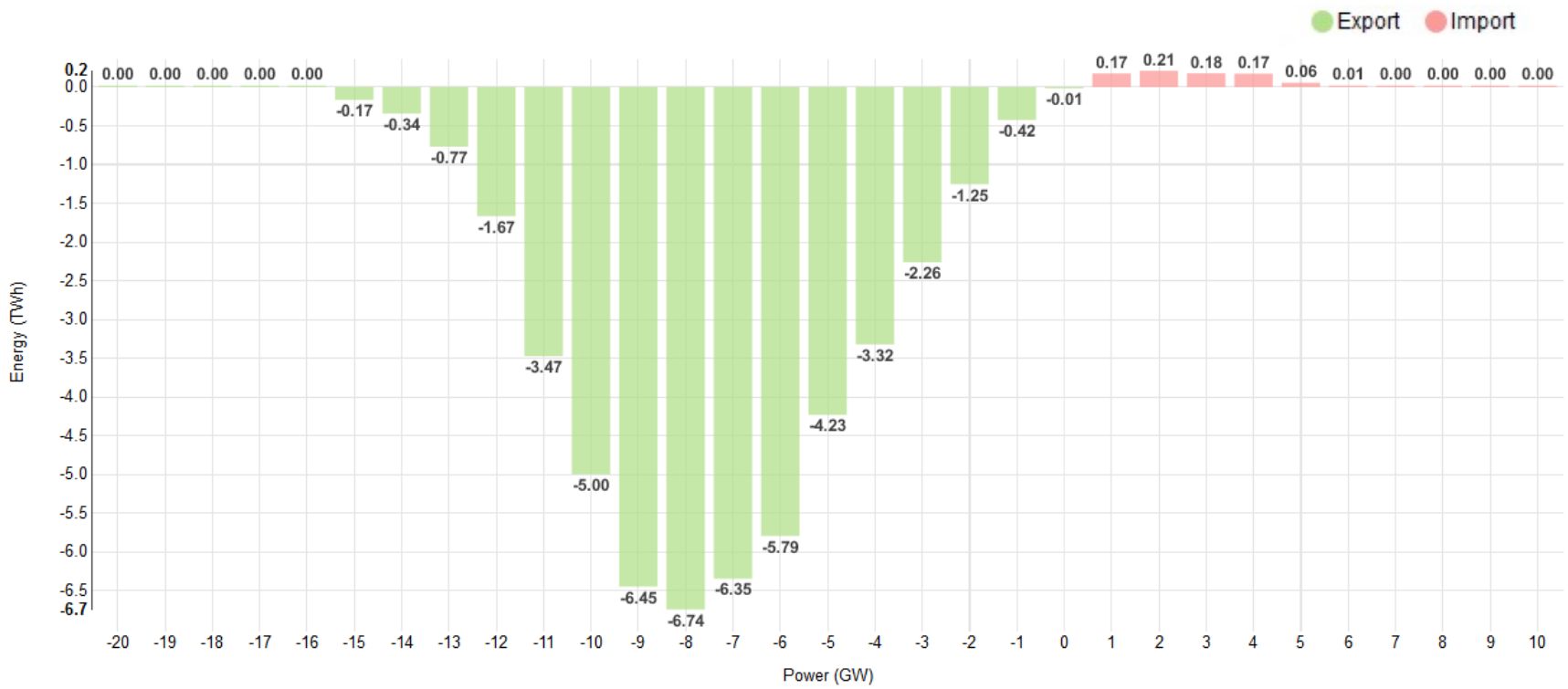
German power import / export histogram
Year 2017



Physical flows. Positive values indicate import. Negative values indicate export.

Graphic: B. Burger, Fraunhofer ISE; data: TSOs and ENTSO-E

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German power import / export

Year 2017

Physical flows. Positive values indicate import. Negative values indicate export.

Graphic: B. Burger, Fraunhofer ISE; data: TSOs and ENTSO-E; source: https://www.energy-charts.de/energy.htm

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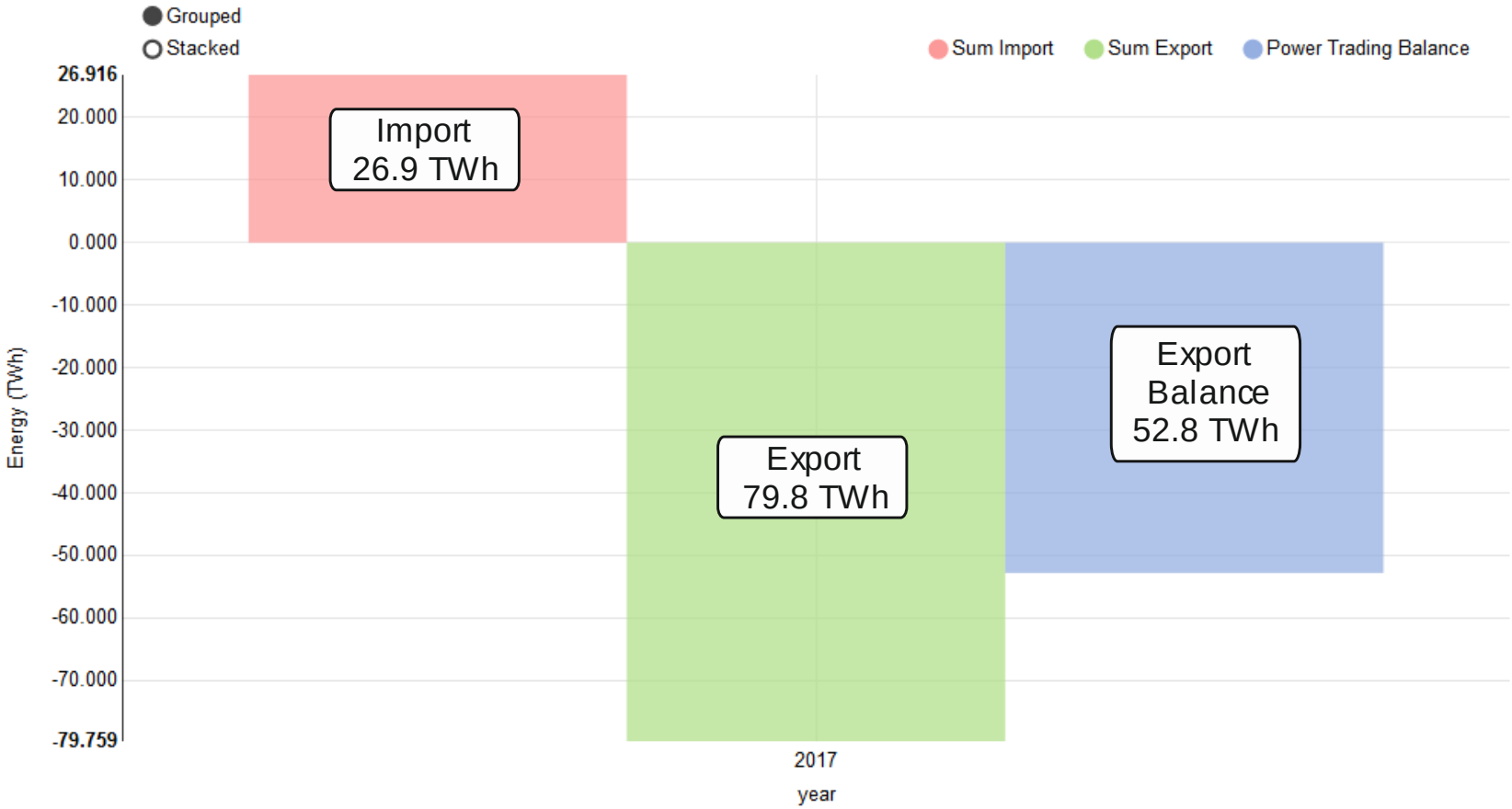
German power trading
Year 2017



Physical flows. Positive values indicate import. Negative values indicate export.

Graphic: B. Burger, Fraunhofer ISE; data: TSOs and ENTSO-E; source: https://www.energy-charts.de/trade.htm

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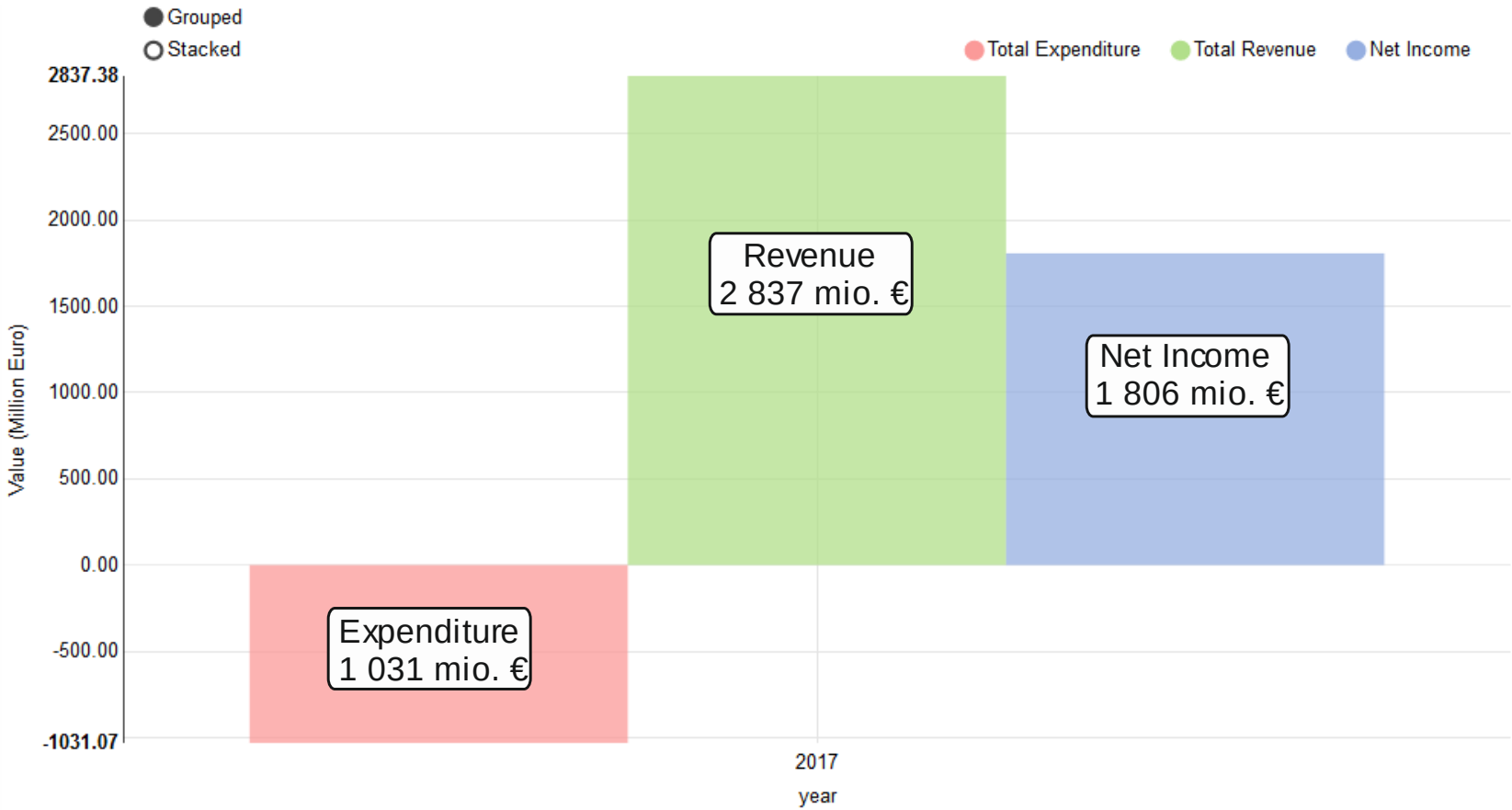
German power trading
Year 2017



Positive values indicate income. Negative values indicate expenditure.

Graphic: B. Burger, Fraunhofer ISE; data: TSOs and ENTSO-E; source: https://www.energy-charts.de/trade.htm

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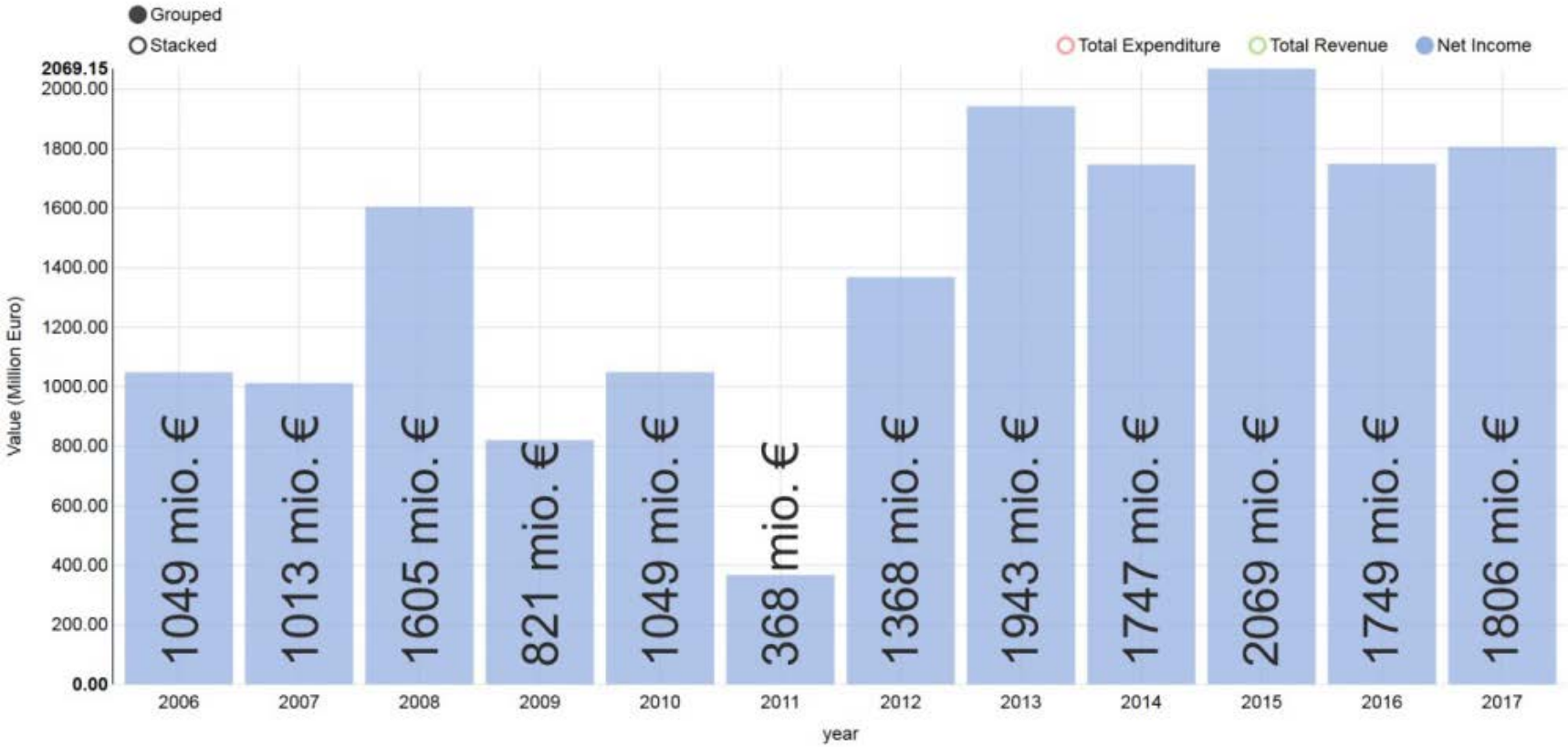
German power trading

Net income in millions of euros



Positive values indicate income. Negative values indicate expenditure.

*Data of 2017 only from January to October; source: https://www.energy-charts.de/trade.htm

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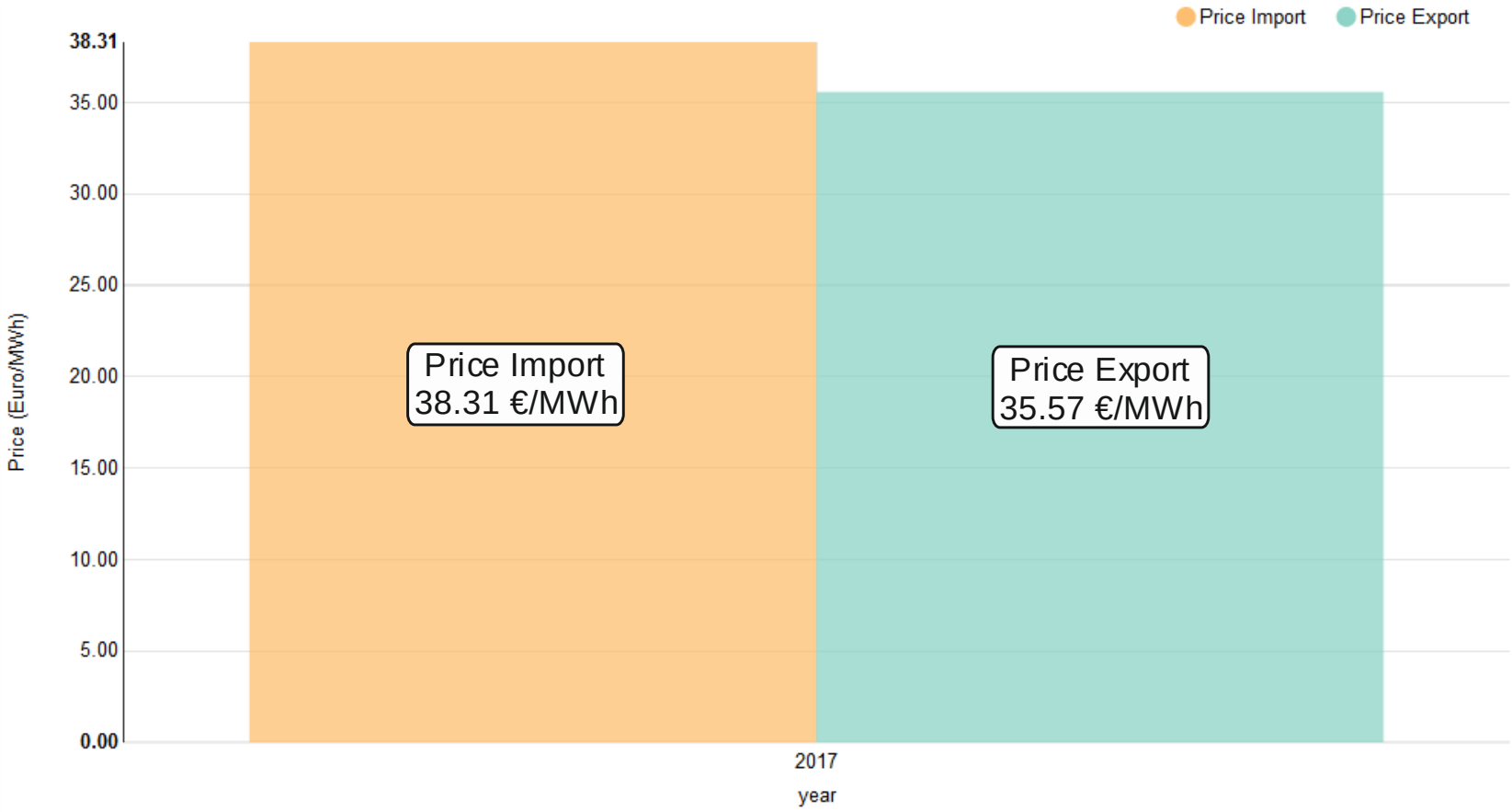
German power trading
Year 2017



Physical flows. Positive values indicate import. Negative values indicate export.

Graphic: B. Burger, Fraunhofer ISE; data: TSOs and ENTSO-E; source: https://www.energy-charts.de/trade.htm

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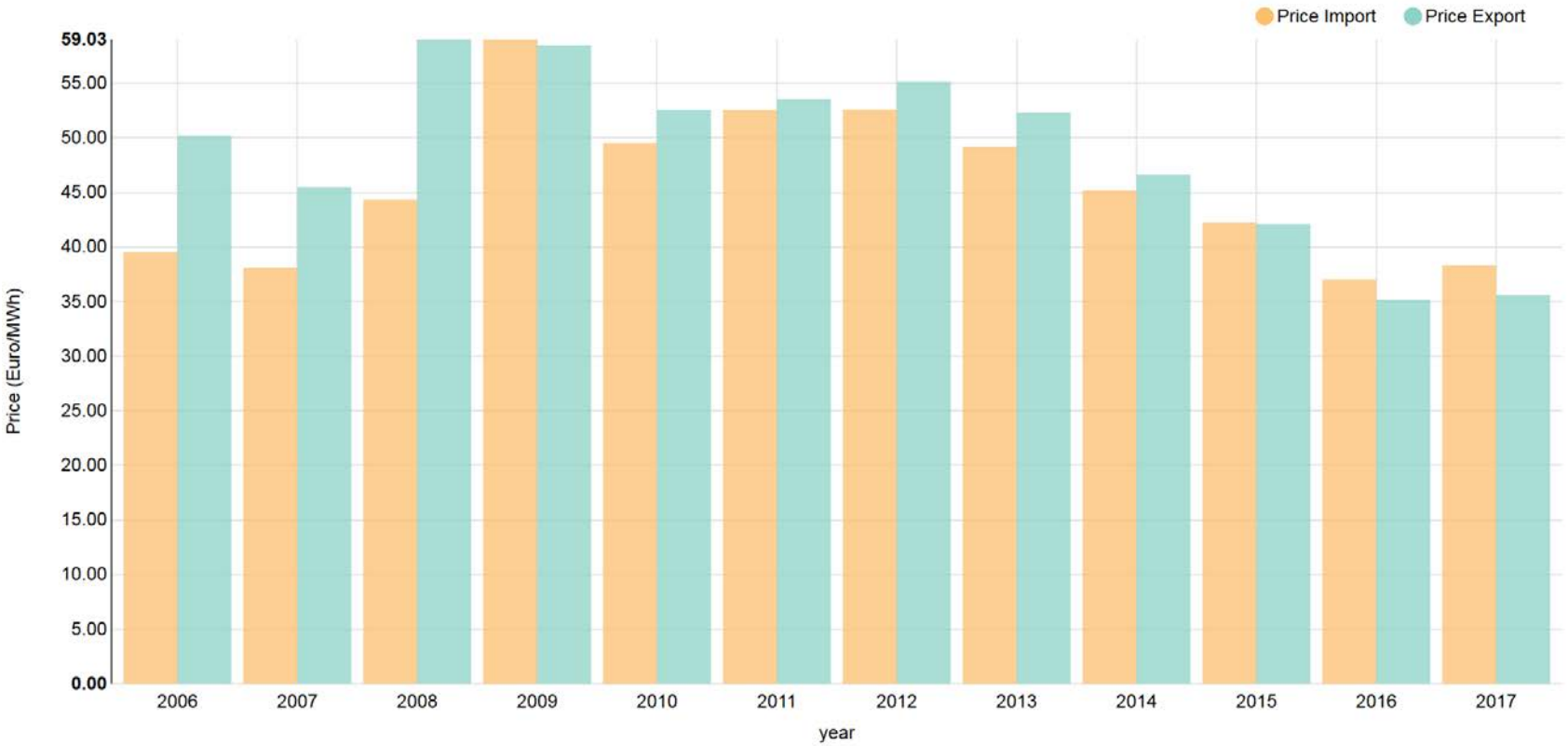
German power trading

Volume weighted average prices in Euro/MWh



Positive values indicate income. Negative values indicate expenditure.

*Data of 2017 only from January to October; source: https://www.energy-charts.de/trade.htm

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EPEX day ahead spot price

Weighted by volume, nominal prices, not inflation-adjusted

Graphic: B. Burger, Fraunhofer ISE; data: EPEX; source: https://www.energy-charts.de/price_avg.htm

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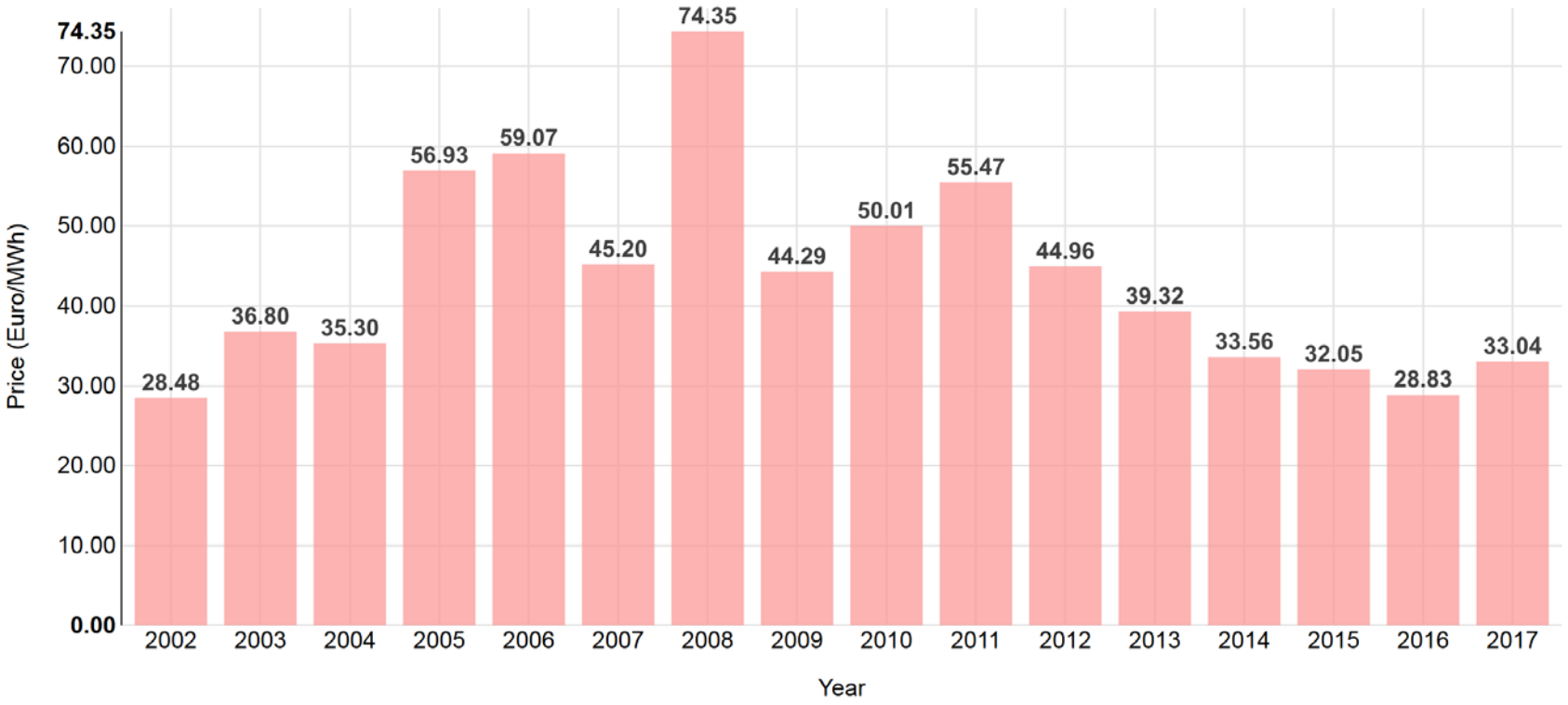
EPEX day ahead spot price

Weighted by volume, real prices, inflation-adjusted



Graphic: B. Burger, Fraunhofer ISE; data: EPEX; source: www.energy-charts.de/price_avg.htm

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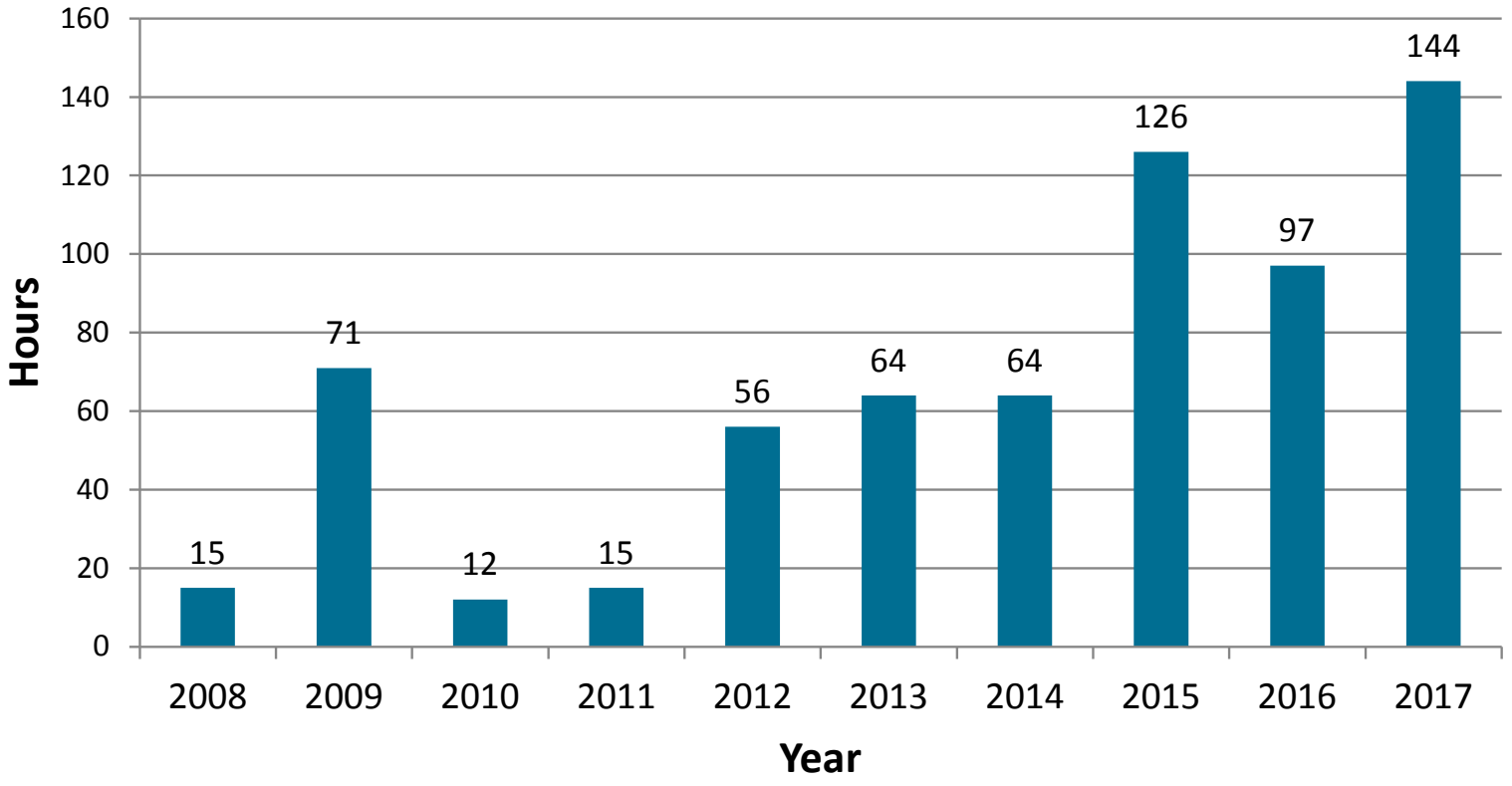
Negative Day Ahead Electricity Prices

Hours per Year



Source: B. Burger, Fraunhofer ISE; Data: EPEX

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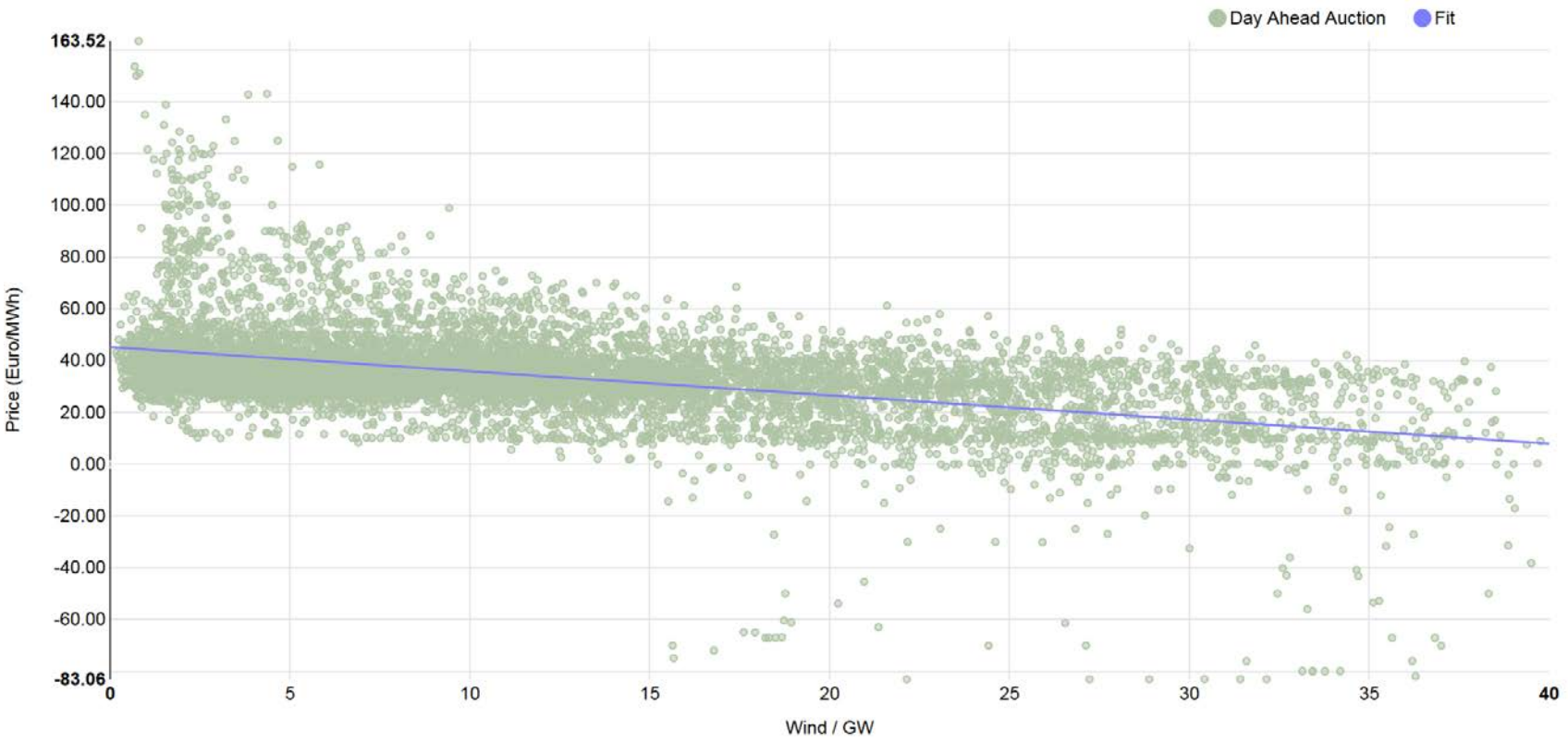
Day Ahead Spot Price vs. Wind Power

Hourly values in 2017



Wind power reduces the Day Ahead Spot Market Price by 0.93 Euro/MWh per GW.
Graph: B. Burger, Fraunhofer ISE; Data: EPEX; Source: www.energy-charts.de/price_scatter.htm

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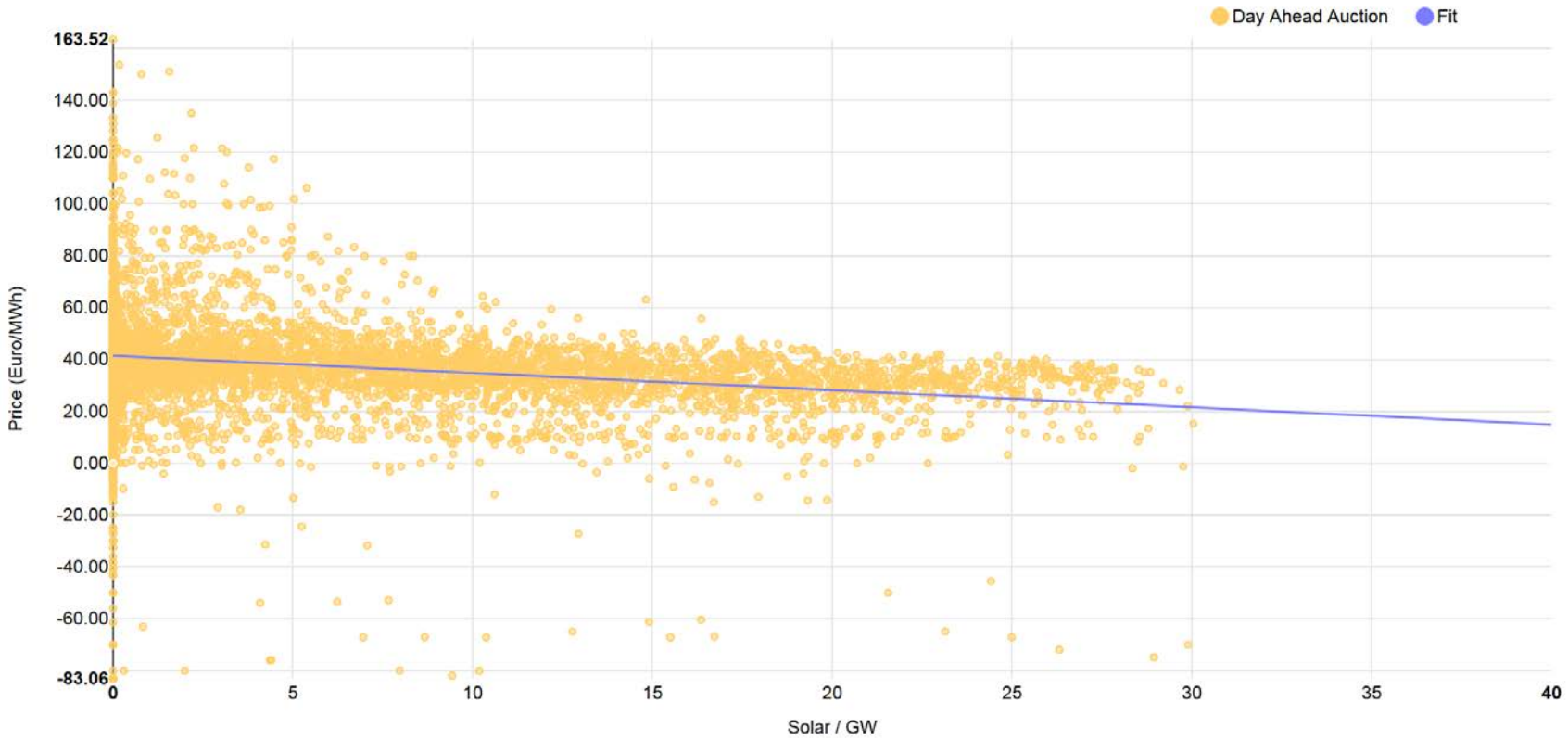
Day Ahead Spot Price vs. Solar Power

Hourly values in 2017



Solar power reduces the Day Ahead Spot Market Price by 0.66 Euro/MWh per GW.
Graph: B. Burger, Fraunhofer ISE; Data: EPEX; Source: https://www.energy-charts.de/price_scatter.htm

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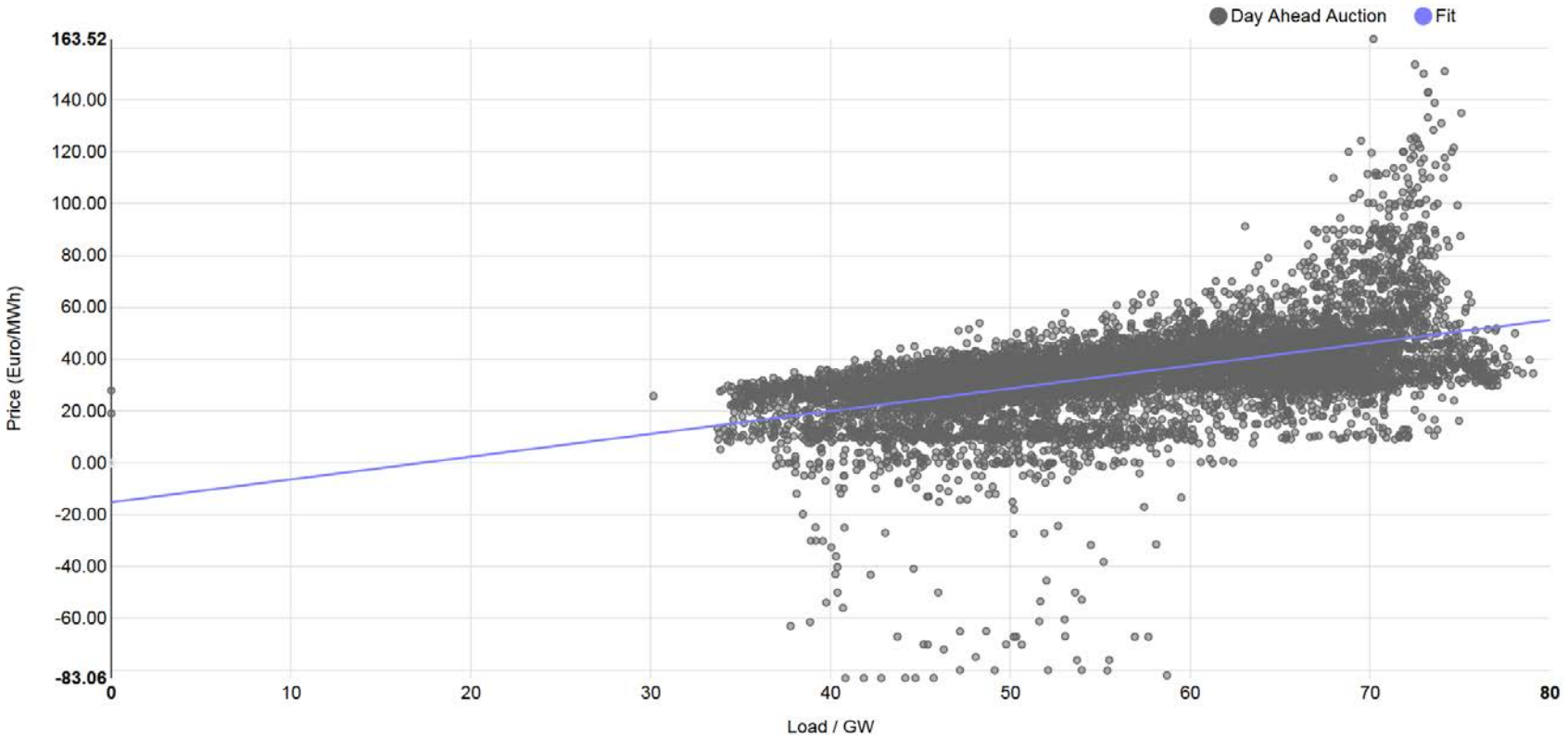
Day Ahead Spot Price vs. Load

Hourly values in 2017



The load increases the Day Ahead Spot Market Price by 0.88 Euro/MWh per GW.
Graph: B. Burger, Fraunhofer ISE; Data: EPEX; Source: https://www.energy-charts.de/price_scatter.htm

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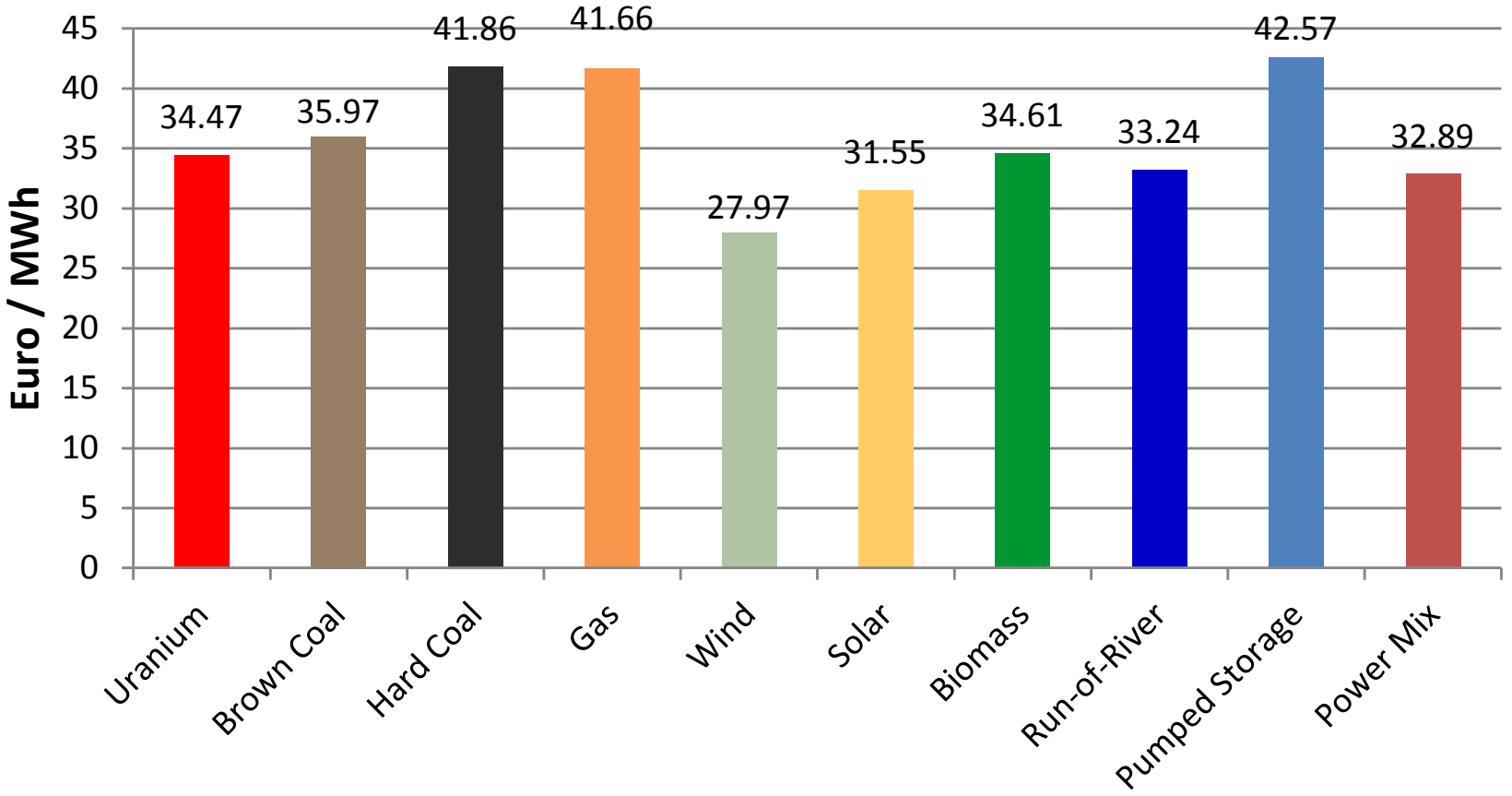
Day Ahead market values, weighted by volume
Year 2017



Graph: B. Burger, Fraunhofer ISE; Data: EPEX

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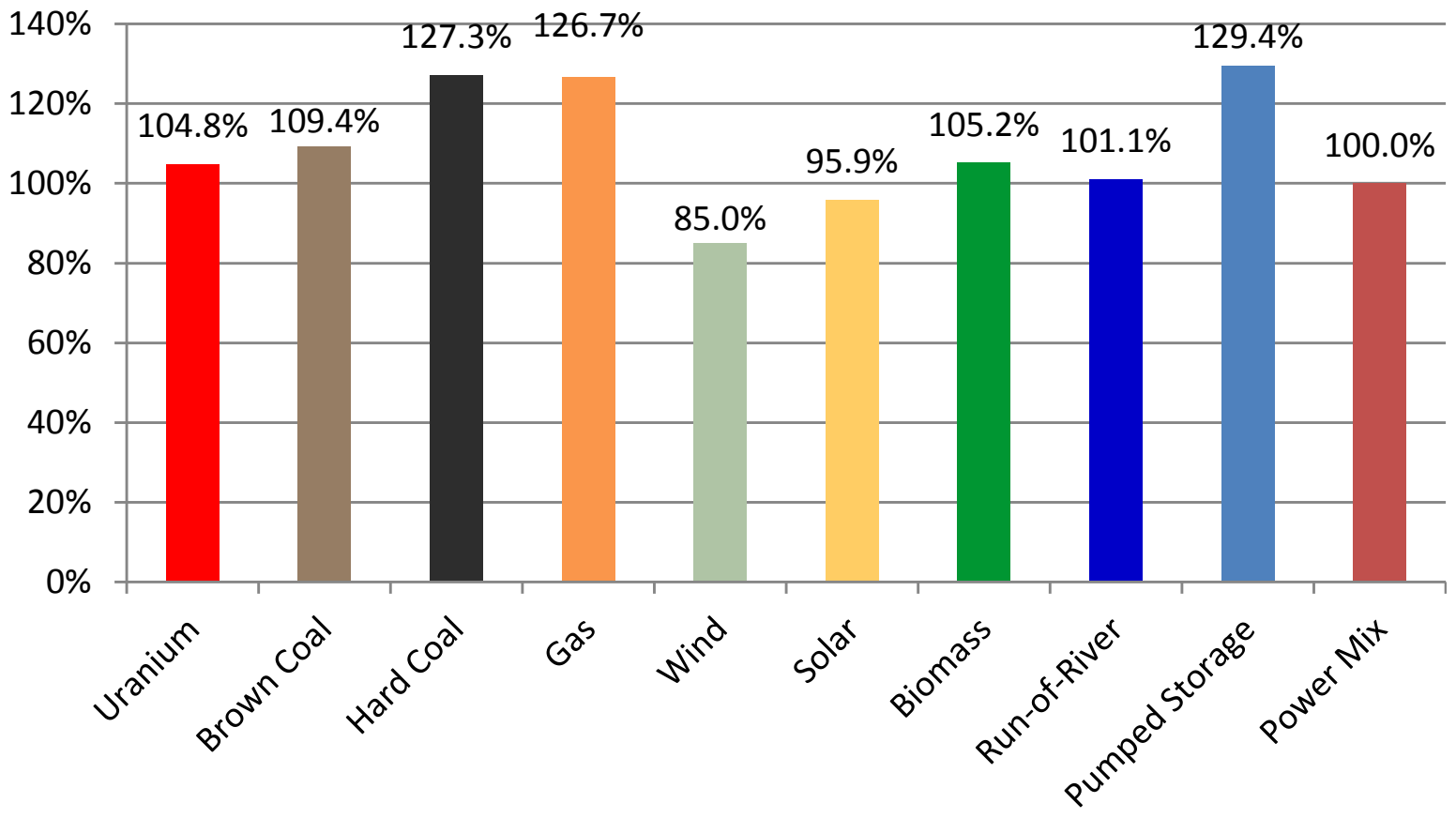
Relative Day Ahead market values, weighted by volume
Year 2017



Grafik: B. Burger, Fraunhofer ISE; Daten: EPEX

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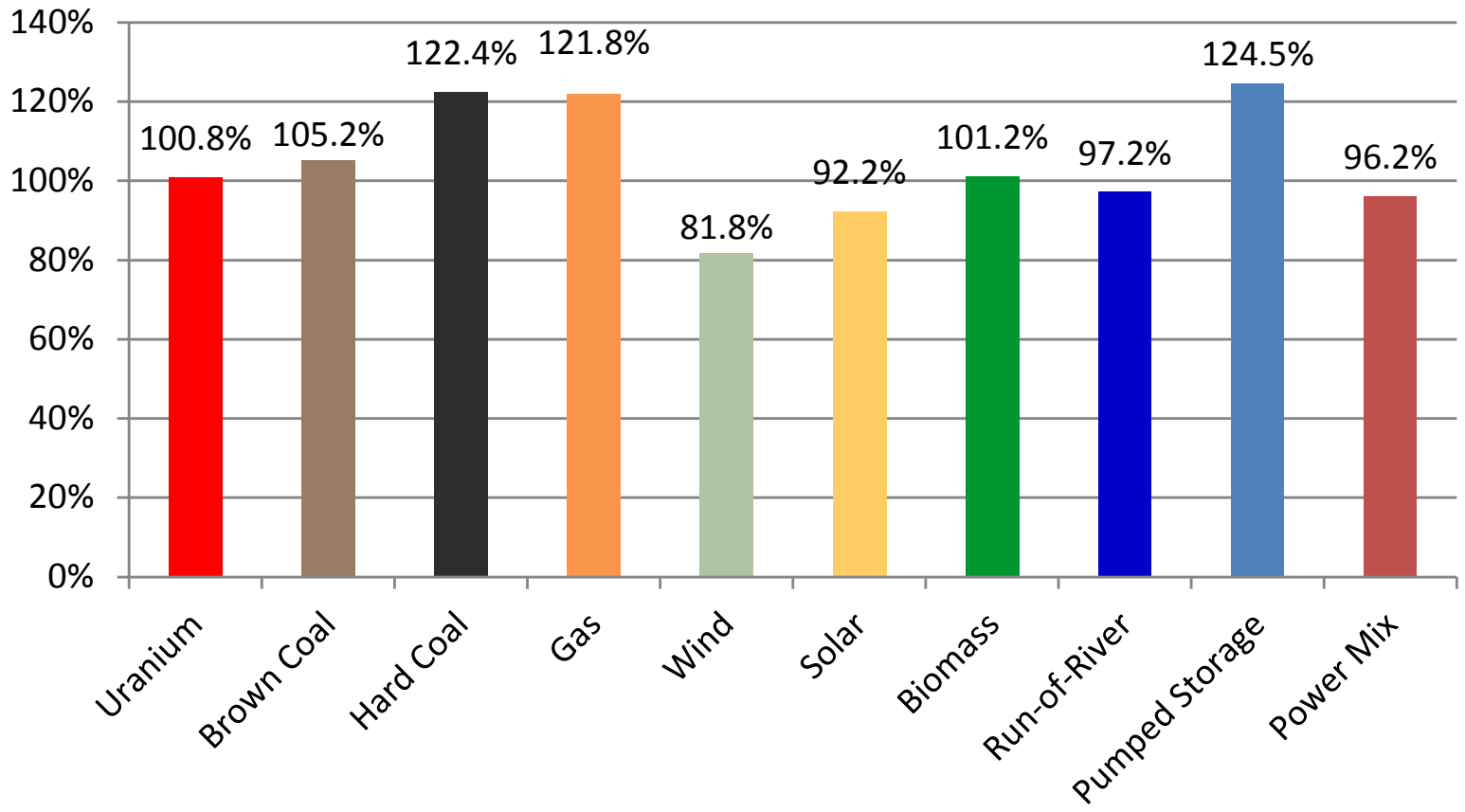
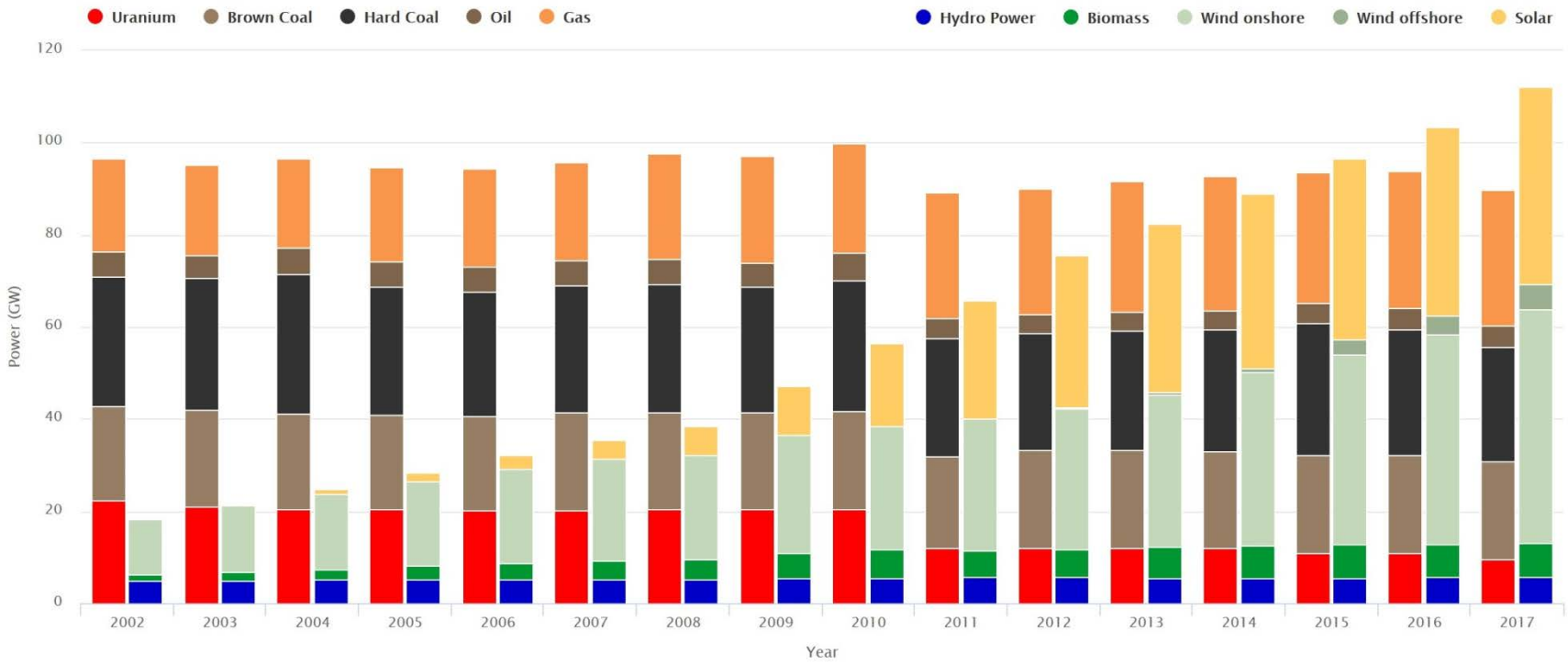
Market value factors
Year 2017



Grafik: B. Burger, Fraunhofer ISE; Daten: EPEX

Installed power for electricity production
fossil plus nuclear compared to renewables



Since 2015, the installed power of renewables is greater than the installed power of fossil and nuclear.
Graph: B. Burger, Fraunhofer ISE; Data: Bundesnetzagentur, Source: https://www.energy-charts.de/power_inst.htm

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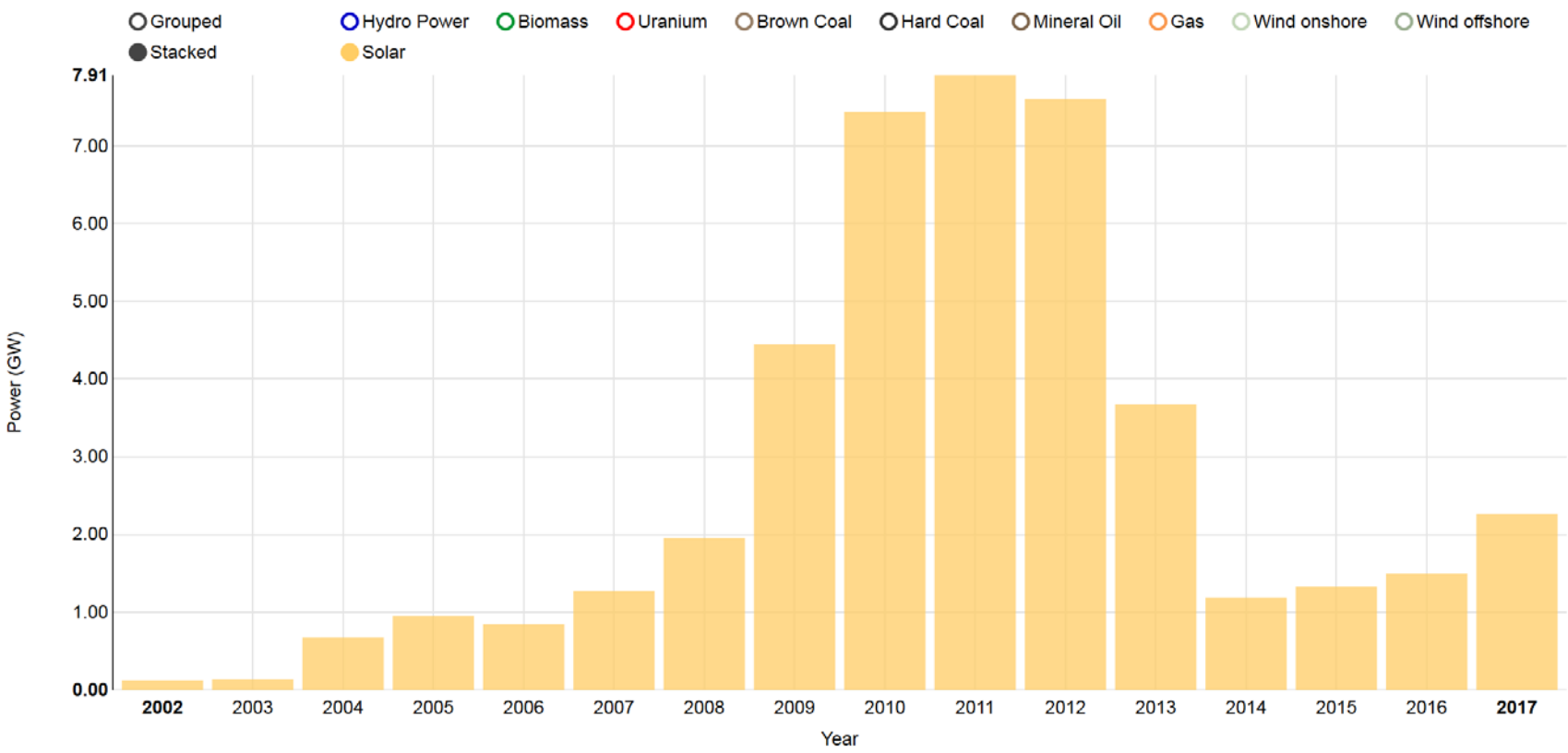
Annual increase of net installed generation capacity
Solar



Graph: B. Burger, Fraunhofer ISE; Data: Bundesnetzagentur, Source: https://www.energy-charts.de/power_inst.htm

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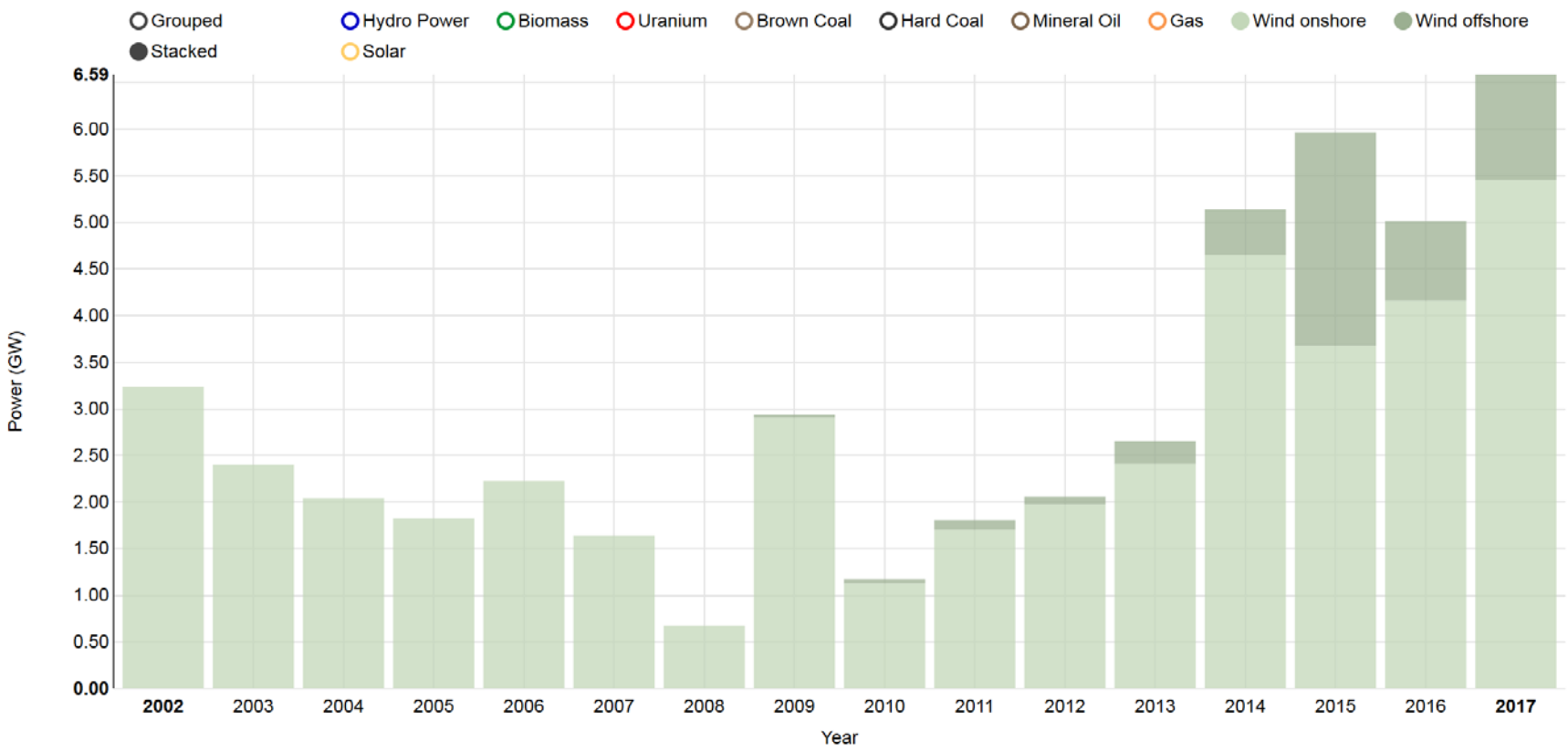
Annual increase of net installed generation capacity
Wind



Graph: B. Burger, Fraunhofer ISE; Data: Bundesnetzagentur, Source: https://www.energy-charts.de/power_inst.htm

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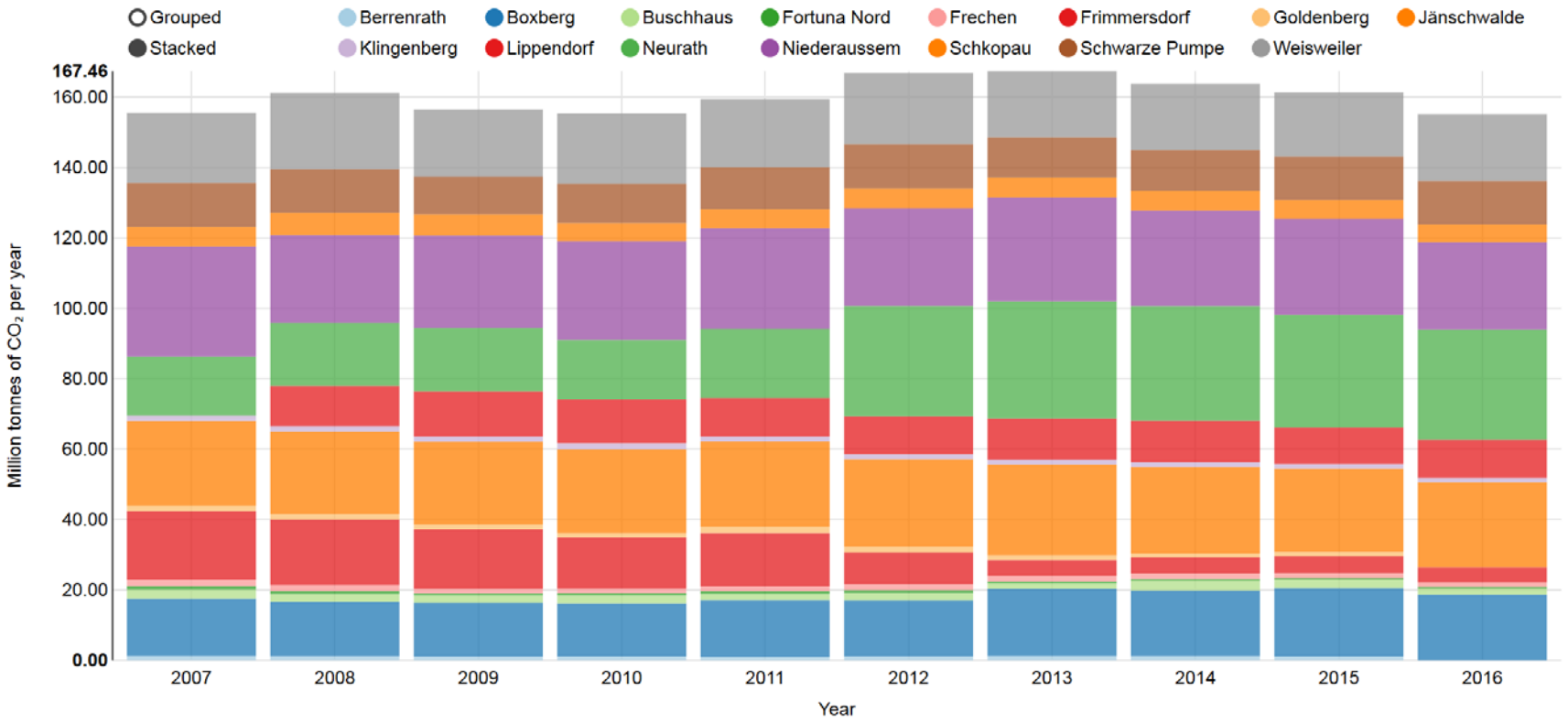
Annual carbon dioxide (CO_2) emissions of power plants

Brown coal



Releases to air. Pollutant Threshold: 0.1 Million tonnes of CO_2 per year.
Graph: B. Burger, Fraunhofer ISE; Datasource: Umweltbundesamt (UBA), PRTR Register
Source: https://www.energy-charts.de/emissions.htm?source=lignite

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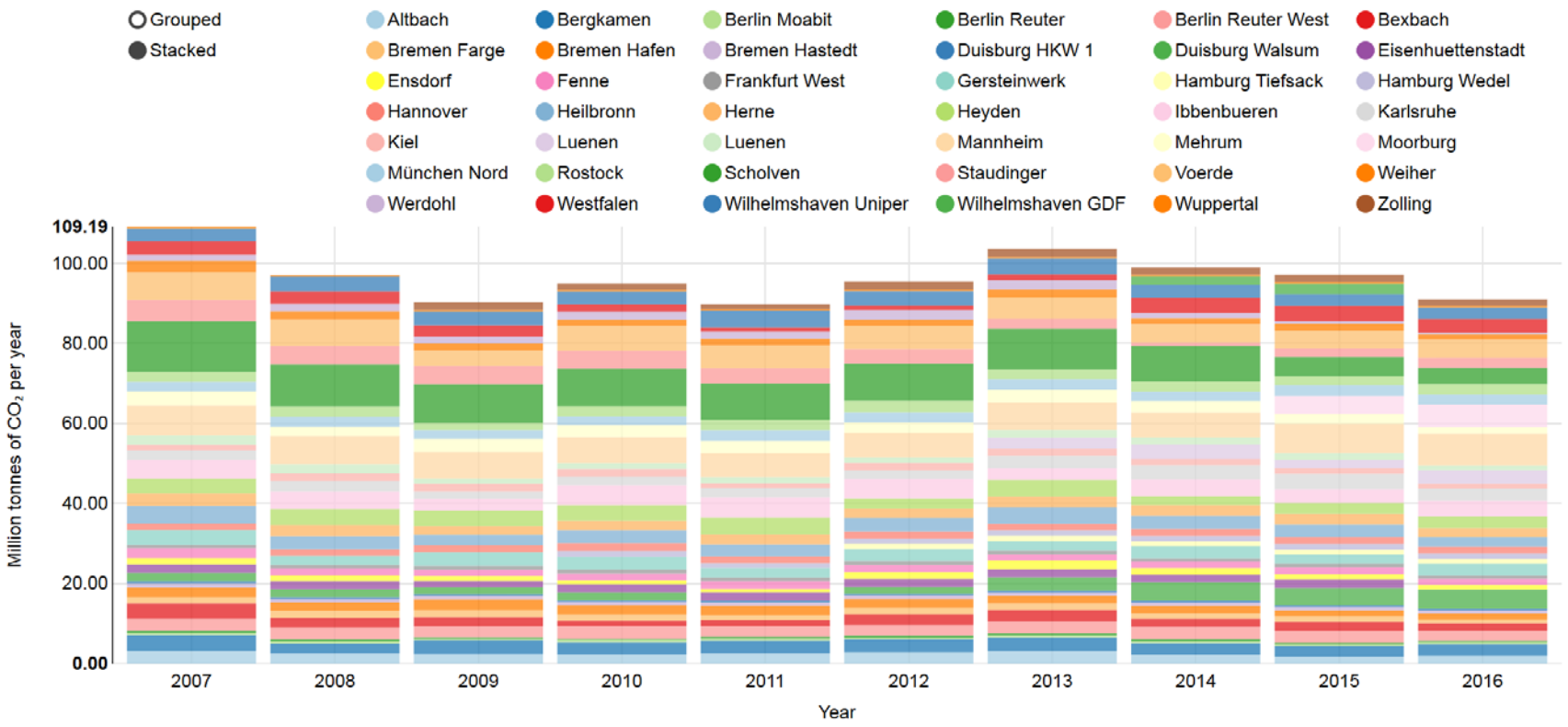
Annual carbon dioxide (CO_2) emissions of power plants

Hard coal



Releases to air. Pollutant Threshold: 0.1 Million tonnes of CO_2 per year.
Graph: B. Burger, Fraunhofer ISE; Datasource: Umweltbundesamt (UBA), PRTR Register
Source: https://www.energy-charts.de/emissions.htm?source=coal

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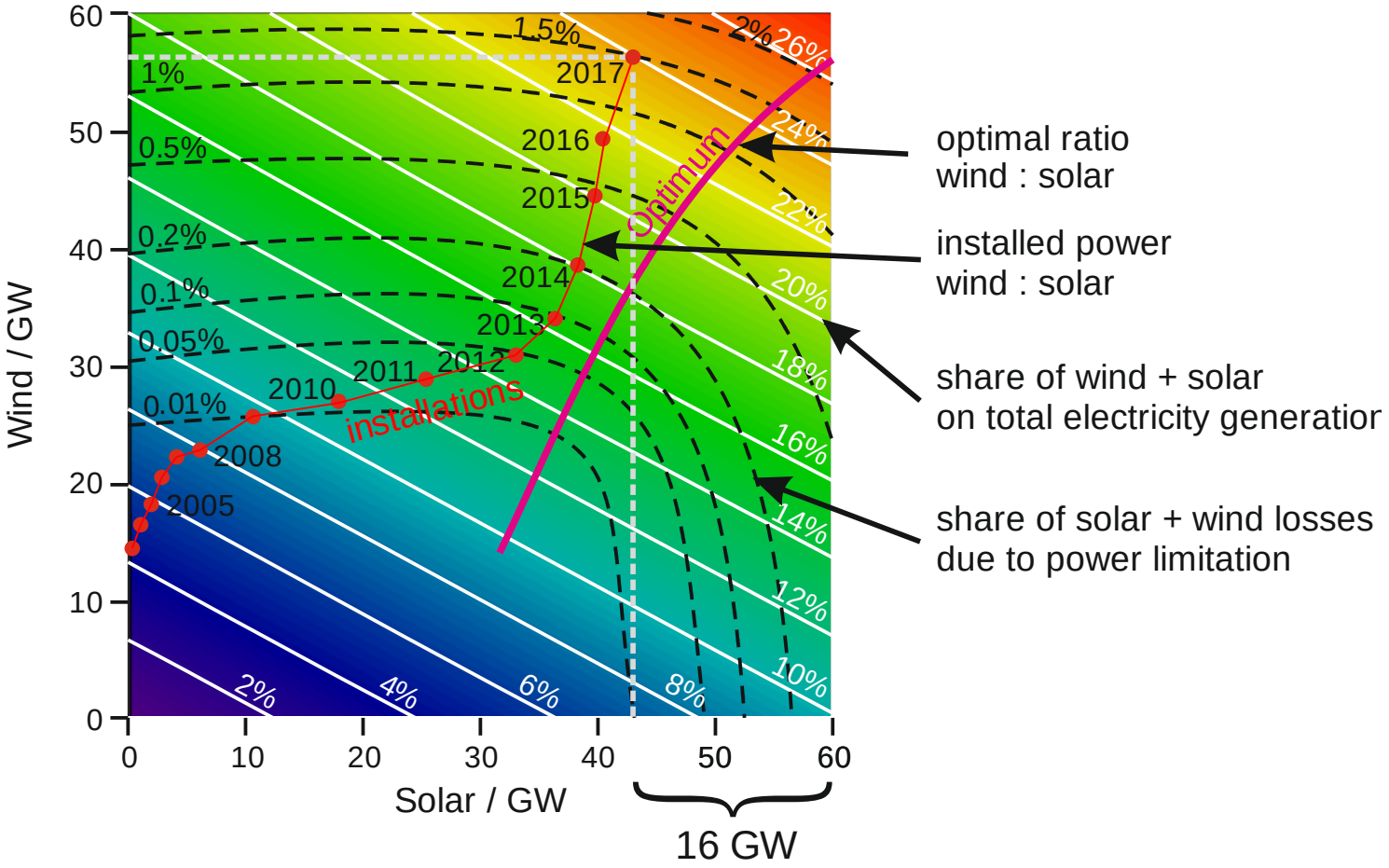
Optimum ratio of installed power

Wind : Solar



At the end of 2017, 16 GW of installed solar power was missing for the optimal ratio of wind to solar.
Graph: B. Burger, Fraunhofer ISE

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Thank you for your Attention!

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