FRAUNHOFER INSTITUTE FOR SOLAR ENERGY SYSTEMS ISE

Net Public Electricity Generation in Germany in 2018

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www.ise.fraunhofer.de

www.energy-charts.de/index.htm

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Net Public Electricity Generation in Germany in 2018

This second version from January 4, 2019 contains corrections and improvements.

The first version from January 1, 2019 takes into account all electricity generation data of the Electricity Exchange EEX in Leipzig up to and including December 31, 2018. The hourly data of the EEX have been energetically corrected for the available monthly data of the Federal Statistical Office (Destatis) on electricity generation up to and including September 2018 and the monthly data on imports and exports of electricity up to and including October 2018. For the remaining months, the correction factors were estimated on the basis of previous annual data. The extrapolated values are subject to larger tolerances.

Hourly updated data can be found on the Energy Charts: https://www.energy-charts.de/index.htm

Net Public Electricity Generation in 2018

The Difference between Gross and Net Production

This report presents the data on German **net electricity generation** for public electricity supply. The figures thus represent the electricity mix that actually comes out of the socket at home and that is consumed in the household or is used to charge electric vehicles publicly. On the German electricity exchange EEX, only net electricity generation is traded and only net figures are measured for cross-border electricity flows.

The **AG Energiebilanzen**, on the other hand, uses data on 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 power grid at all. On the consumption side, the electrical losses of the power plants are also added to the gross electricity consumption so that the balance is correct again. In addition, the AG Energiebilanzen also takes into account the industry's own electricity generation, the so-called companies in the manufacturing industry as well as in mining and quarrying. This own generation is consumed directly in the companies and is not fed into the public grid.

The data on public net electricity generation and total gross electricity generation differ considerably. This also results in significantly different shares of renewable energies.

Net Public Electricity Generation in 2018

Renewable Energy Sources: Solar and Wind

Photovoltaic systems fed approx. 45.7 TWh into the public grid in 2018. Production increased by approx. 6.3 TWh or 16% compared to the previous year. The installed PV capacity at the end of November was approx. 45.5 GW. The increase in 2018 amounted to approx. 3.2 GW. The maximum solar capacity was approx. 32 GW on 02.07.2018 at 1:15 pm. At this time, 39% of the total electricity generation came from photovoltaics. The maximum share of solar energy in the total daily energy of all electricity sources was 22.6% on 6 May. From April to August 2018, the monthly power generation of PV systems was higher than that of coal-fired power plants.

Wind energy produced around 111 TWh in 2018 and production was around 5.4% higher than in 2017. Wind energy is thus the second strongest source of energy after lignite, but ahead of hard coal and nuclear energy. In ten months, wind power generation exceeded generation from hard coal and nuclear energy. The maximum capacity generated was approx. 45.9 GW on 08.12.2018 at 12:00 noon. The share of **onshore** wind was approx. 87.4 TWh, 2 TWh more than in 2017. **Offshore** wind increased production from 17.4 TWh in 2017 to over 18.8 TWh in 2018. Approximately 16.6 TWh were generated in the **North Sea**. Offshore production in the **Baltic Sea** was approx. 2.3 TWh. At the end of November 2018, the installed capacity of onshore wind was 52.7 GW and of offshore wind 5.86 GW.

Together, solar and wind turbines produced approx. 157 TWh in 2018. This puts them ahead of lignite, hard coal and nuclear energy.

1 TWh = 1 terawatt hour = 1000 gigawatt hours (GWh) = 1 million megawatt hours (MWh) = 1 billion kilowatt hours (kWh)

Net Public Electricity Generation in 2018

Renewable Energy Sources: Hydropower and Biomass

Hydropower produced only approx. 17 TWh compared to 20 TWh in 2017, the second lowest value achieved in the last 30 years. Only in 1991, production was even lower at 14.9 TWh. From May to December 2018, monthly electricity generation was below that of the previous year.

About 44.8 TWh were produced from **biomass**. Production is exactly at the level of the previous year.

In total, the renewable energy sources solar, wind, water and biomass produced approx. **219 TWh** in 2018. This is 4.3% above the previous year's level of 210 TWh. The **share of public net electricity generation**, i.e. the electricity mix that actually comes from the socket, **was over 40%.**
The share of the total gross electricity generation including the power plants of the "companies in the manufacturing industry as well as in mining and quarrying" is approx. 35% according to BDEW.
See https://www.bdew.de

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Net Public Electricity Generation in 2018

Non-renewable Electricity Generation

Net electricity production from **nuclear power plants** amounted to 72.1 TWh and was thus at the previous year's level of 72.2 TWh.

Lignite-fired power plants produced 131.3 TWh net. This is approx. 2.7 TWh or 2% less than in 2017. The lignite-fired power plants reacted more flexibly to low exchange electricity prices than in previous years and reduce their output to below 6 GW, e.g. on January 5, 2018, May 21 2018, October 3rd 2018 and December 8 2018. The reduction occurs mainly at low or negative exchange electricity prices. However, lignite-fired power plants are still inflexible in their reaction to the high feed-in of renewable energies.

Net production from **hard coal-fired power plants** amounted to 75.7 TWh. It was 6 TWh or 7.4% lower than in 2017, when 81.7 TWh were produced net.

Gas-fired power plants produced 40 TWh net for the public electricity supply. They were thus 9.1 TWh or 18.5% below the level of the previous year. In addition to the power plants for public electricity supply, there are also gas-fired power plants in the mining and manufacturing industries for the company's own electricity supply. These also produced an additional 20 to 25 TWh for **industrial own consumption**, which is not included in this publication.

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Net Public Electricity Generation in 2018

Export Surplus

In 2018, an **export surplus (physical flows)** of approx. 45.6 TWh was achieved. This is a slight decline compared to 2017, when the export surplus was 52.5 TWh. The majority of exports went to the Netherlands (19.2 TWh), which transmits a large part of its electricity to Belgium and the UK. Austria ranked second with 11.6 TWh. Switzerland received 11.5 TWh, which was mainly forwarded to Italy. Poland ranks fourth with 7 TWh, which transports part of the electricity from eastern Germany via the Czech Republic to southern Germany.
Germany imported 8.3 TWh of electricity from France, which is mainly forwarded to neighboring countries. The average exported capacity was approx. 5.2 GW. This corresponds to the output of four nuclear power plants. During 7927 hours of the year (90,5%) electricity was exported and during 833 hours (9,5%) electricity was imported.

In **foreign trade** with electricity, 26.4 TWh were imported at a value of 1.12 billion euros from January to October. Exports amounted to 64.8 TWh and a value of 2.5 billion euros. On balance, there was an **export surplus of 38.5 TWh** and income worth 1.38 billion euros. Imported electricity costs on average 42.39 Euro/MWh and exported electricity 38.60 Euro/MWh.

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Net Public Electricity Generation in 2018

Load, Exchange Electricity Prices and Market Value

The **load** was 508.5 TWh. This is approx. 3.1% more than in 2017.
The load includes the electricity consumption and grid losses, but not the pump electricity consumption and the own consumption of conventional power plants.

The average volume-weighted day-ahead electricity price was 43.26 Euro/MWh. This is 28% more than in 2017.
The average volume-weighted hourly intraday electricity price was 45.60 Euro/MWh, 29% more than in 2017.

The market value of wind power was 38.14 Euros/MWh or 88.2%. Solar power had a market value of 43.87 Euro/MWh or 101.4%.

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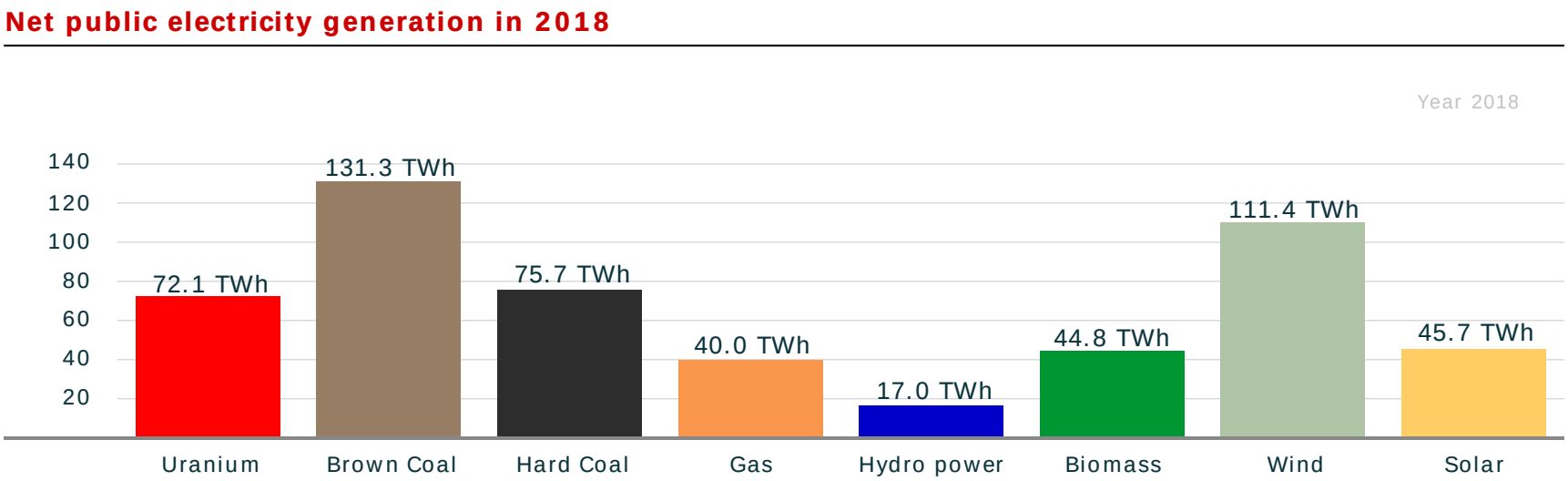
Net public electricity generation
2018



The chart shows the net electricity generation from power plants for the public power supply. Generation from power plants in the manufacturing, mining and quarrying industries, i.e. the self-generation of electricity in industry, is not included.

Graph: B. Burger, Fraunhofer ISE; Data: DESTATIS and Leipzig electricity exchange EEX, energetically corrected values

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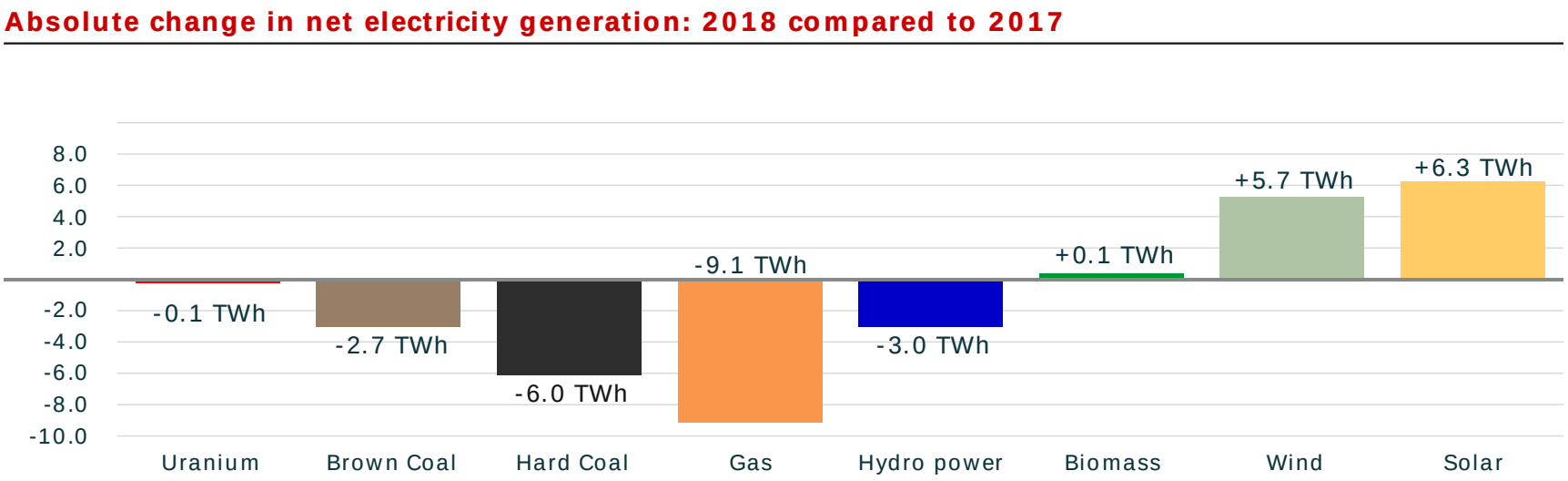
Absolute change in net electricity generation
2018 compared to 2017



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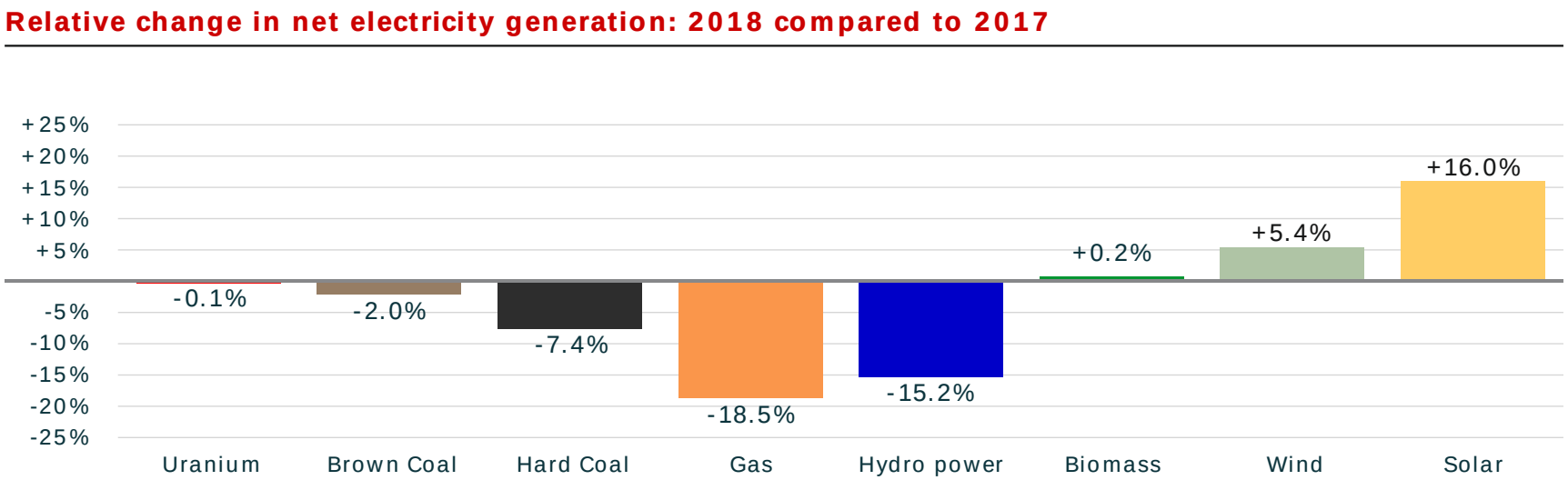
Relative change in net electricity generation
2018 compared to 2017



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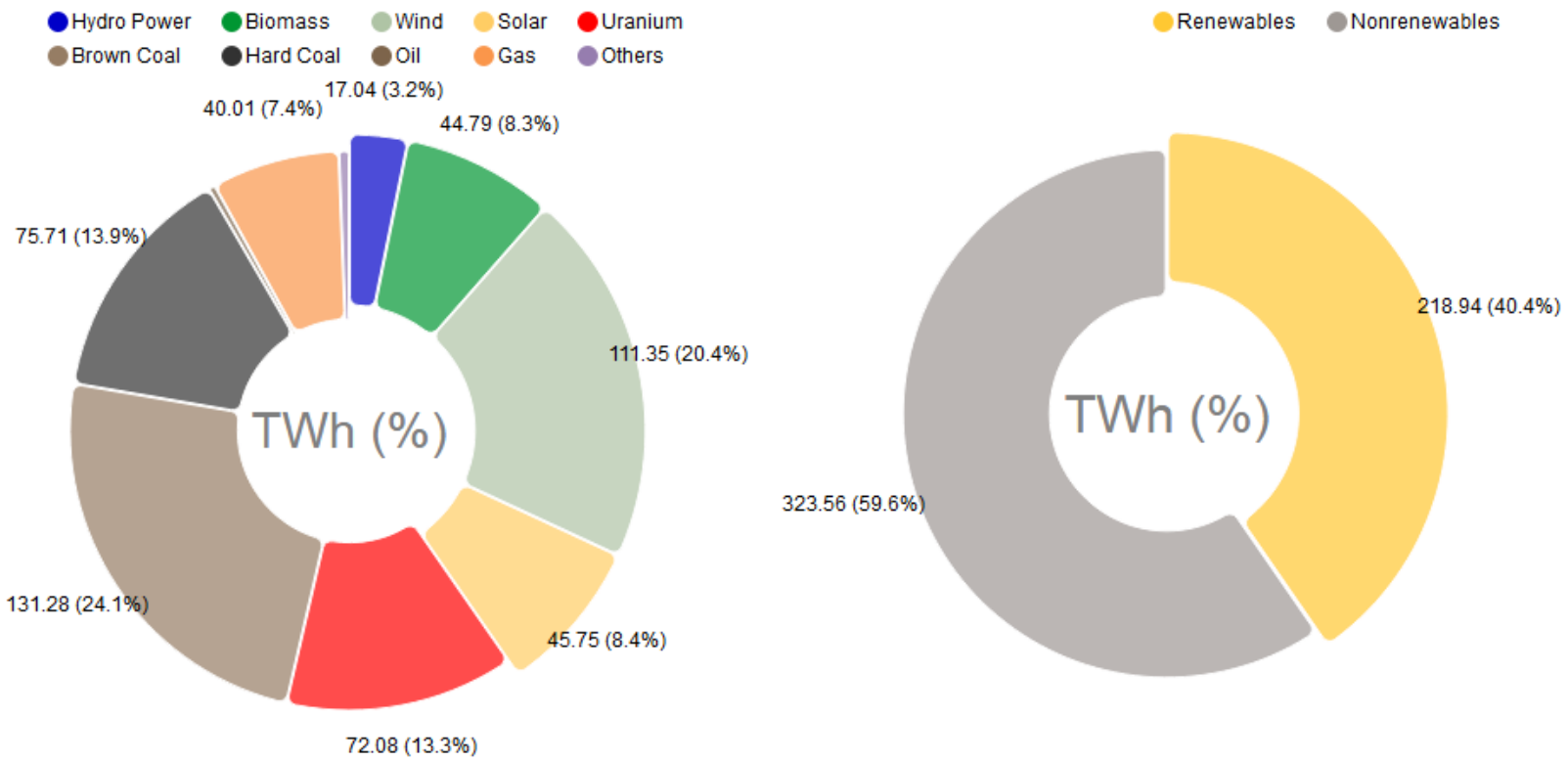
Net public electricity generation
2018



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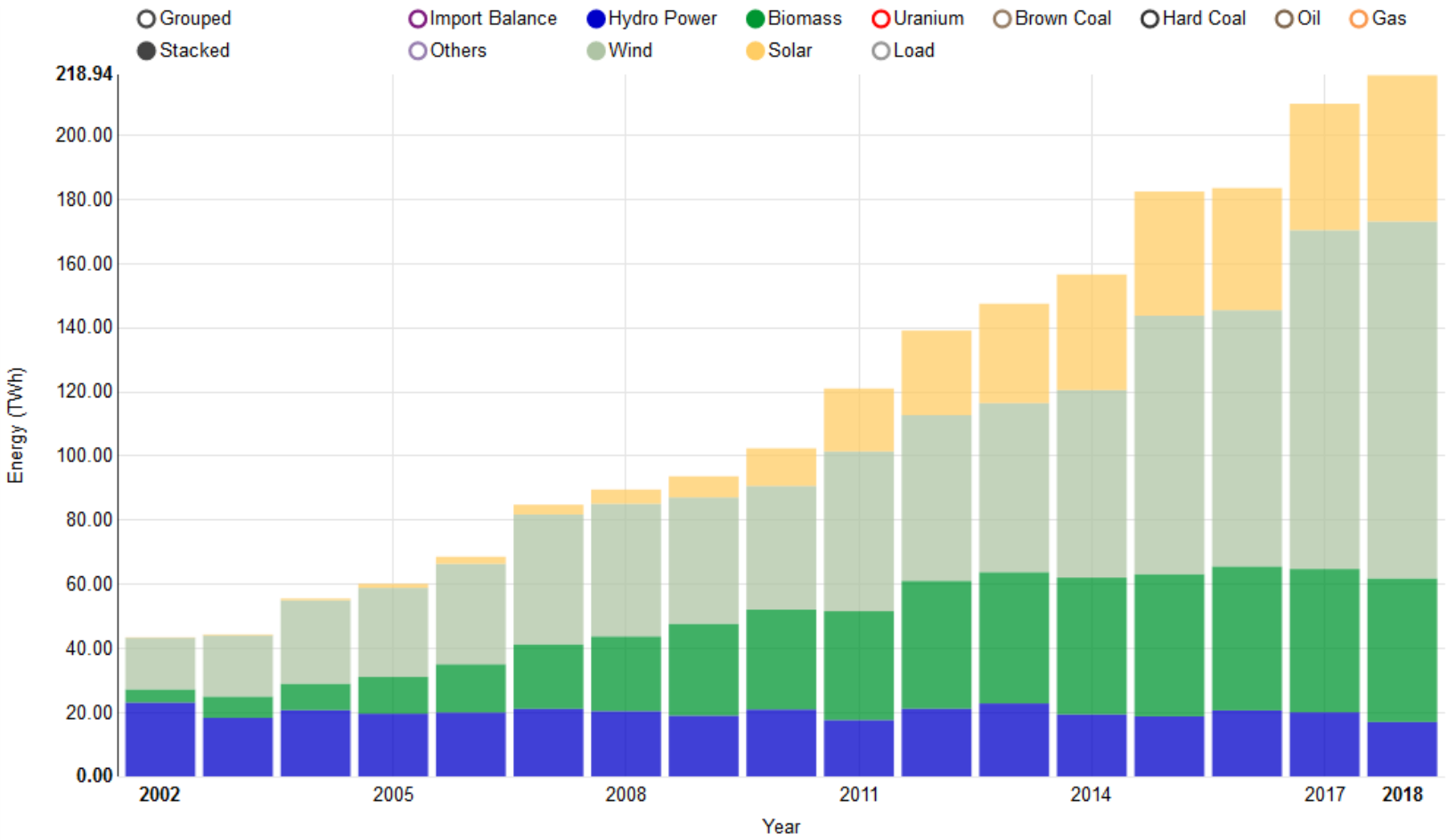
Graph: B. Burger, Fraunhofer ISE; Source: https://www.energy-charts.de/energy_pie.htm?year=2018

Net electricity generation from renewable energies
2002 - 2018



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

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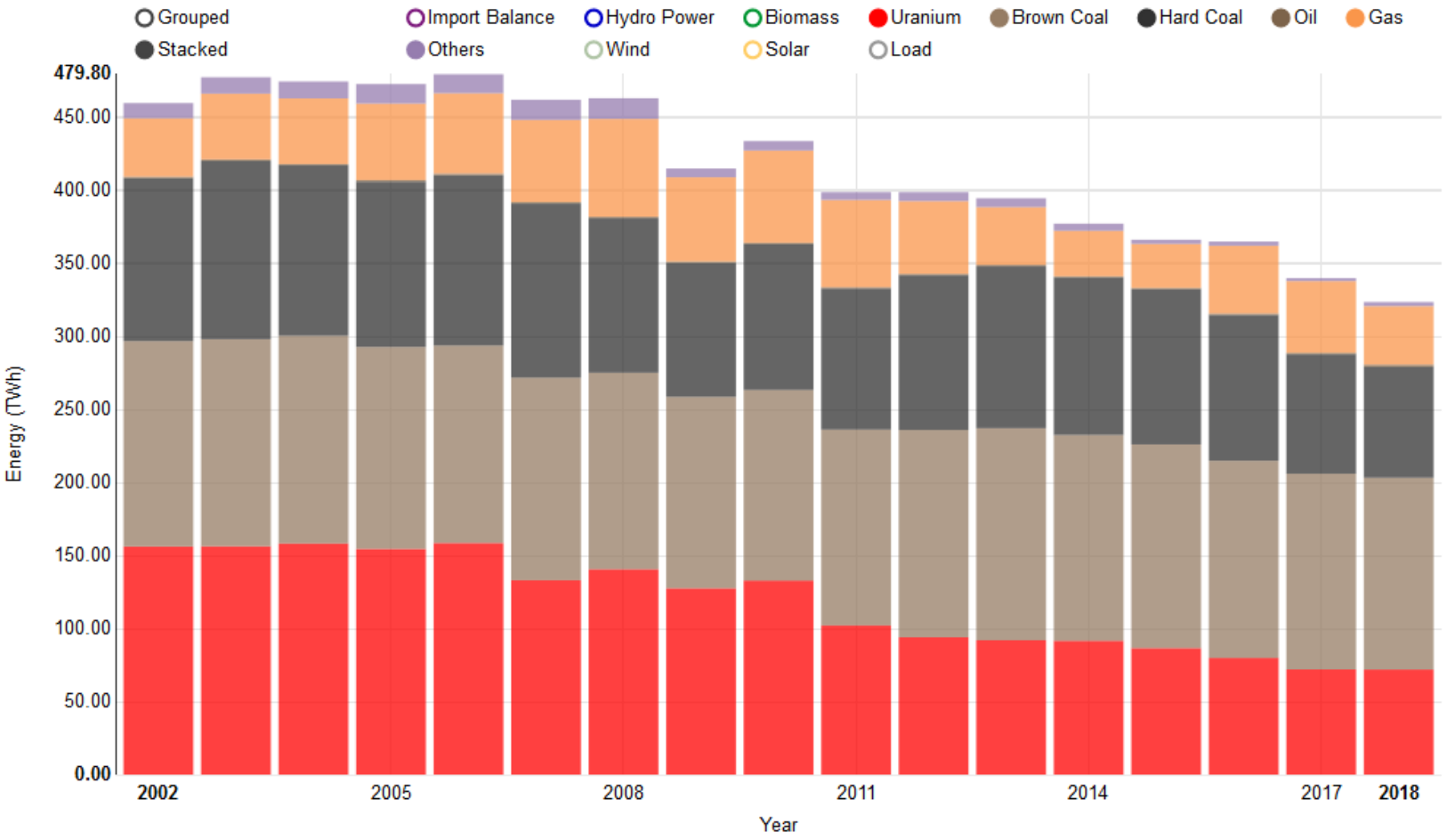
Net electricity generation from conventional sources
2002 - 2018



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

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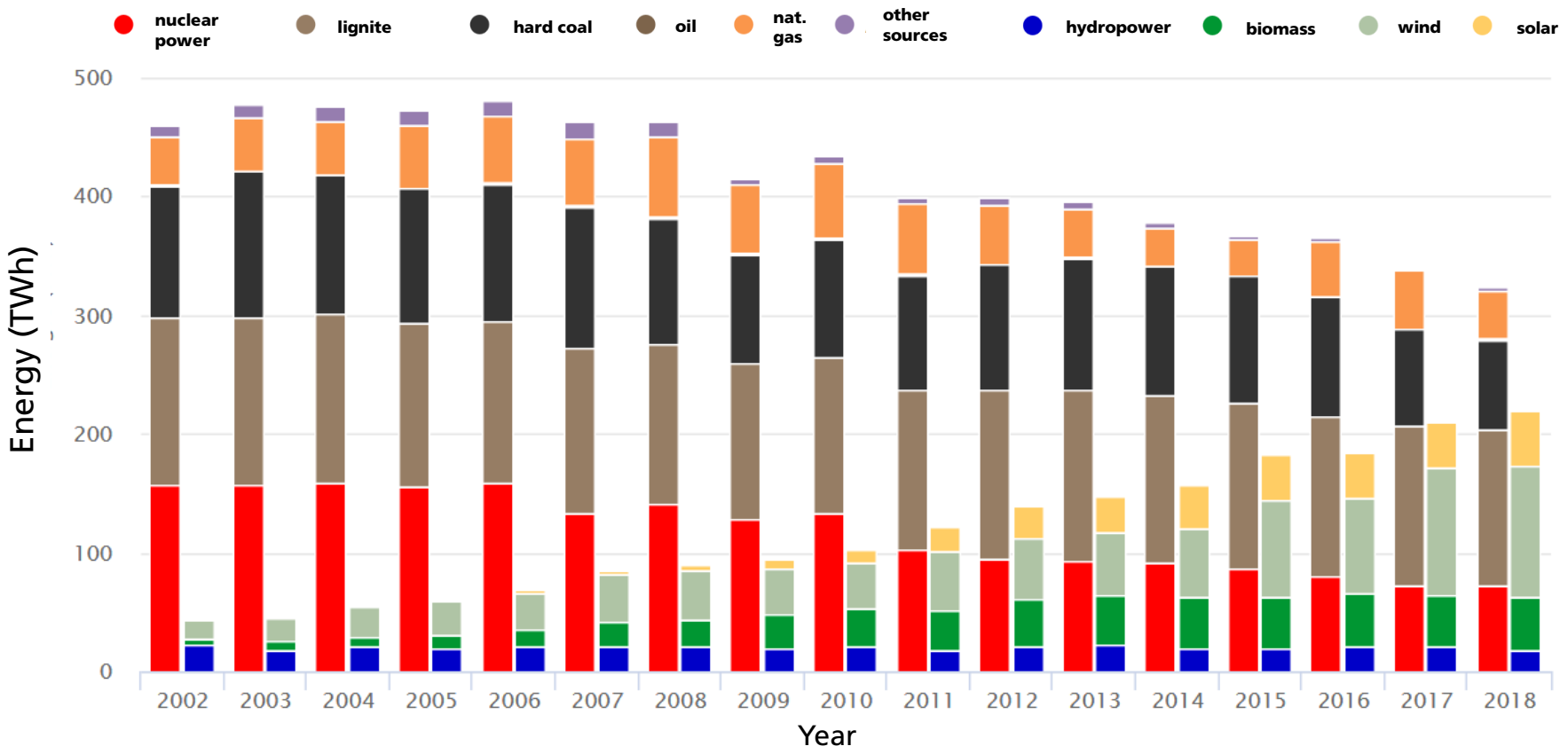
Net electricity generation from conventional and renewable sources

2002 - 2018



Graph: Oliver Blanck; Source: https://www.energy-charts.de/energy_de.htm

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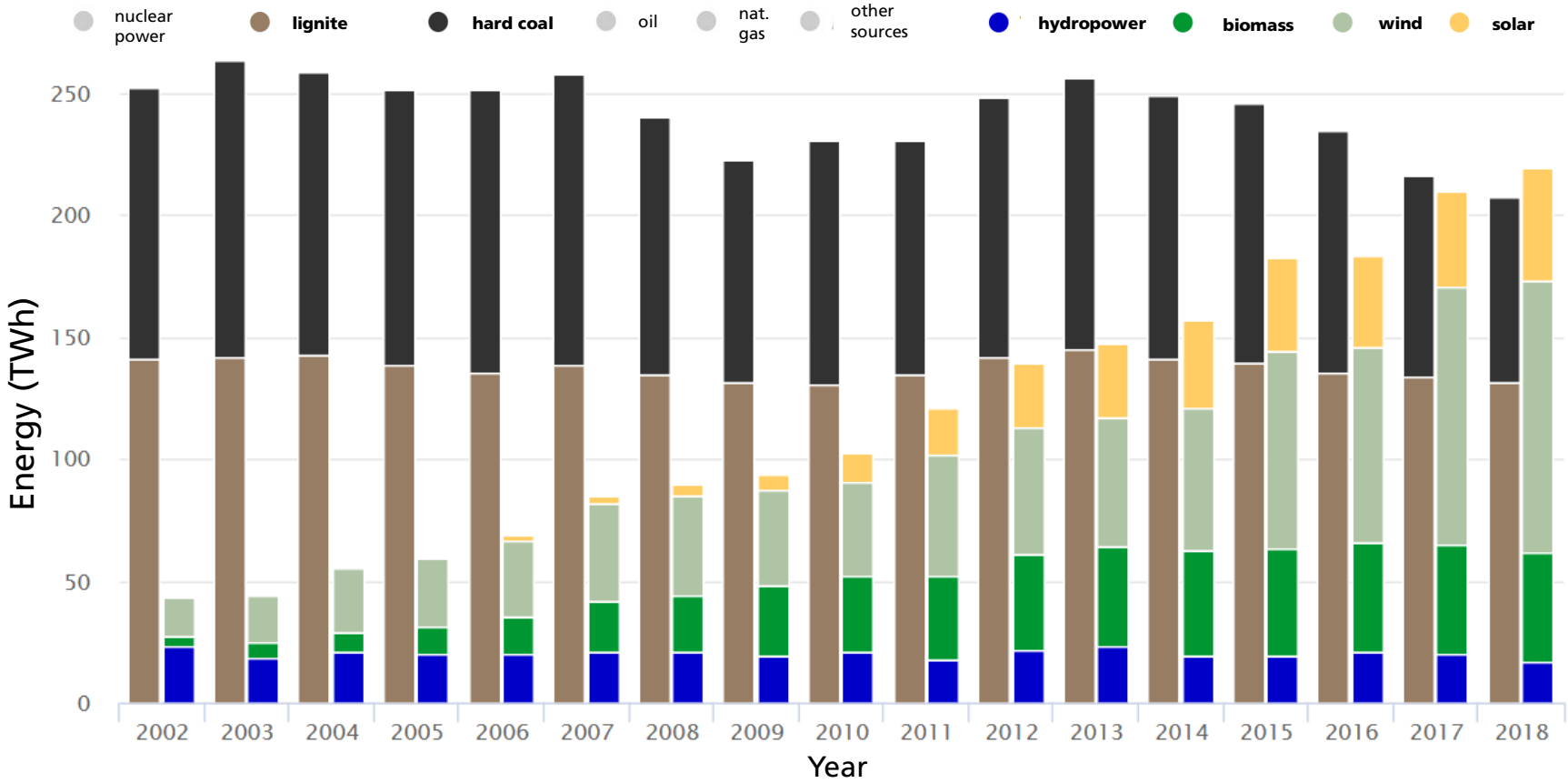
Net electricity generation from coal and renewable sources

2002 - 2018



For the first time, in 2018 renewable power generation was greater than lignite and hard coal power generation.

Graph: B. Burger; Source: https://www.energy-charts.de/energy_de.htm

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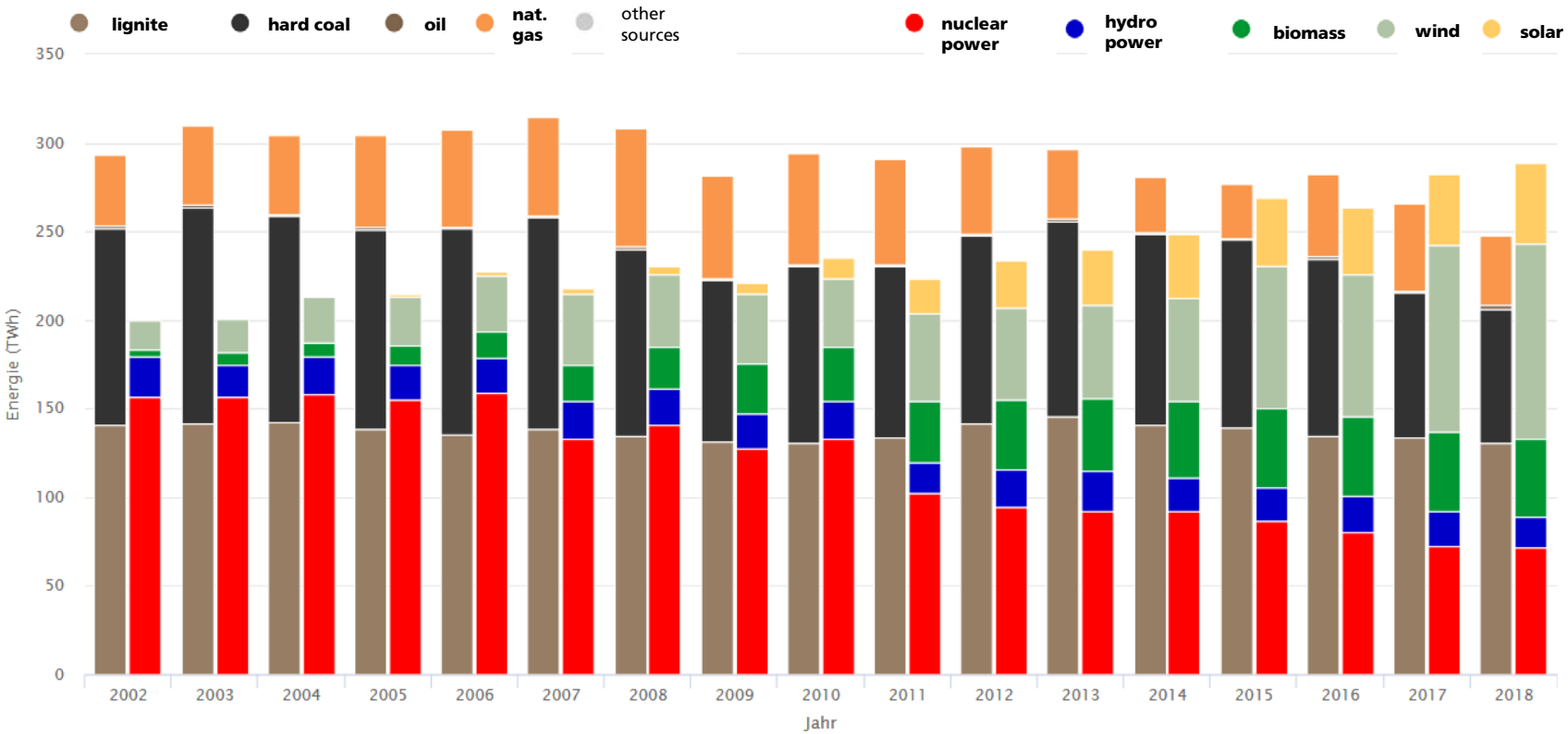
Net electricity generation from CO2-emitting and CO2-free sources

2002 - 2018



Die CO2-freie Stromerzeugung war 2017 erstmals größer als die CO2-emittierende Stromerzeugung.

Grafik: B. Burger; Quelle: https://www.energy-charts.de/energy_de.htm

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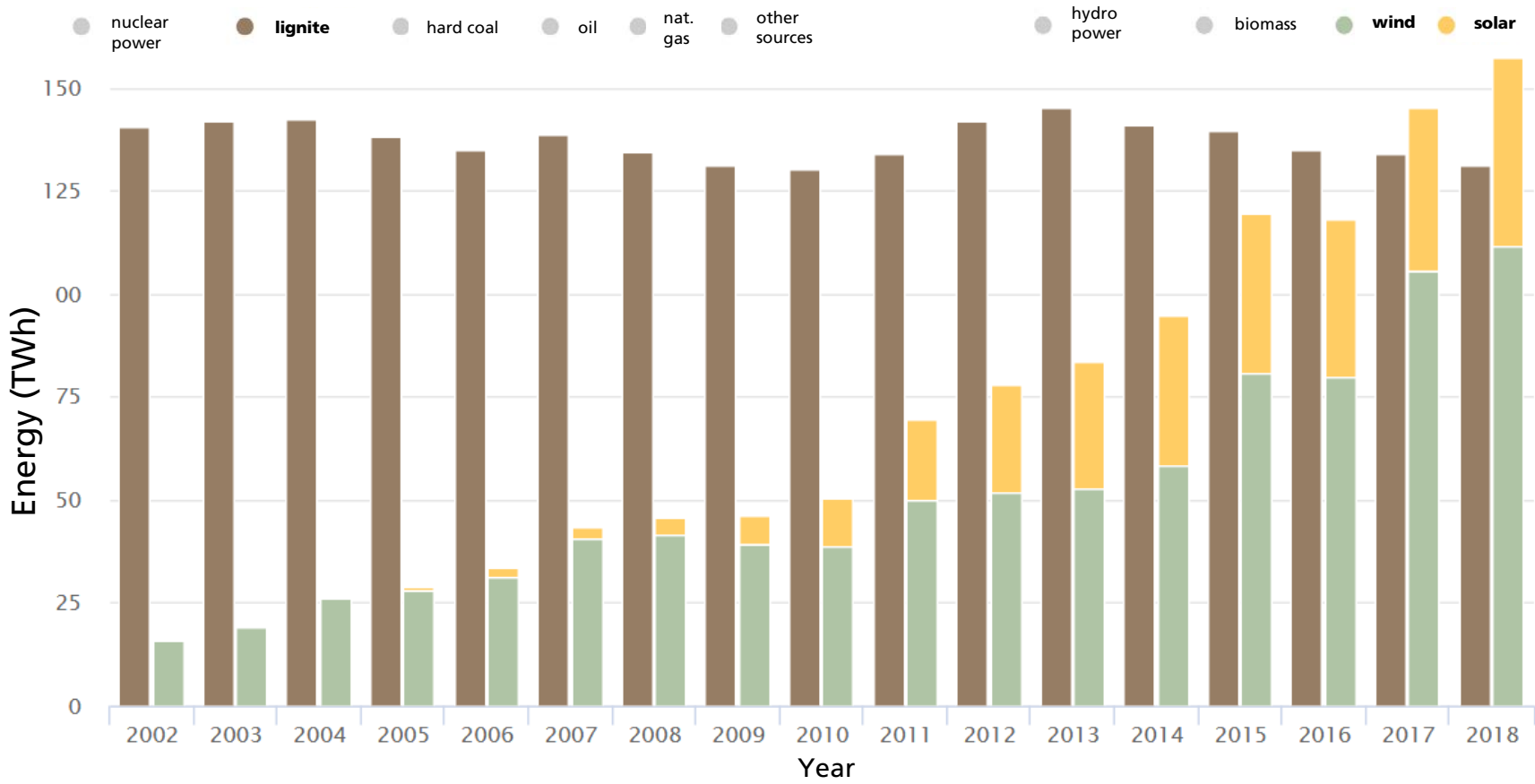
Net electricity generation from lignite and solar plus wind

2002 - 2018



The total of solar and wind power generation was higher than lignite generation for the first time in 2017.

Graph: B. Burger; Source: https://www.energy-charts.de/energy_de.htm

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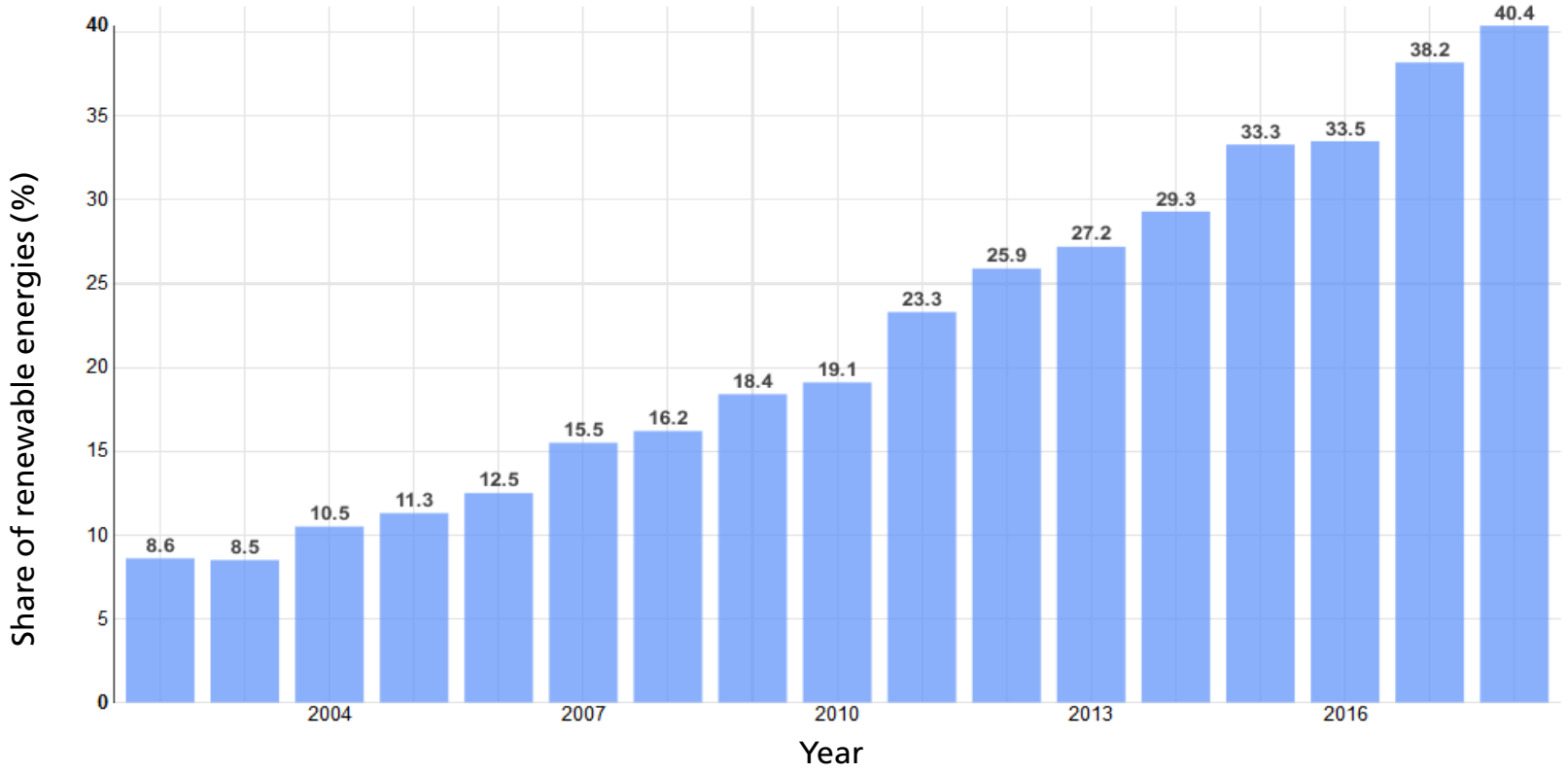
Share of renewable energies in net public electricity generation, 2002 - 2018



The chart shows the net electricity generation from power plants for the public power supply. Generation from power plants in the manufacturing, mining and quarrying industries, i.e. the self-generation of electricity in industry, is not included.

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

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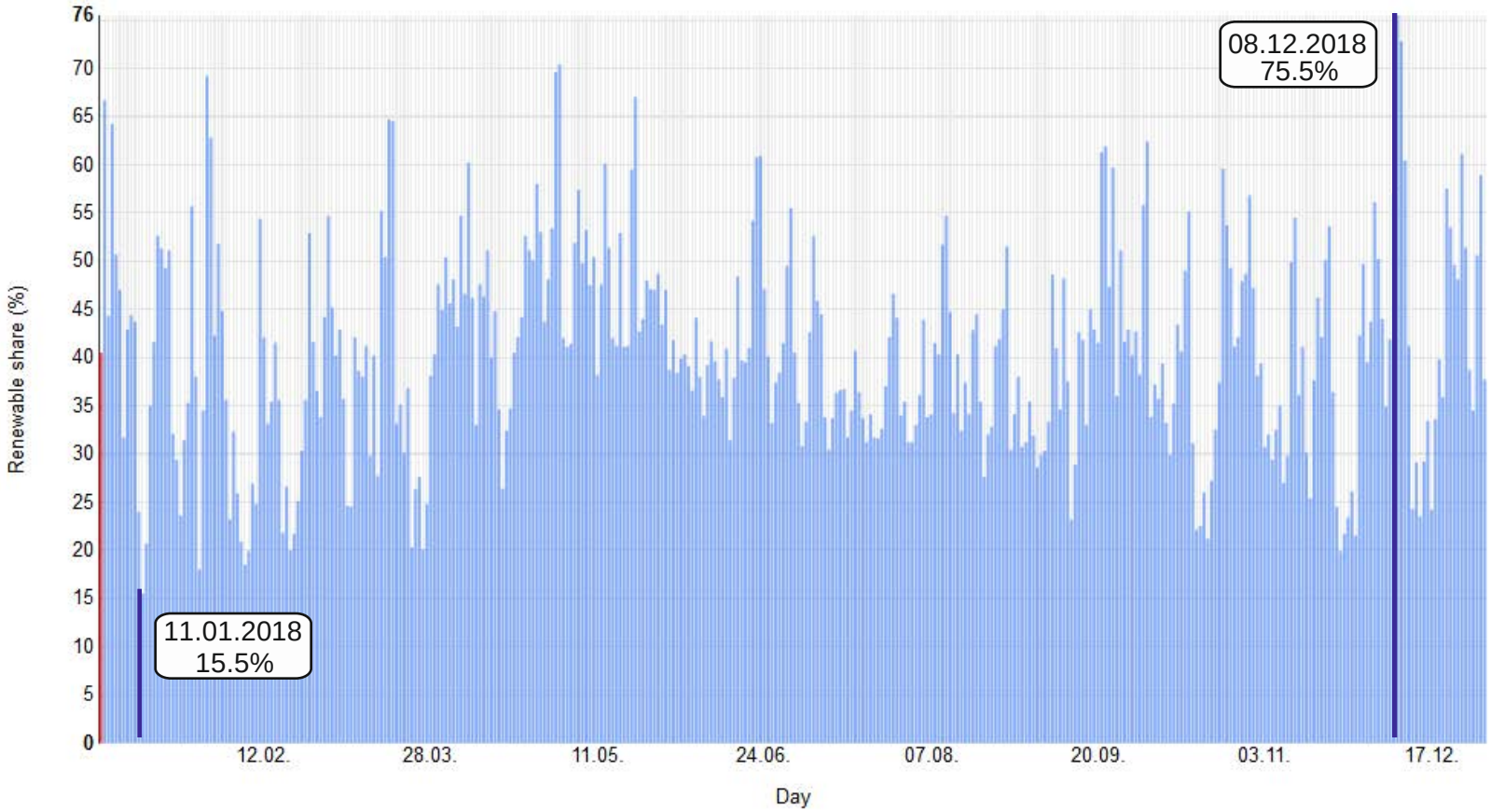
Daily share of renewable energies in net public electricity generation, 2018



The daily share of renewable energies in net electricity generation in 2018 was between 15.5% on 11.01.2018 and 75.5% on 08.12.2018.

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

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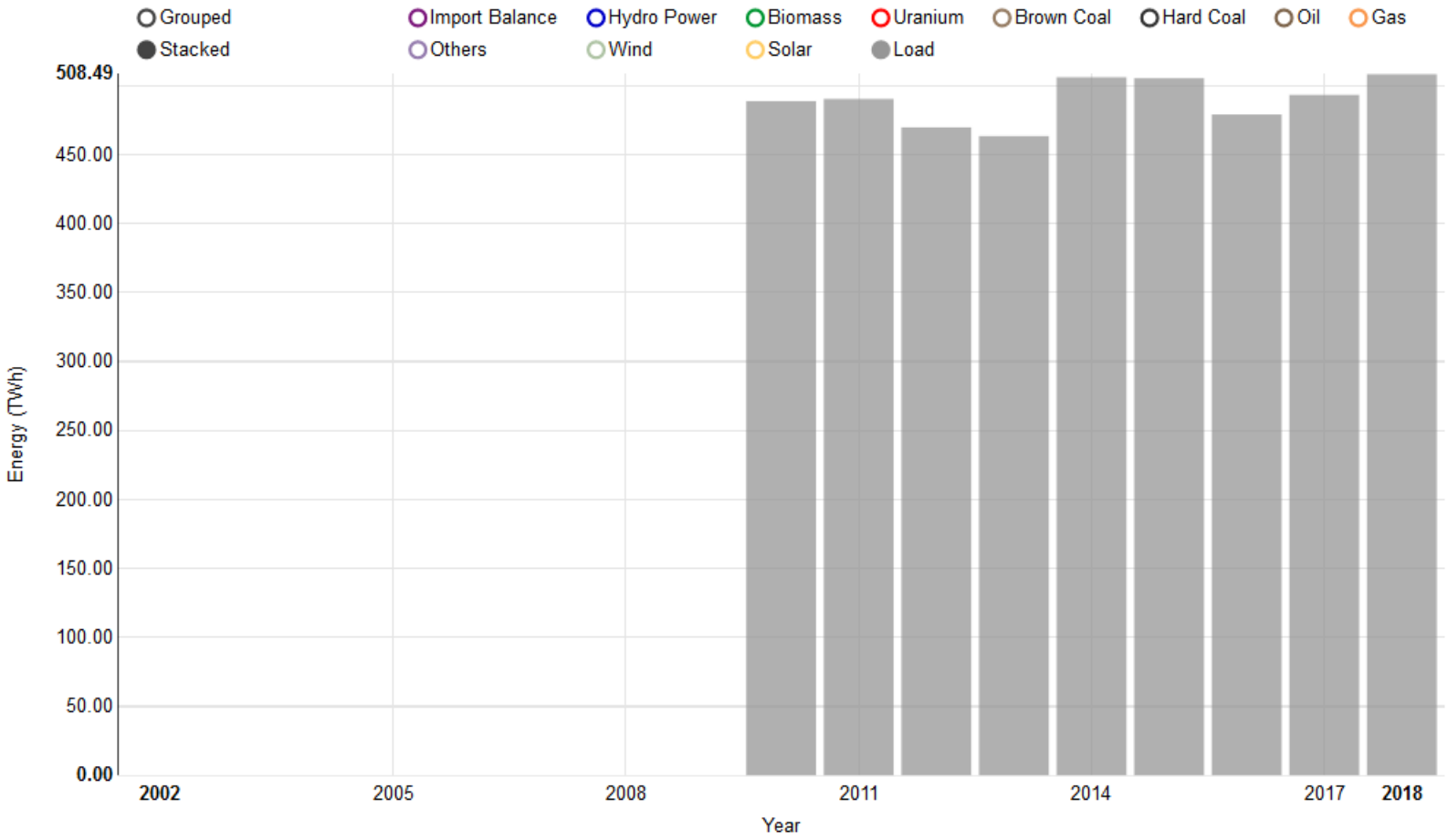
Load

2010 - 2018



The load includes the electricity consumption and grid losses, but not the pump electricity consumption and the own consumption of conventional power plants.

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

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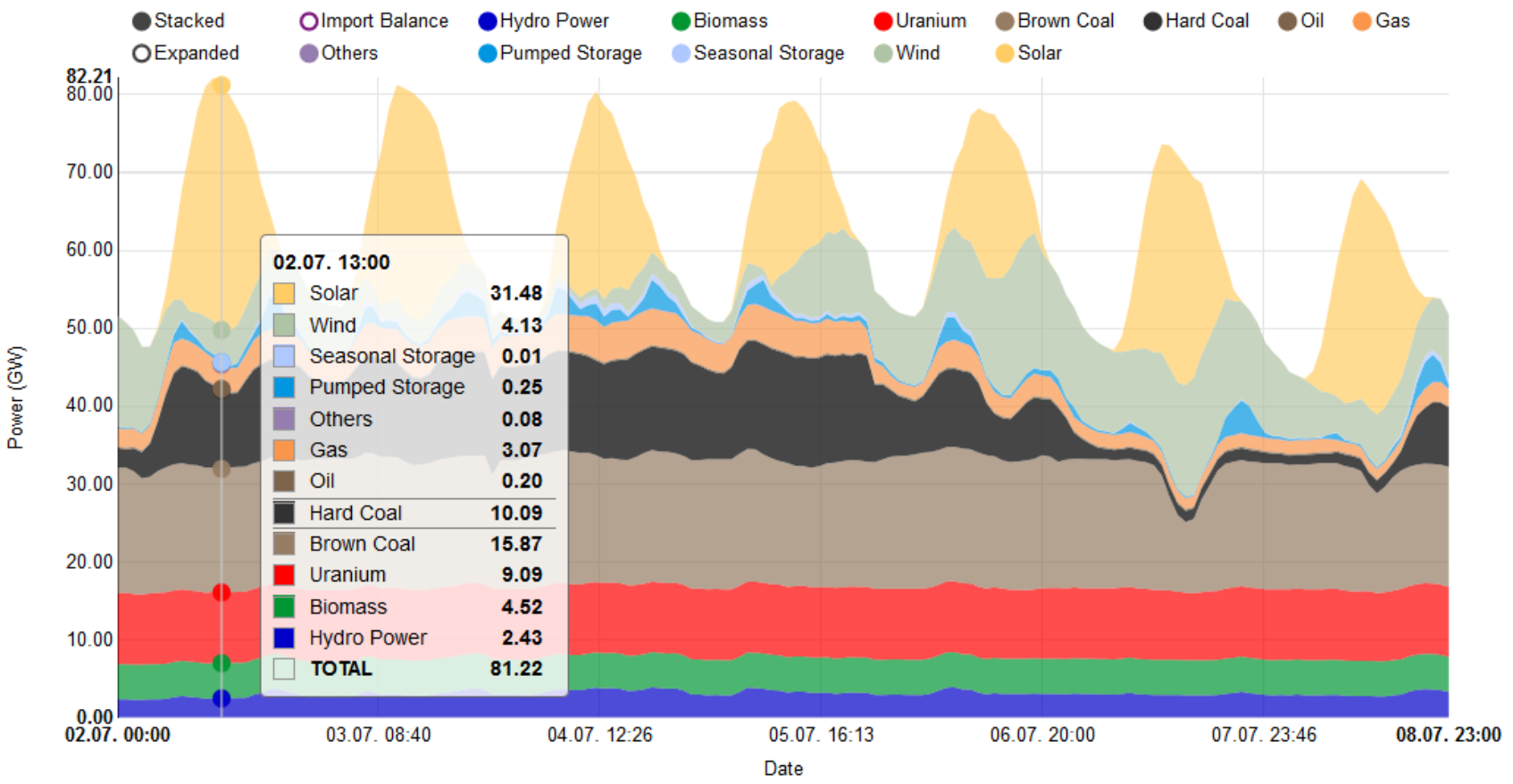
Highest power generation from solar energy
Week 27 2018



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

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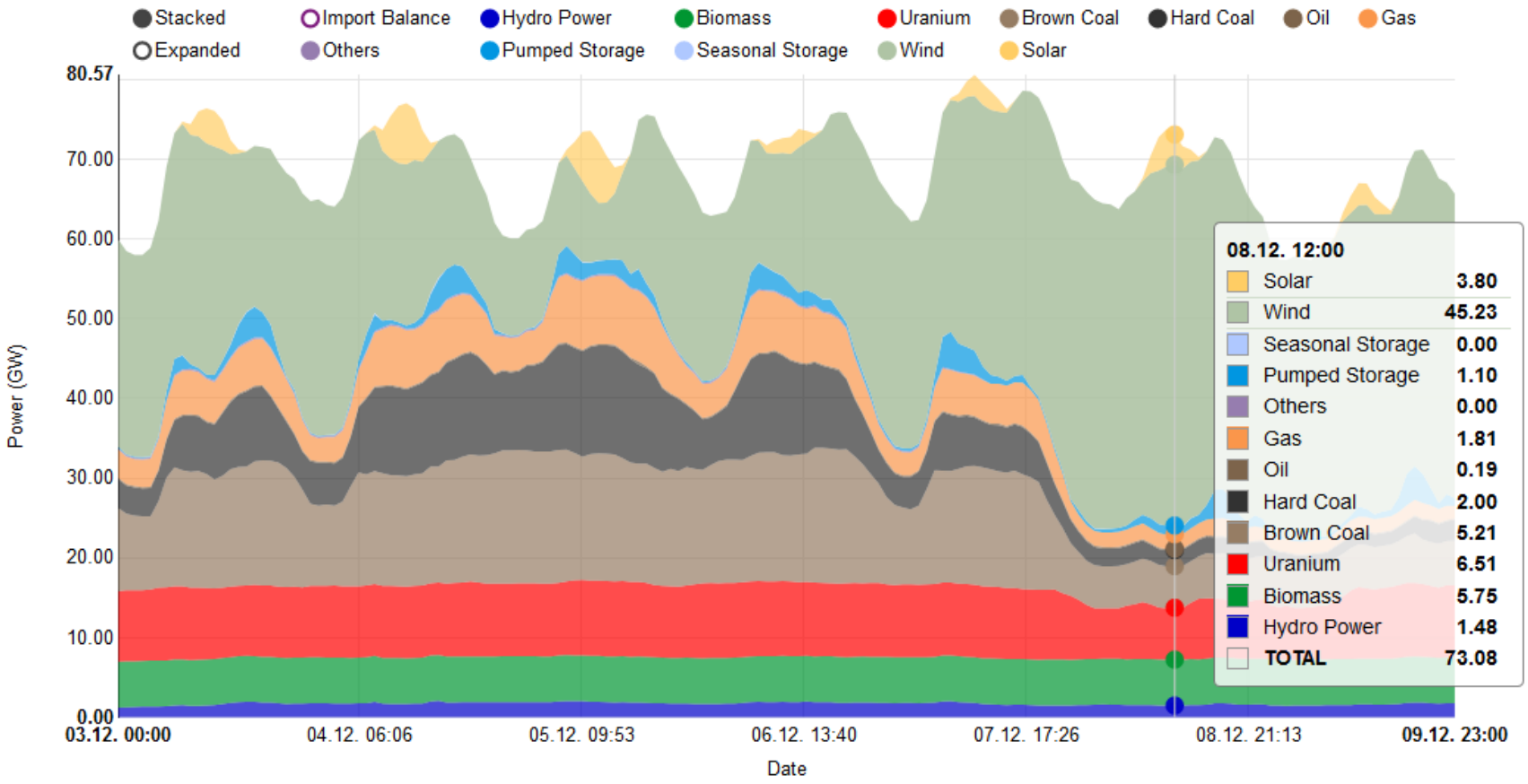
Highest power generation from wind energy
Week 49 2018



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

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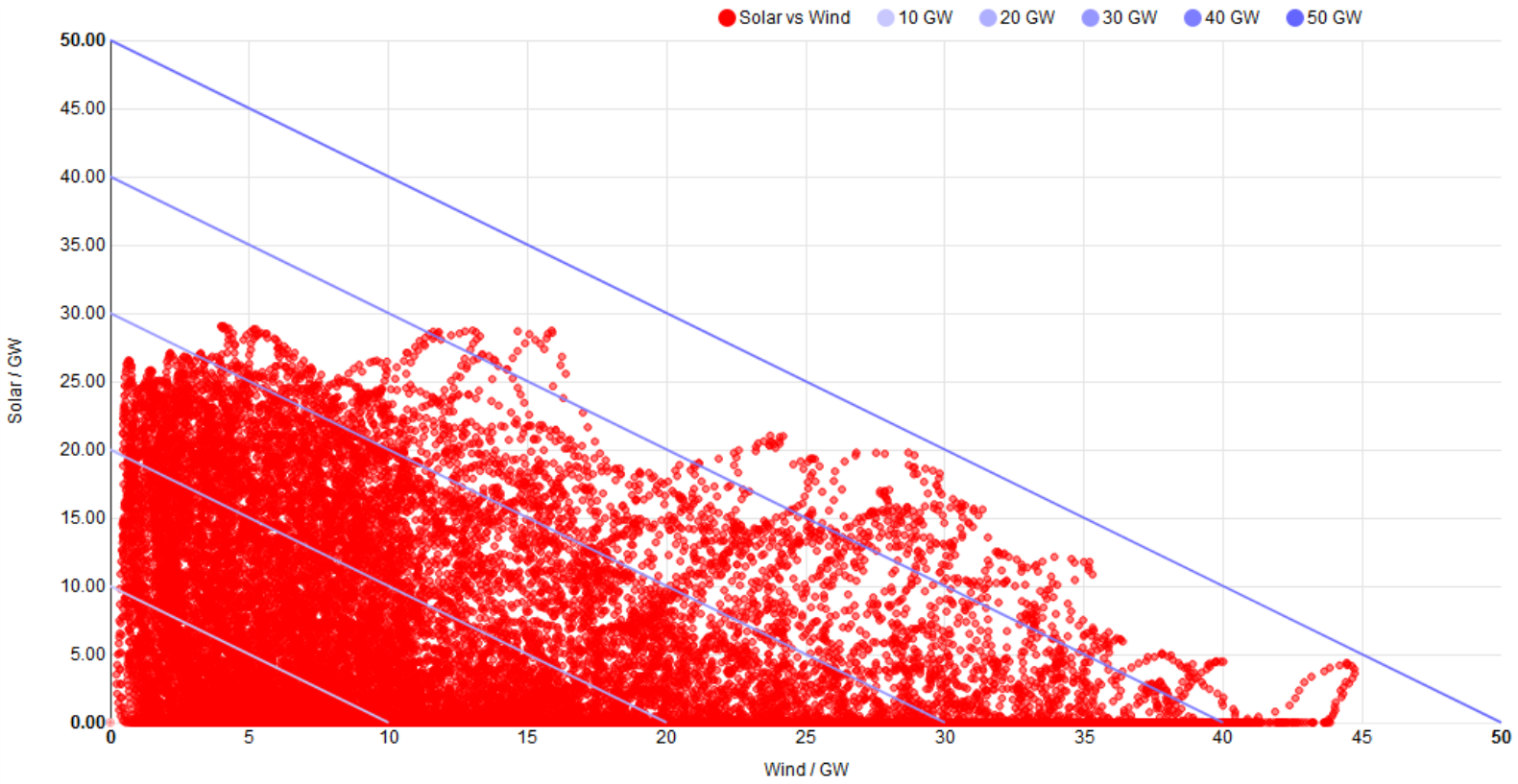
Scatter diagram for solar and wind power

Quarter-hour values from 2018



The graph shows approx. 35 thousand quarter-hour values of the solar output over the wind output in 2018. The maximum sum of solar and wind output was 53.3 GW on June 21 2018. 20.4 GW of this was attributable to solar and 32.9 GW to wind. This is only 53% of the installed capacity of 98 GW (43 GW Solar and 55 GW Wind).

Graph: B. Burger, Fraunhofer ISE; Source: https://www.energy-charts.de/scatter_de.htm?source=solarVSWind

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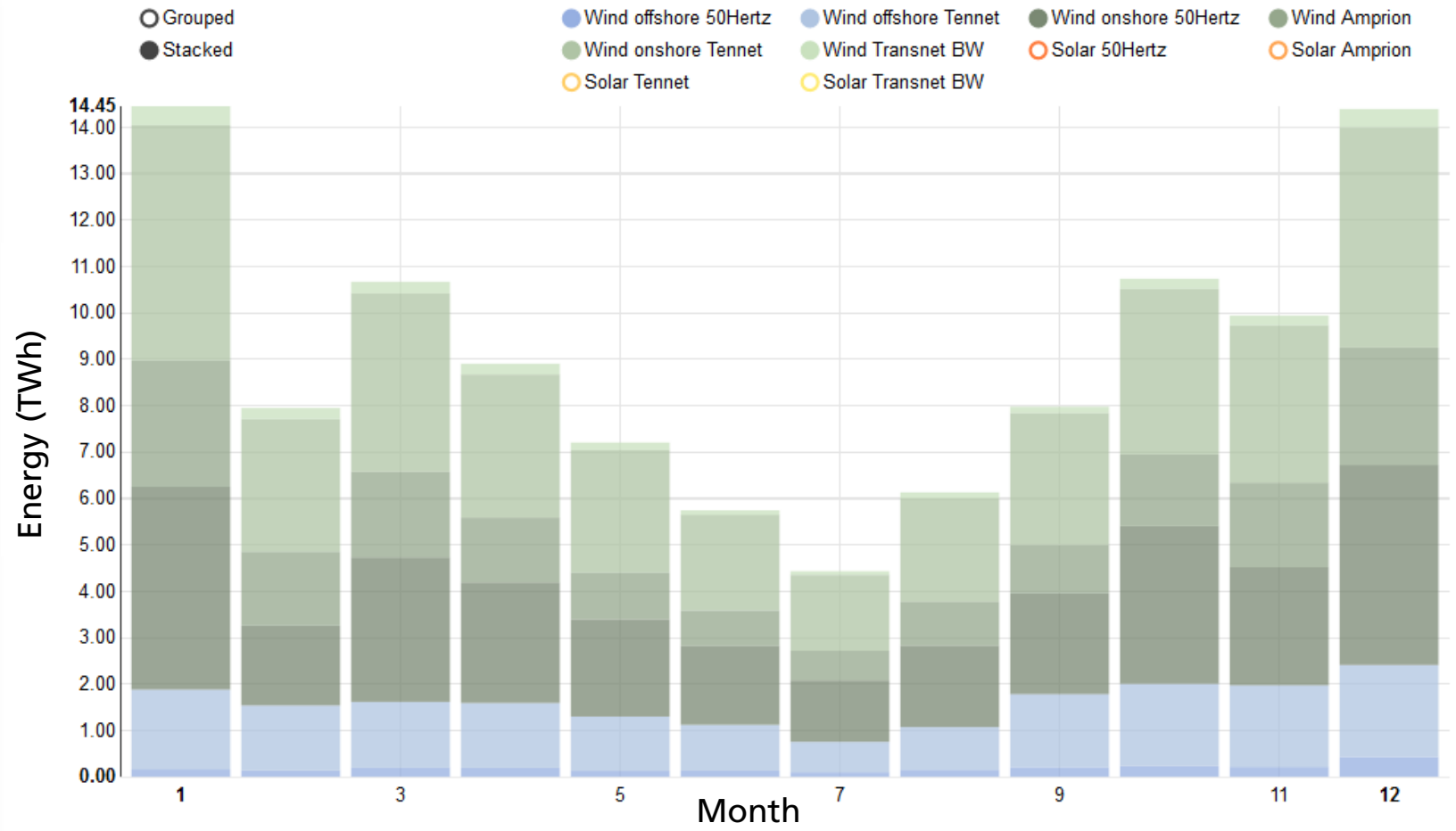
Monthly wind power generation
2018



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

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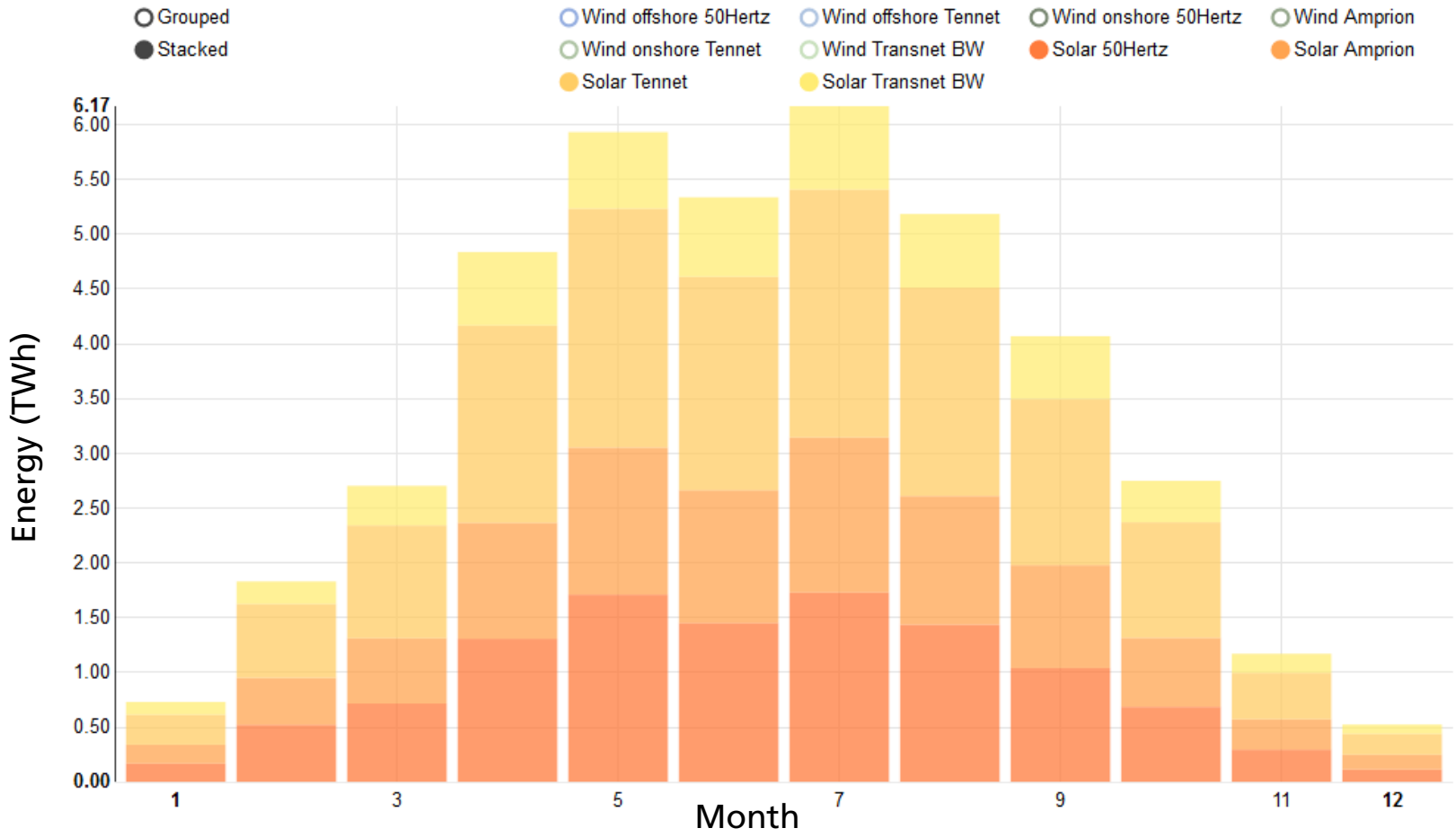
Monthly solar power generation
2018



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

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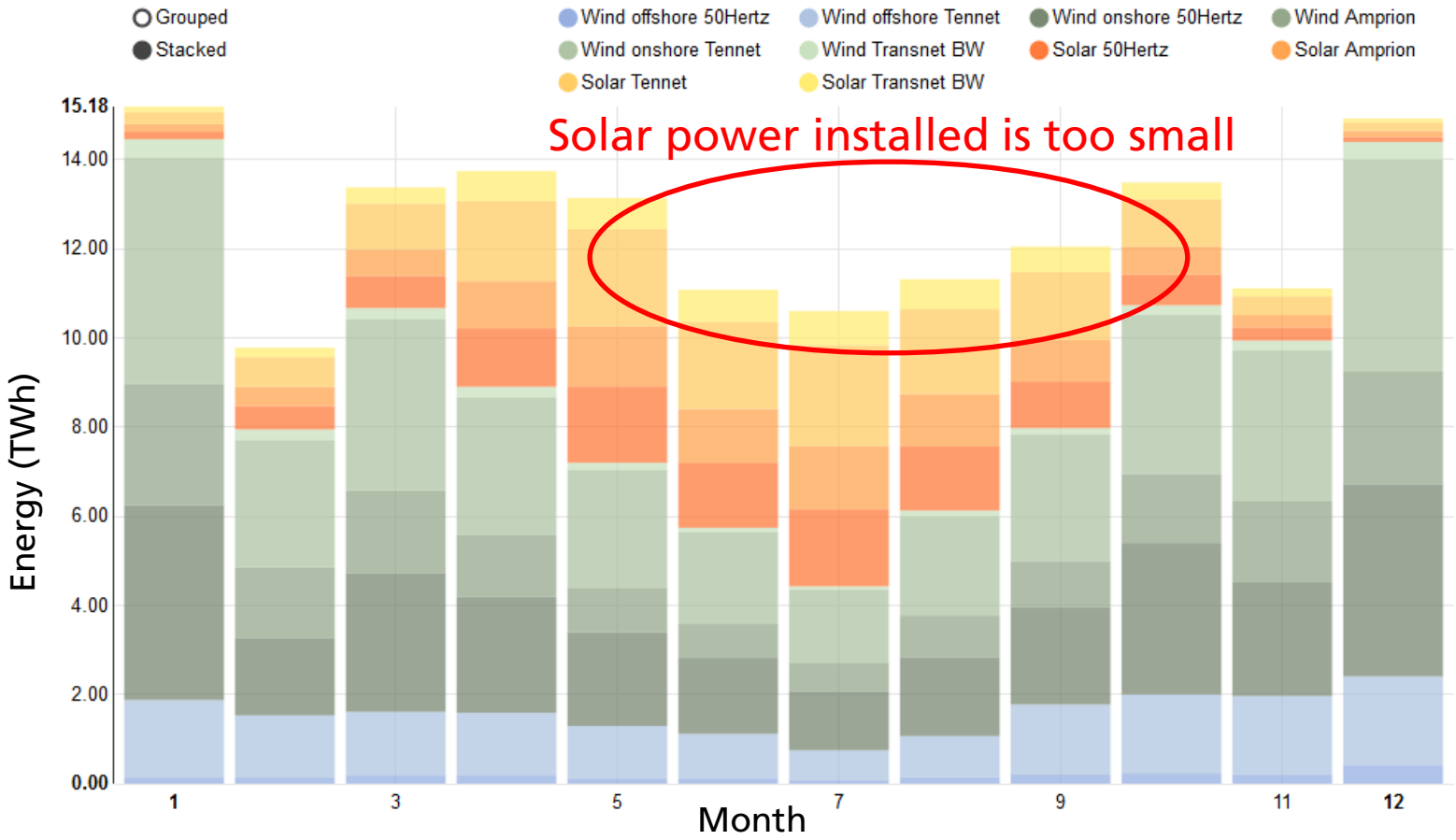
Monthly wind and solar power generation
2018



Despite high irradiation values in summer, solar power generation was too small to compensate for the collapse of the wind generation. The installed solar capacity is too small in relation to the installed wind capacity.
Graph: B. Burger, Fraunhofer ISE; Source: https://www.energy-charts.de/energy_de.htm?source=solar-wind

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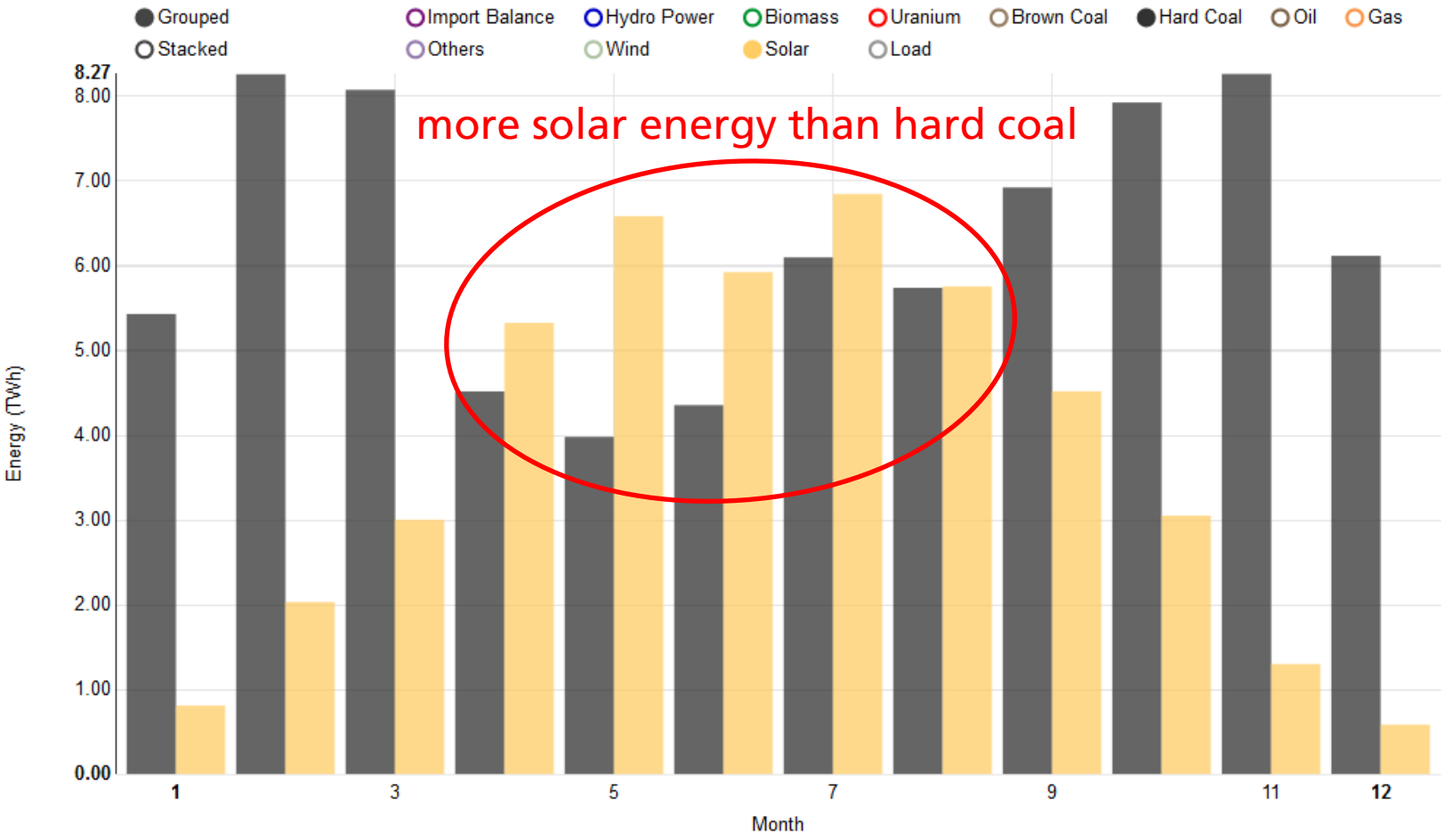
Monthly power generation: Solar energy and hard coal
2018



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

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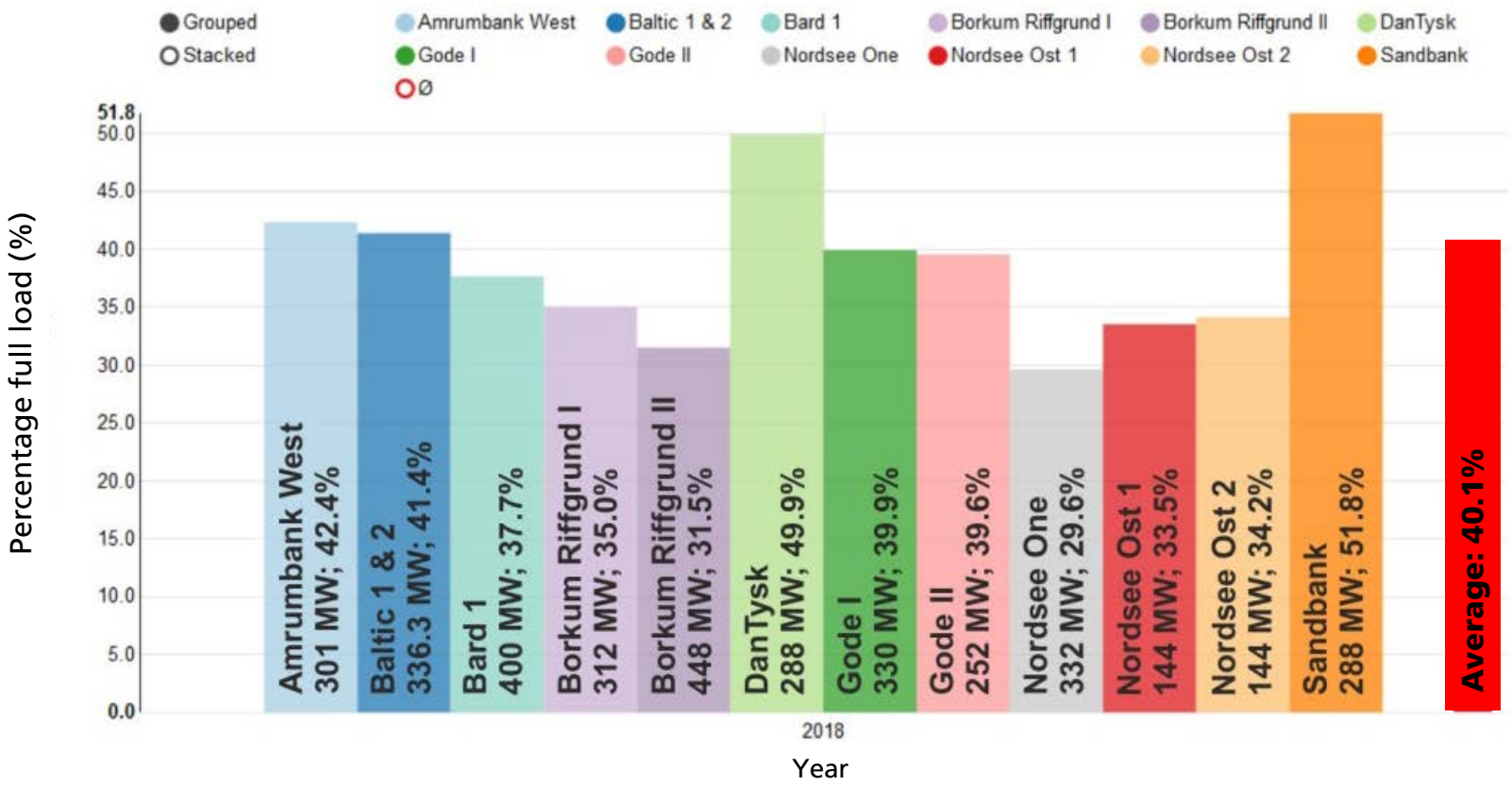
Percentage full load hours of wind offshore
2018



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

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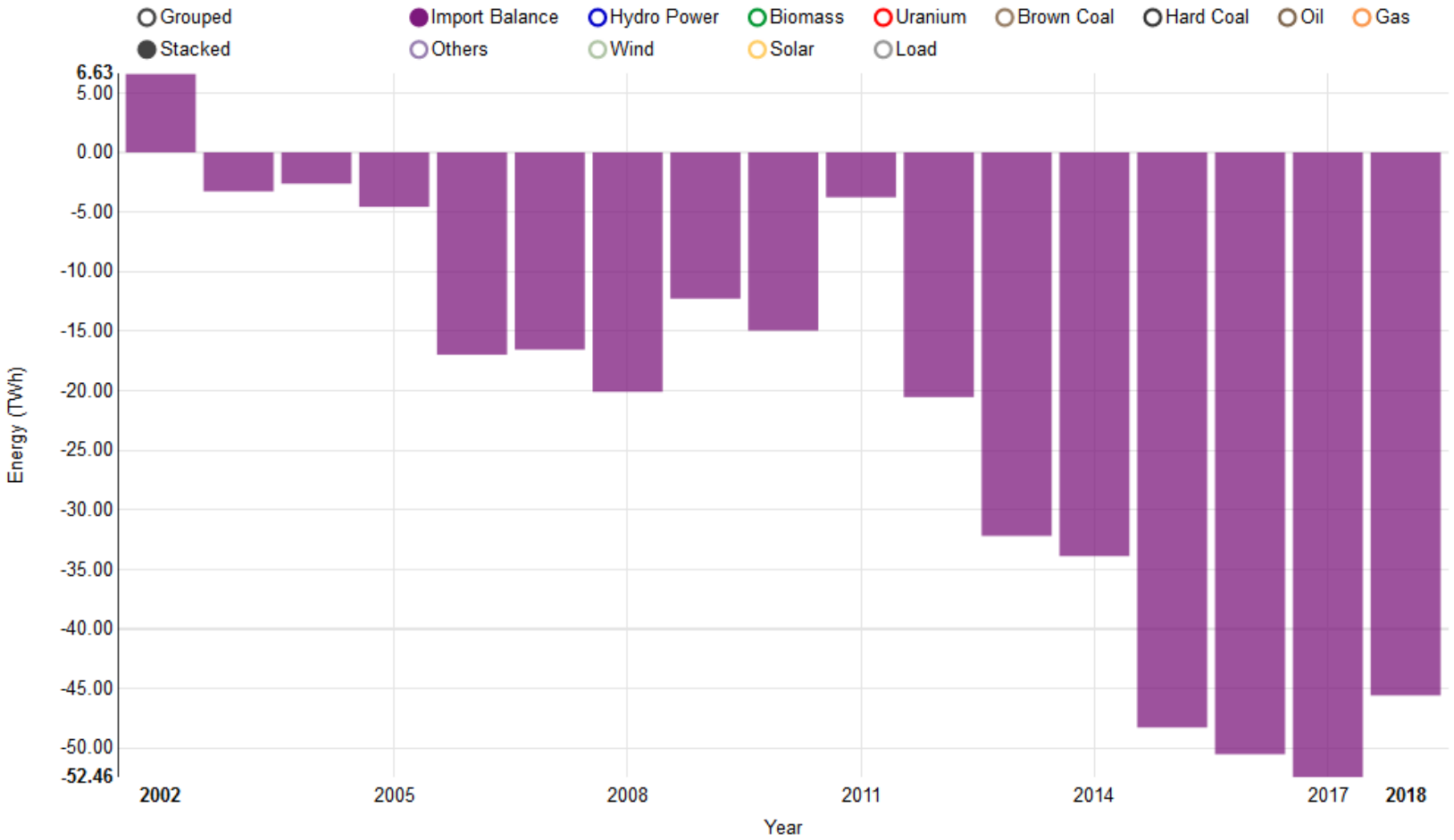
Electricity exchange balance

2002 - 2018



Positive values mean import. Negative values mean export.
Graph: B. Burger, Fraunhofer ISE; Source: https://www.energy-charts.de/energy_de.htm?source=conventional

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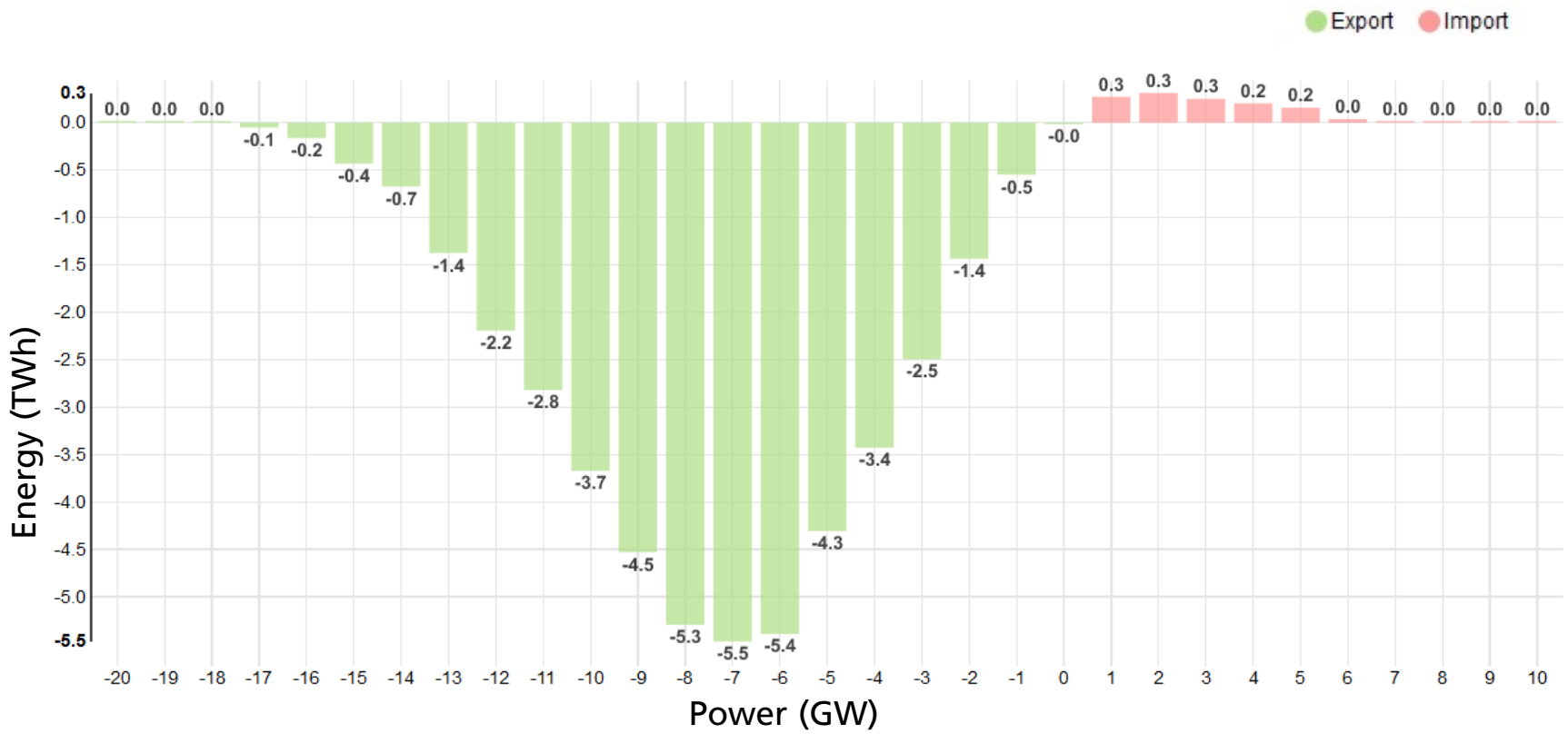
Electricity import and export, histogram
2018



Physikalische Flüsse. Positive Werte bedeuten Import. Negative Werte bedeuten Export.
Während 7927 Stunden des Jahres (90,5% der Zeit) wurde Strom exportiert und während 833 Stunden (9,5% der Zeit) wurde Strom importiert.

Grafik: B. Burger, Fraunhofer ISE

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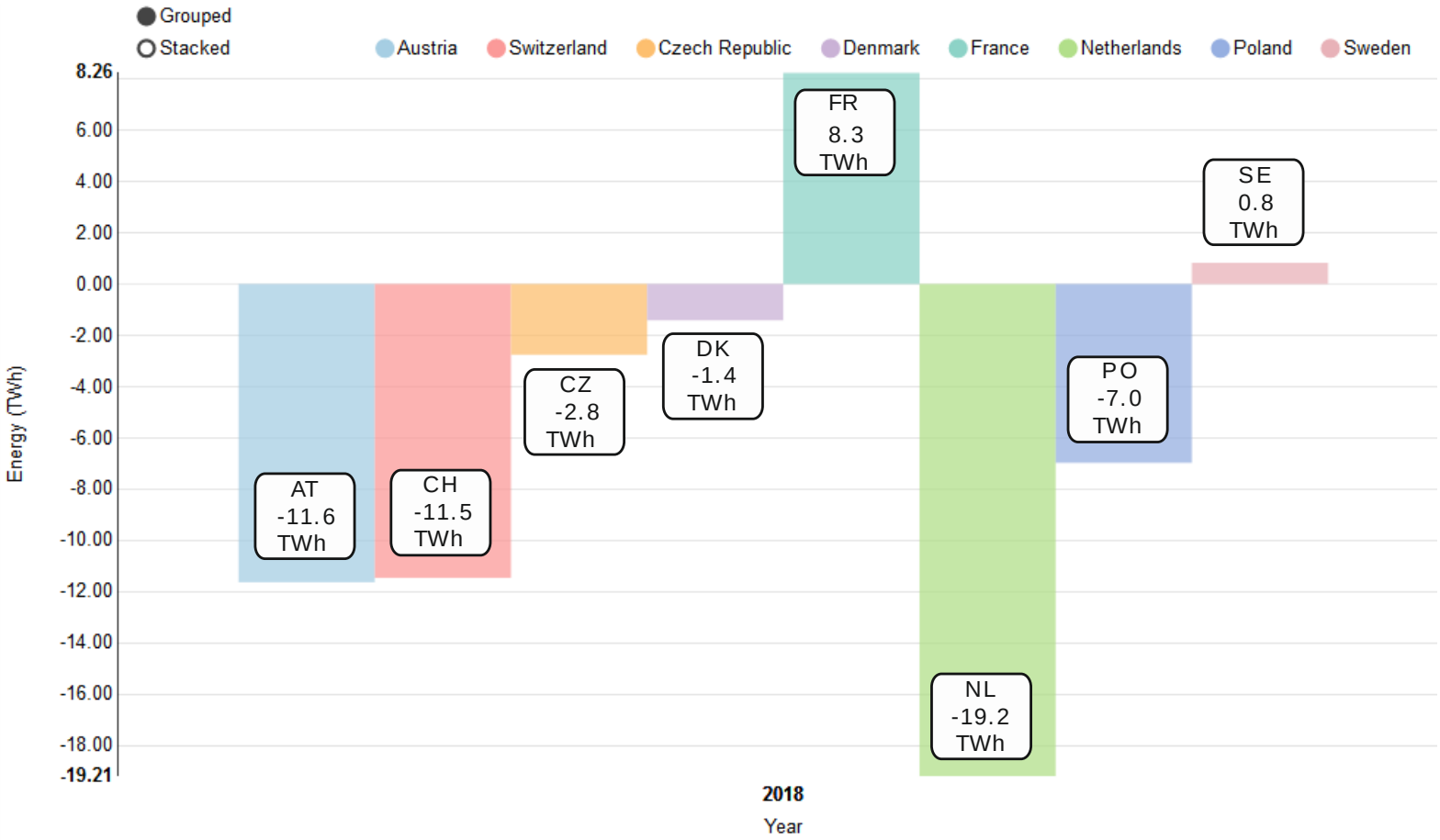
German power import / export
2018



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
January to October 2018

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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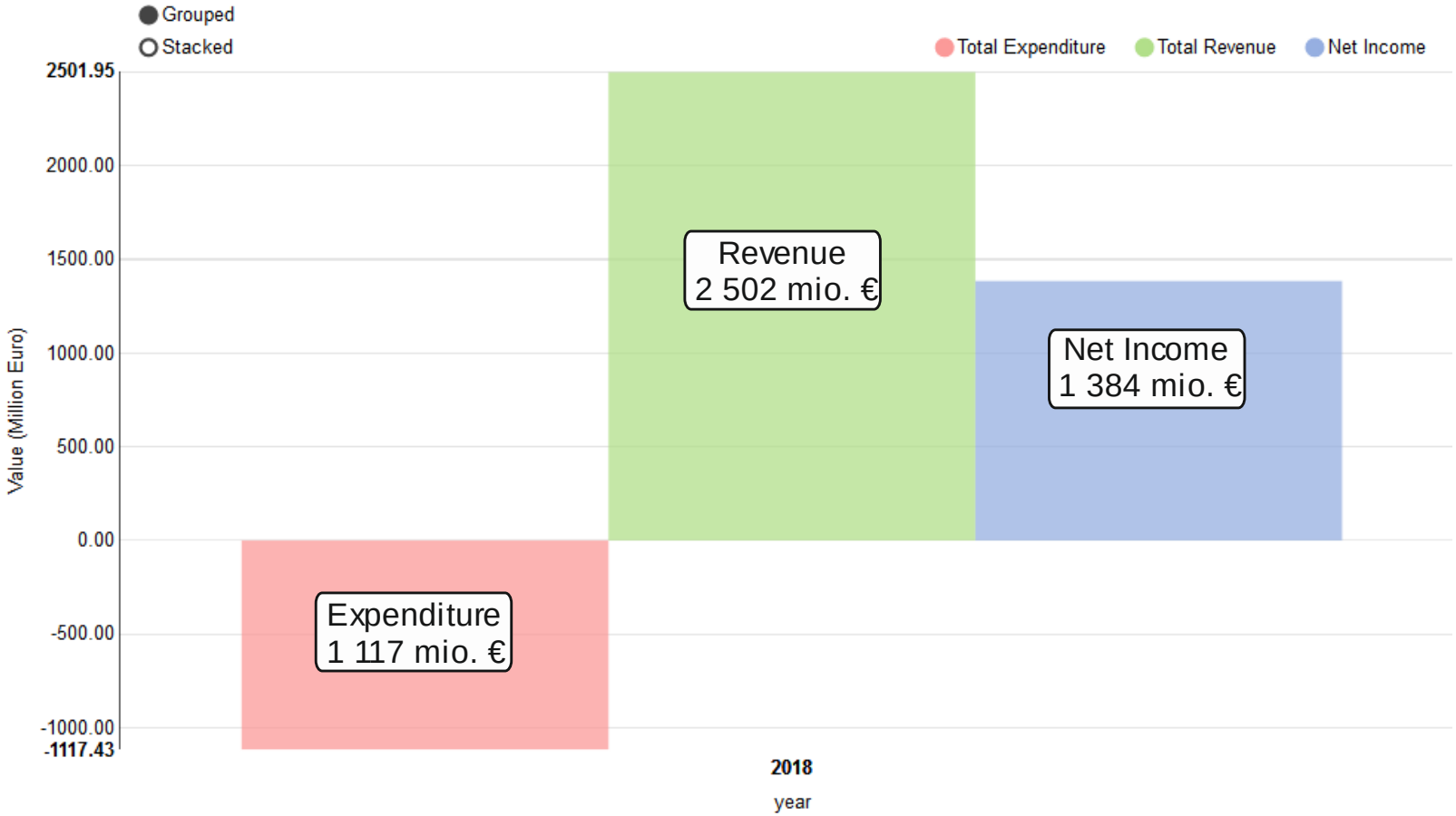
German power trading
January to October 2018



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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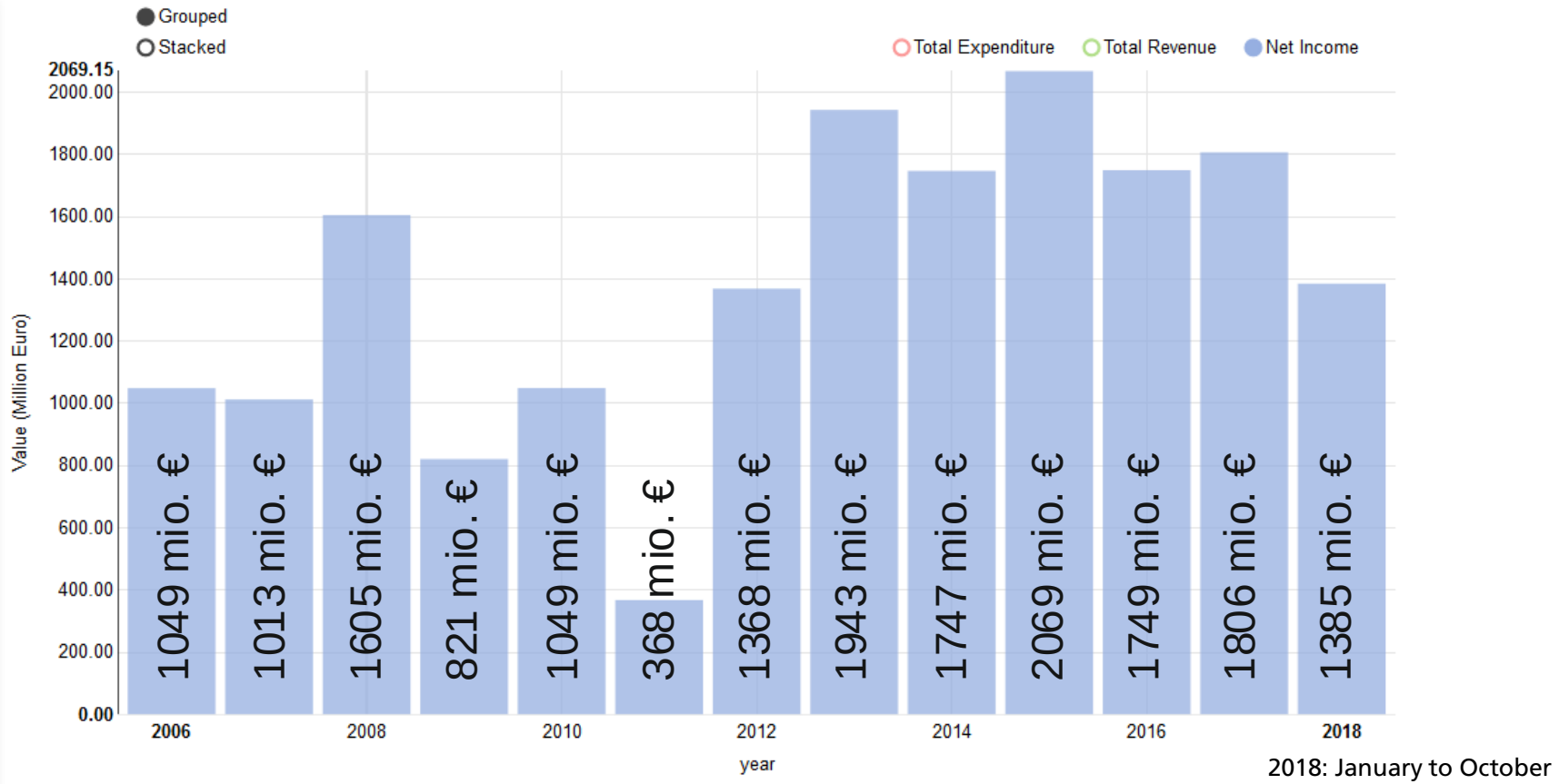
German power trading

Net income in millions of euros



2018: January to October

Graphic: B. Burger, Fraunhofer ISE; Source: https://www.energy-charts.de/trade.htm?year=all

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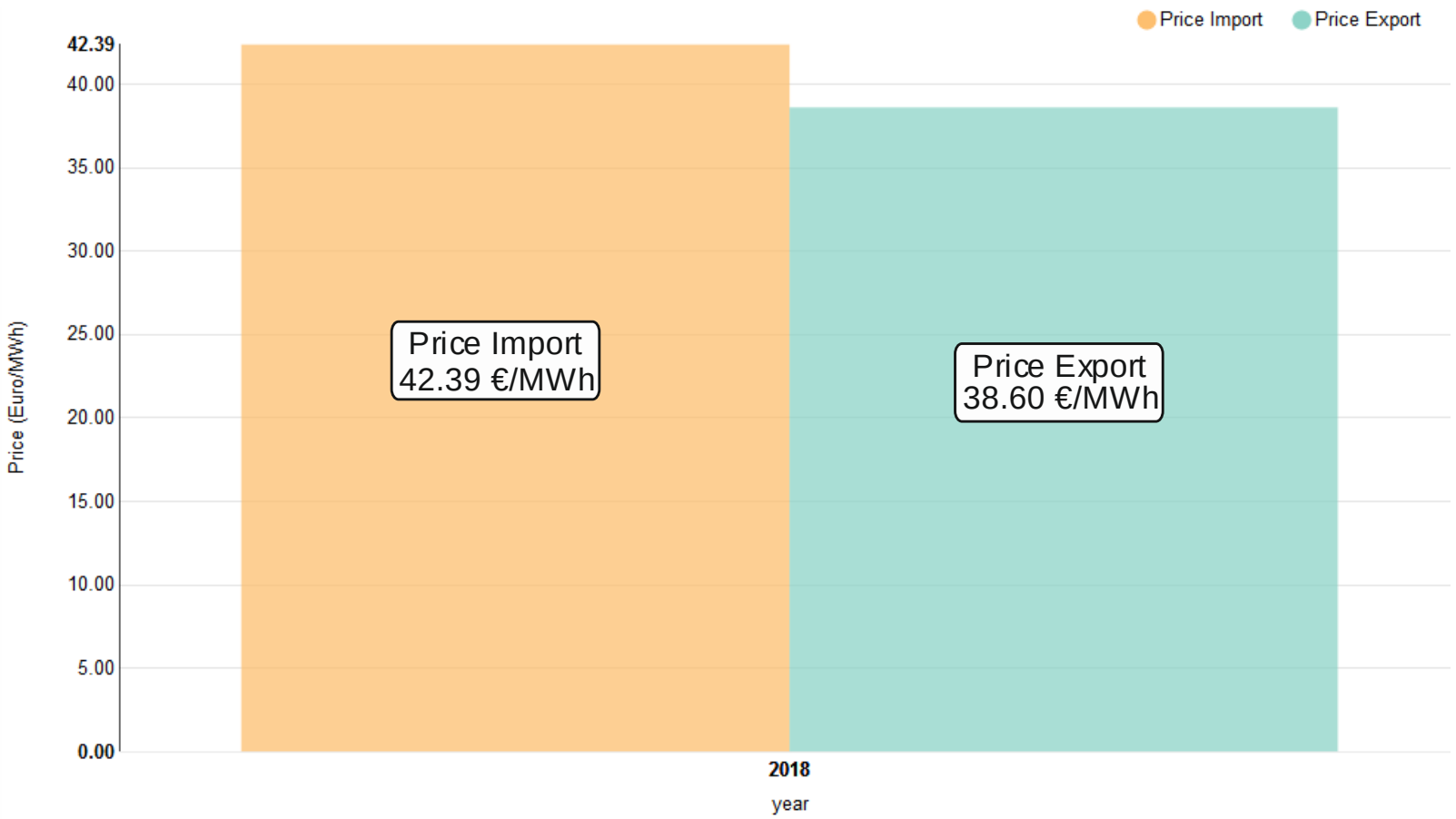
German power trading
January to October 2018



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

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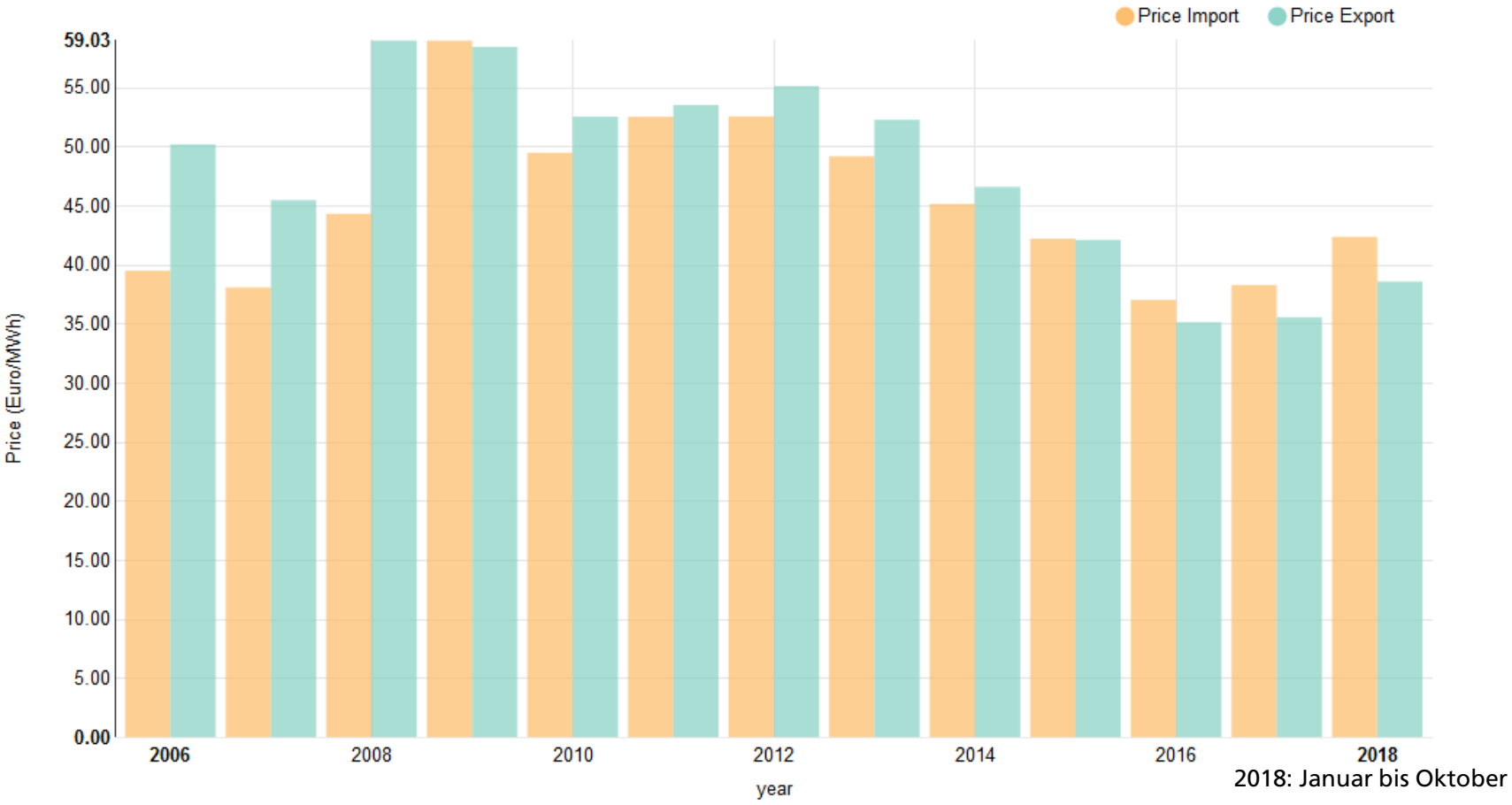
German power trading

Volume weighted average prices in Euro/MWh



2018: Januar bis Oktober

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

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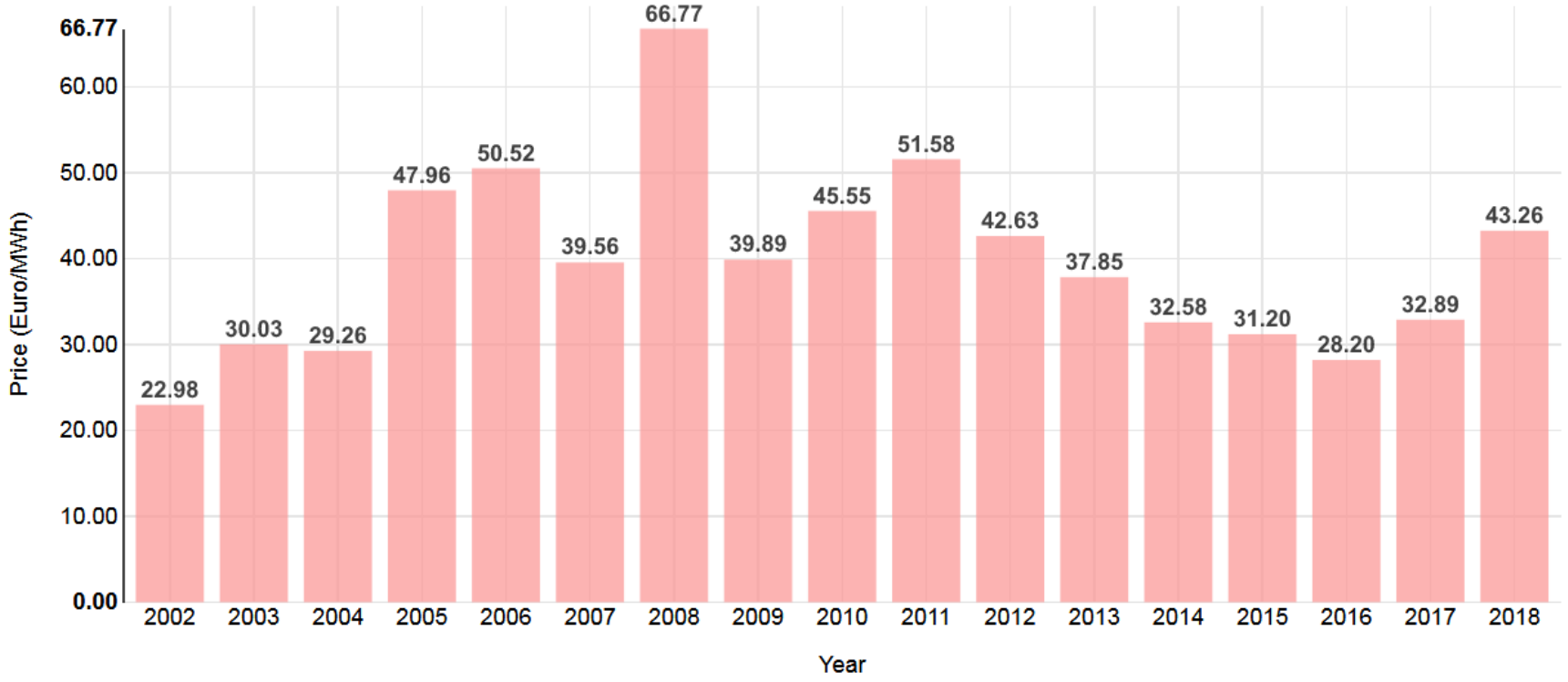
EPEX day ahead spot price

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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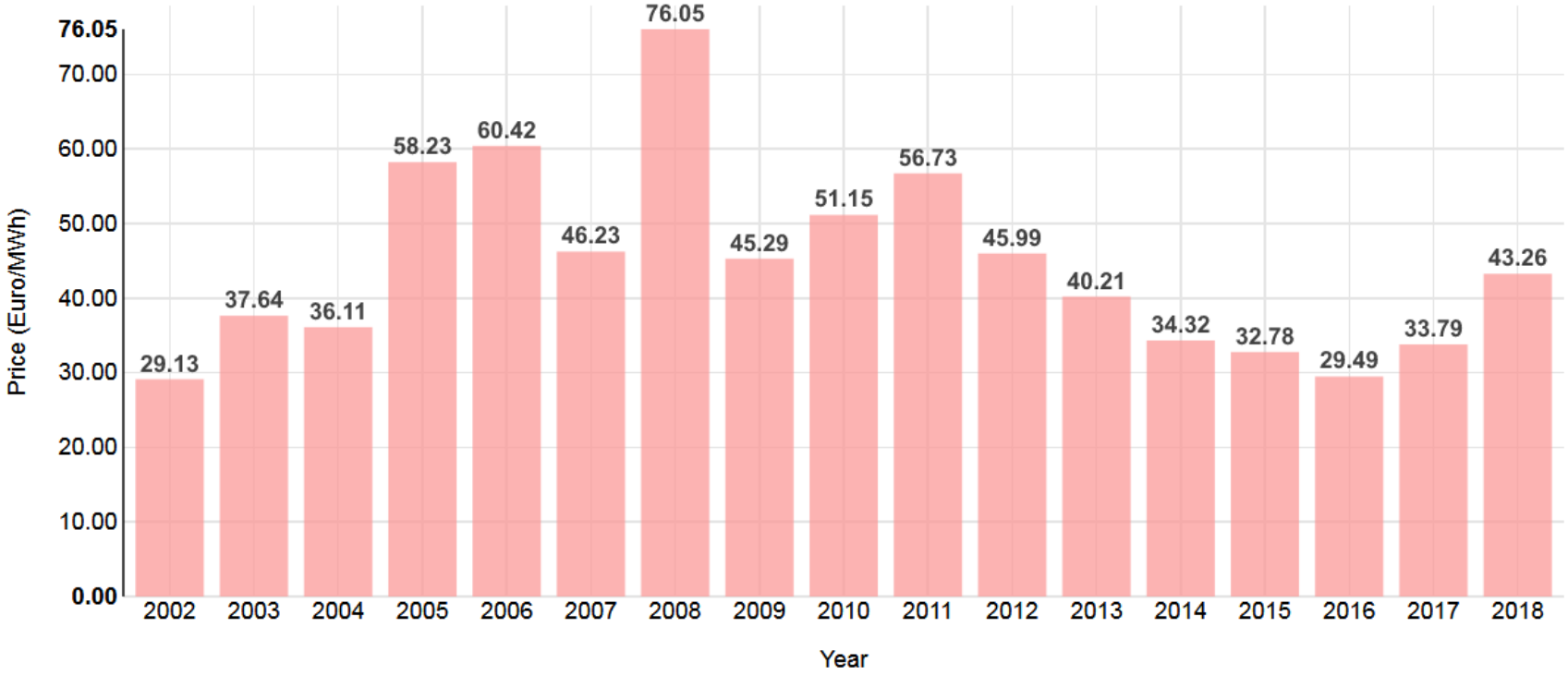
EPEX day ahead spot price

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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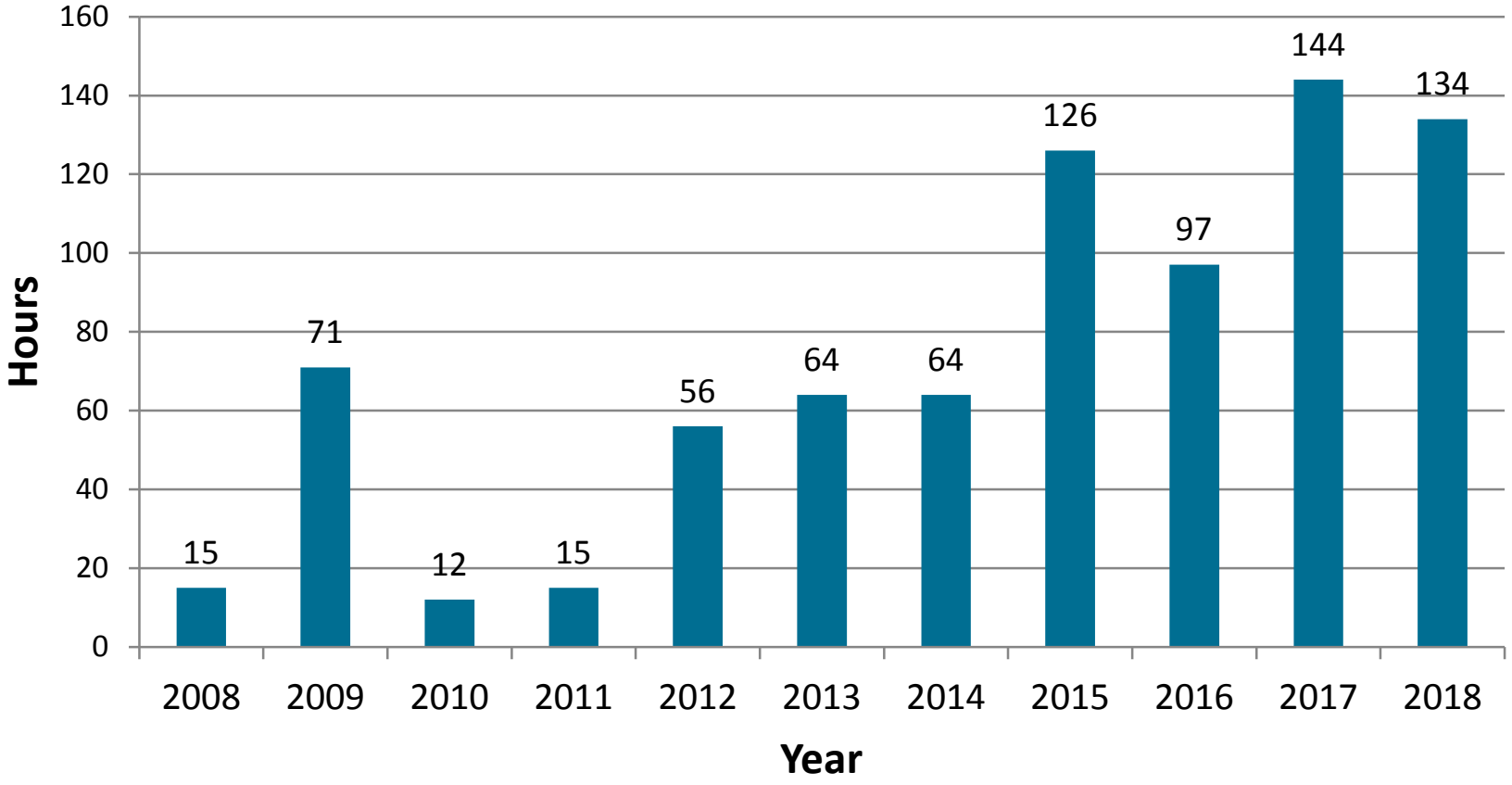
Negative Day Ahead Electricity Prices

Hours per Year



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

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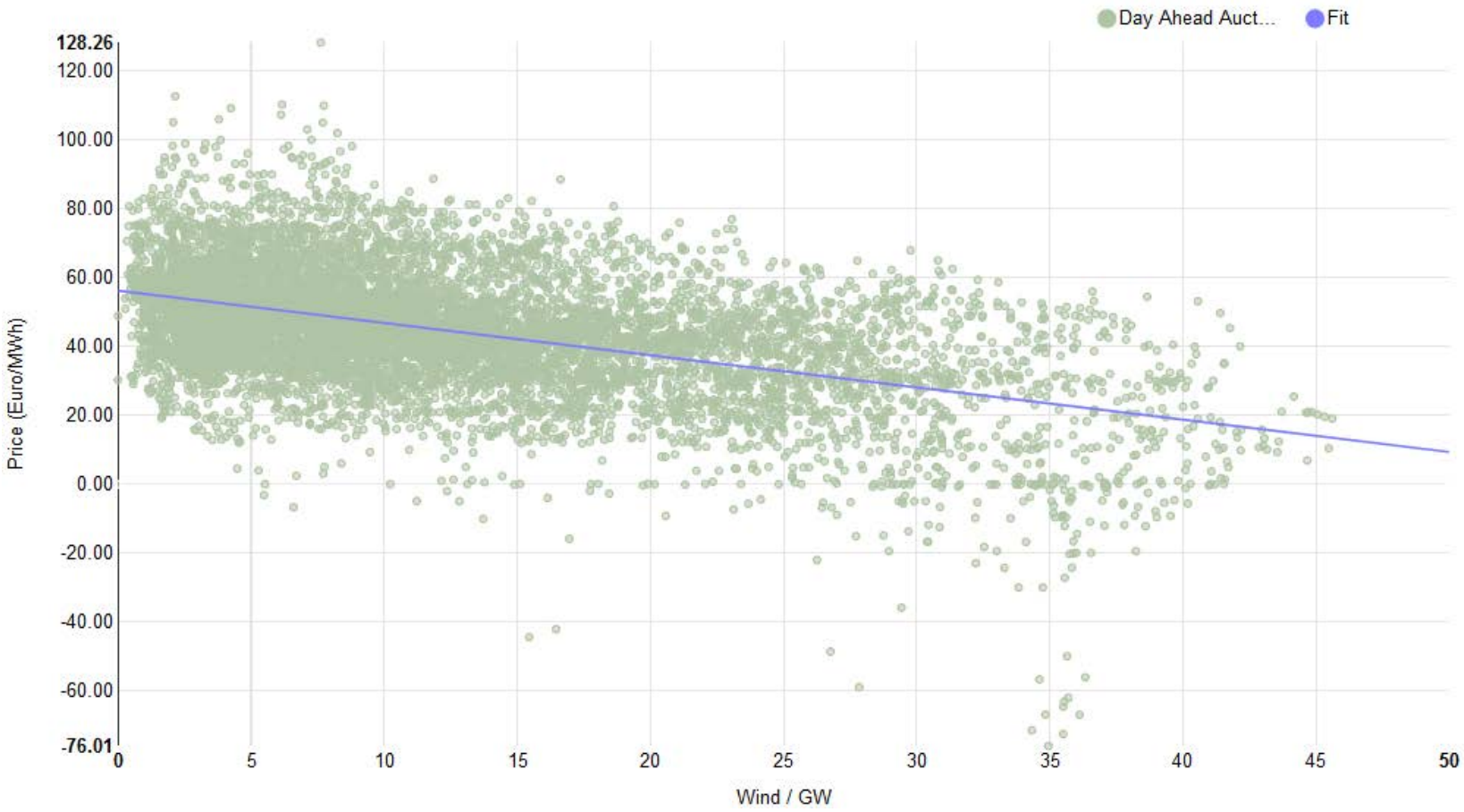
Day Ahead Spot Price vs. Wind Power

Hourly values in 2018



Wind power reduces the Day Ahead Spot Market Price by 0.94 Euro/MWh per GW.
Graph: B. Burger, Fraunhofer ISE; Data: EPEX; Source: www.energy-charts.de/price_scatter.htm

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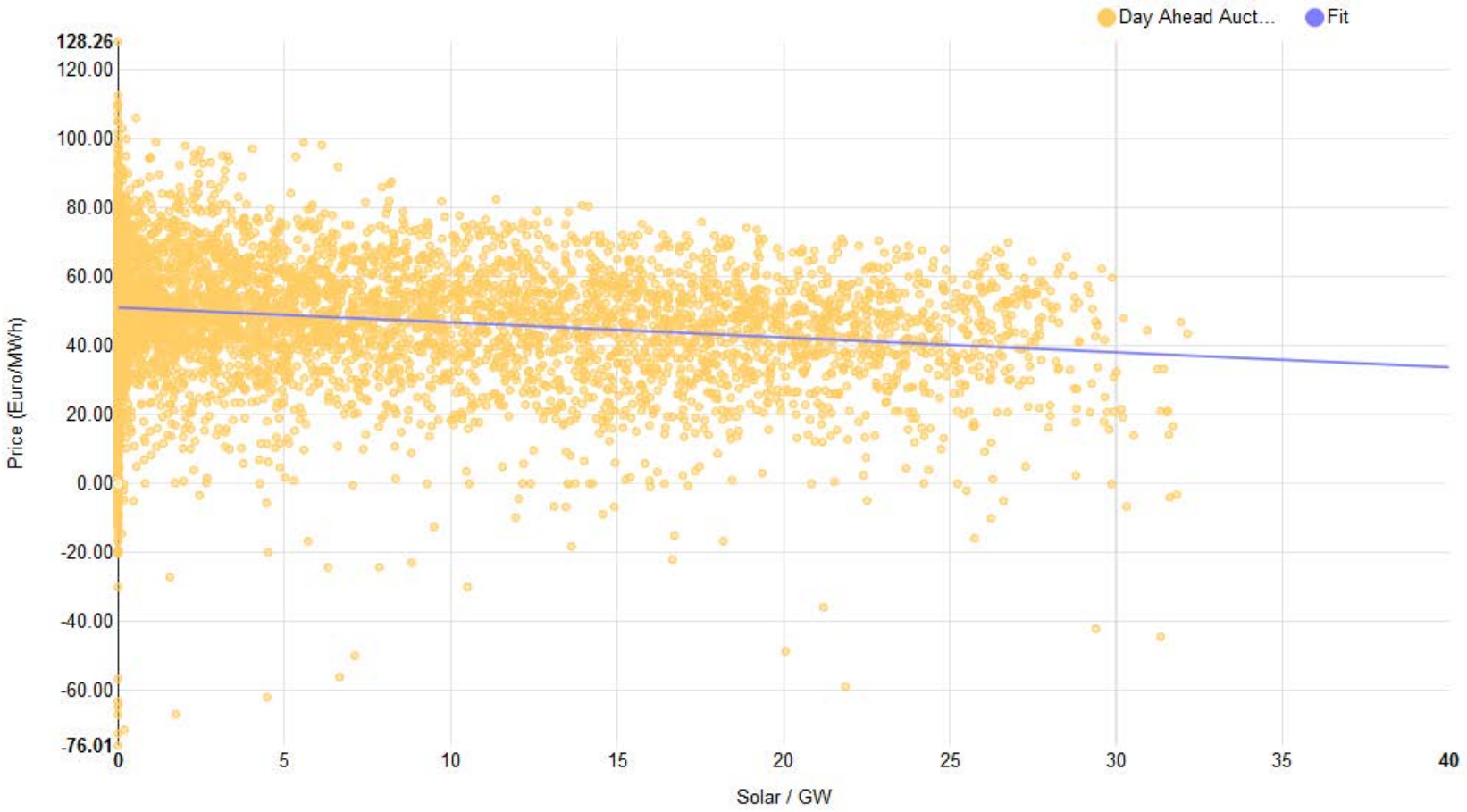
Day Ahead Spot Price vs. Solar Power

Hourly values in 2018



Solar power reduces the Day Ahead Spot Market Price by 0.43 Euro/MWh per GW.
Graph: B. Burger, Fraunhofer ISE; Data: EPEX; Source: https://www.energy-charts.de/price_scatter.htm

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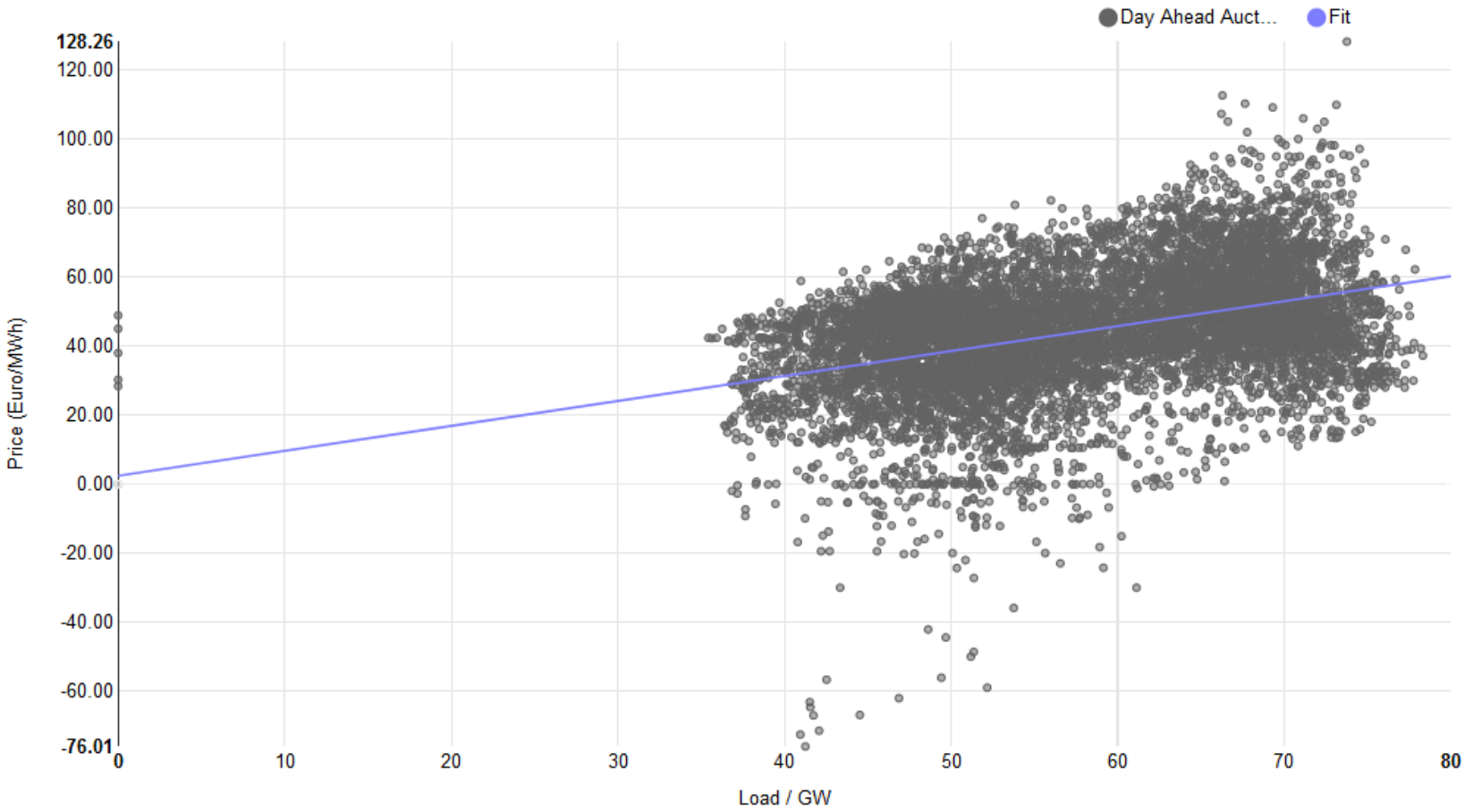
Day Ahead Spot Price vs. Load

Hourly values in 2018



The load increases the Day Ahead Spot Market Price by 0.72 Euro/MWh per GW.
Graph: B. Burger, Fraunhofer ISE; Data: EPEX; Source: https://www.energy-charts.de/price_scatter.htm

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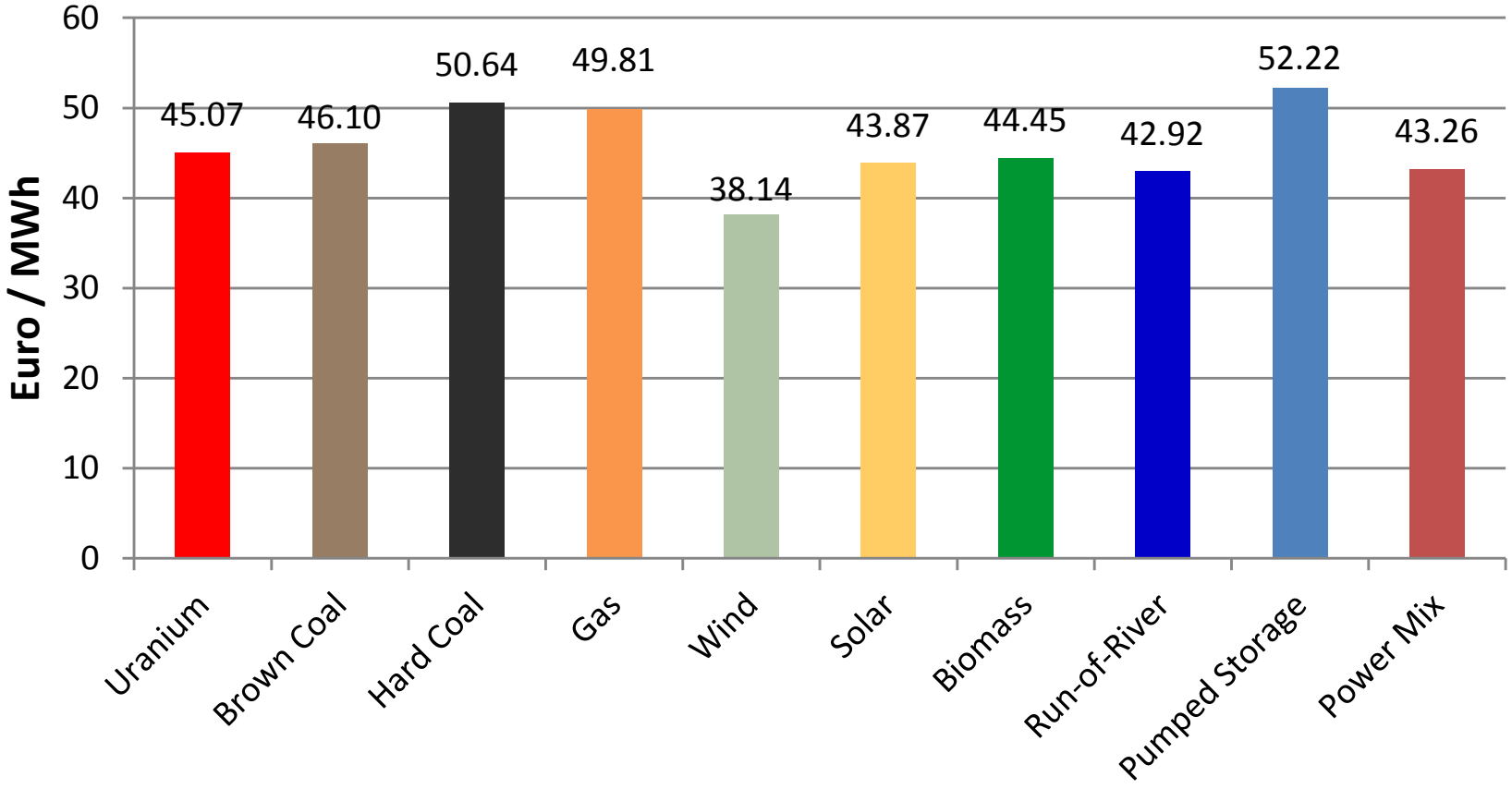
Day Ahead market values, weighted by volume
Year 2018



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

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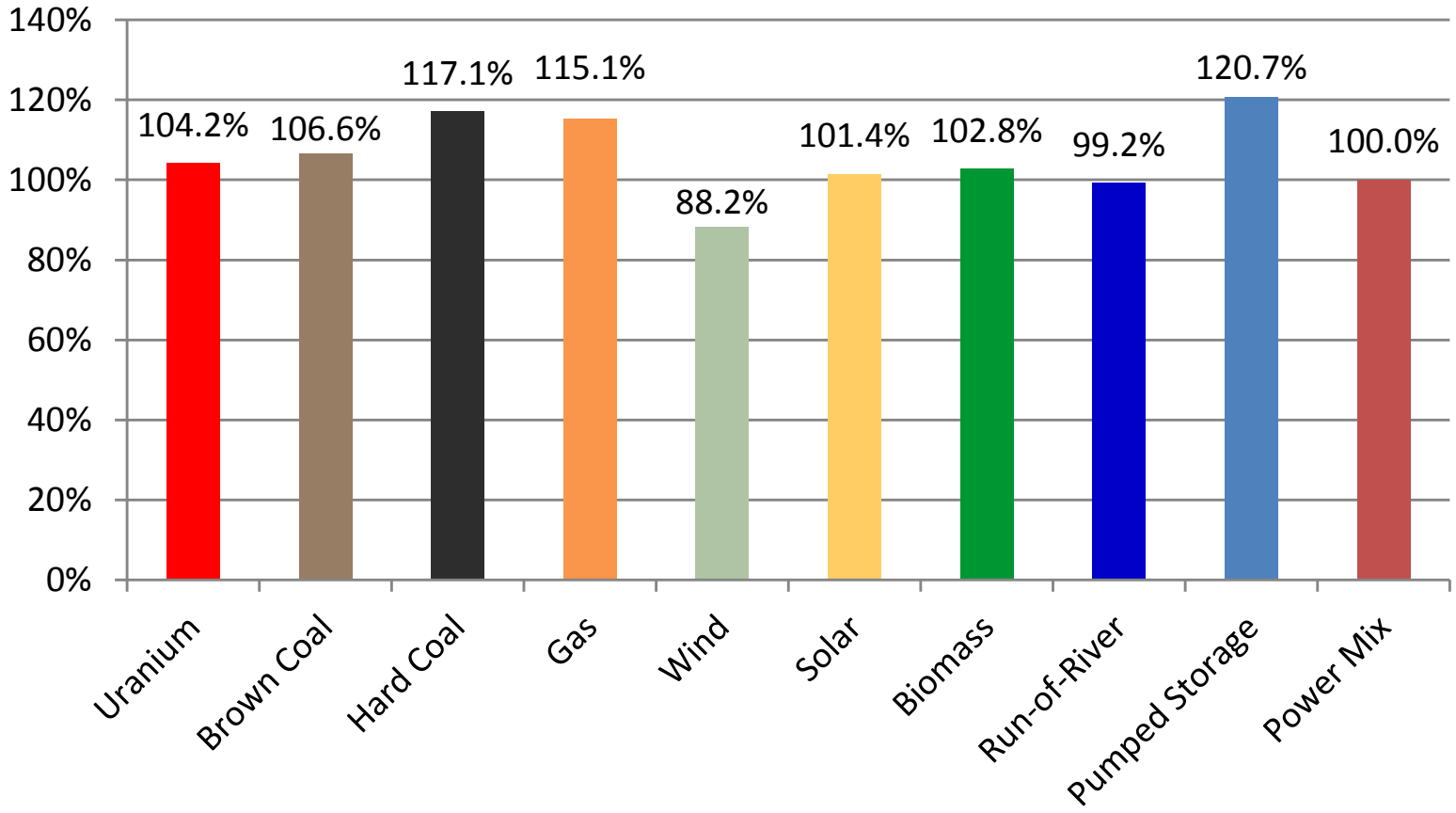
Relative Day Ahead market values, weighted by volume
Year 2018



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

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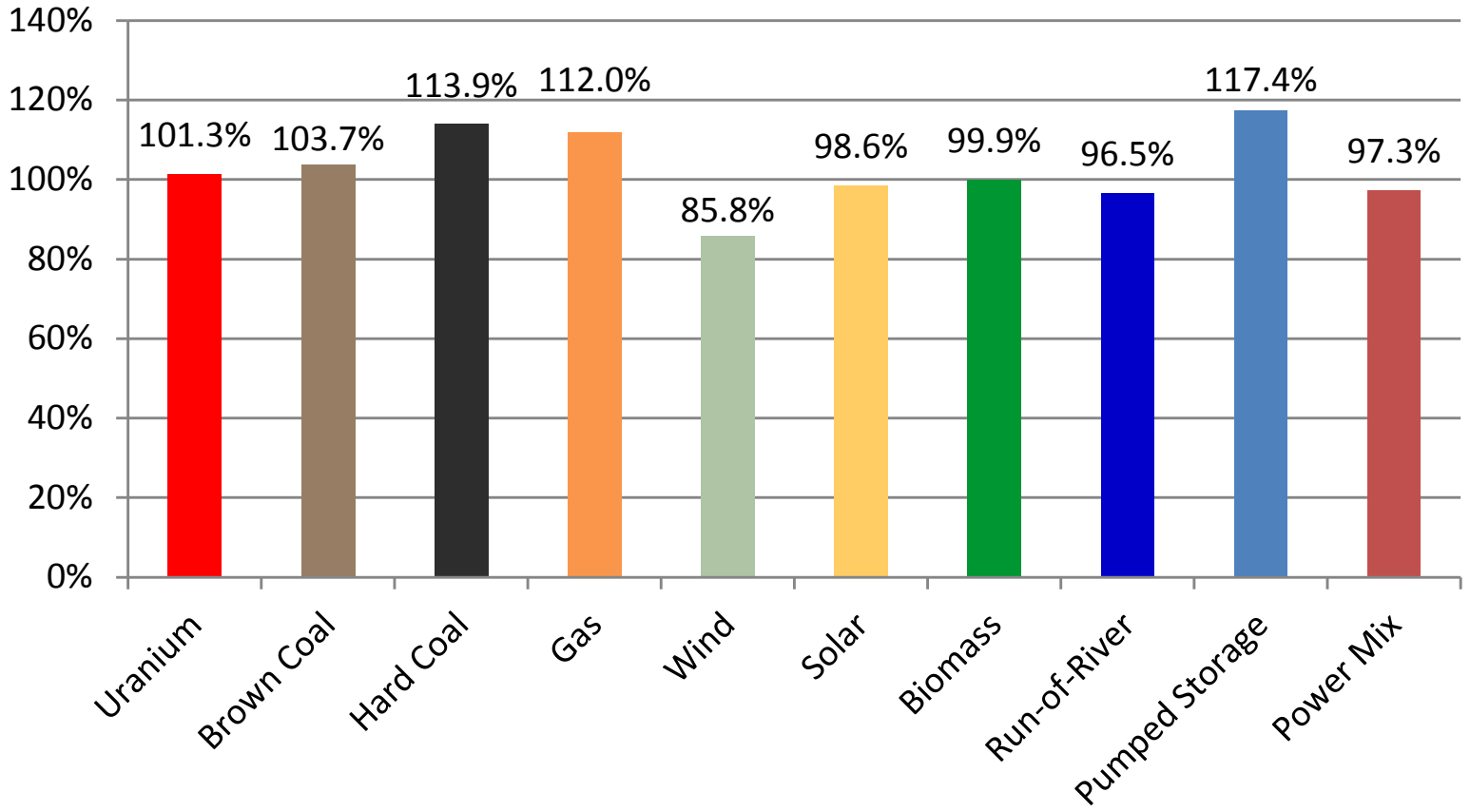
Market value factors
Year 2017



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

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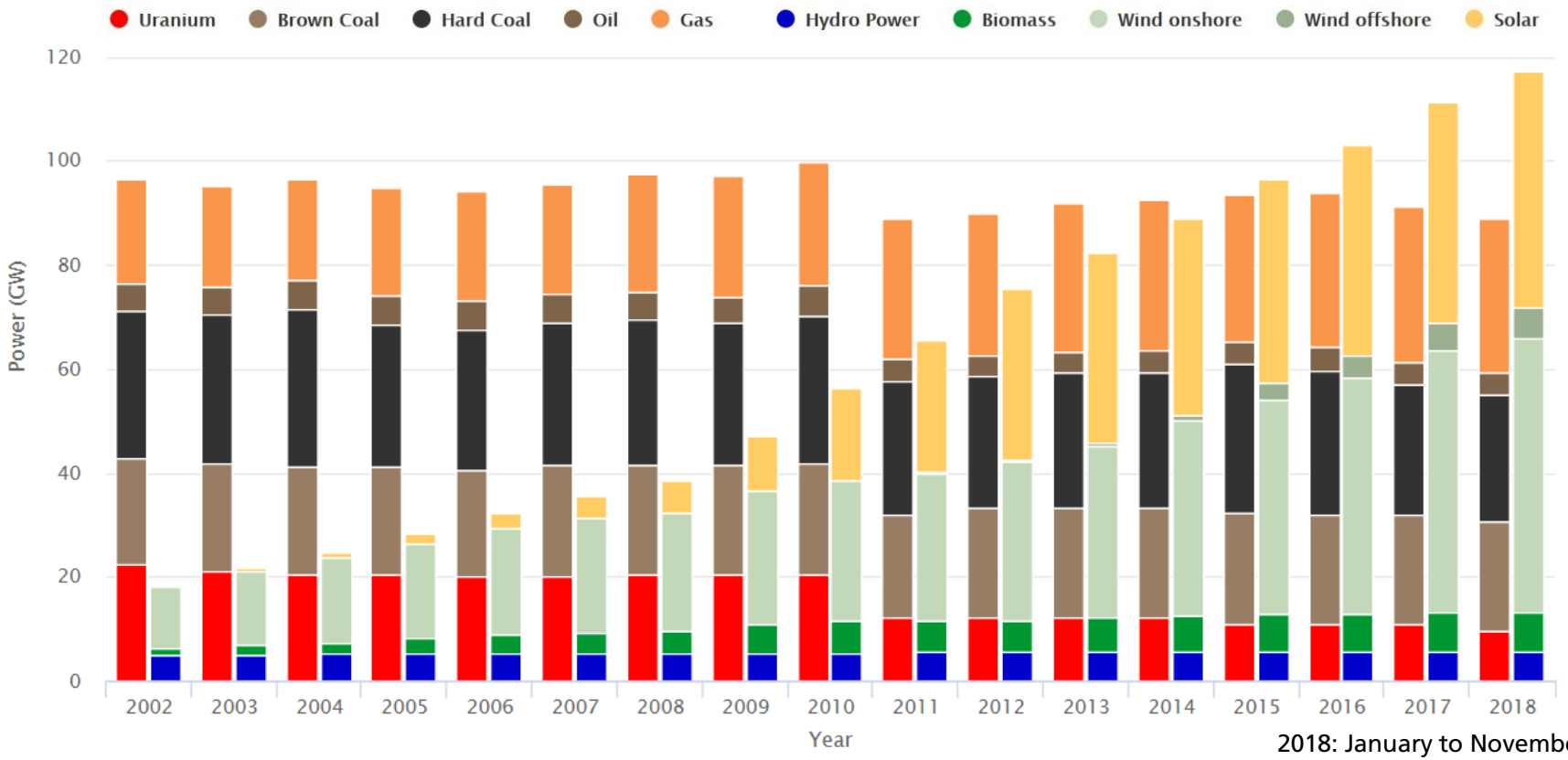
Installed power for electricity production
fossil plus nuclear compared to renewables



2018: January to November

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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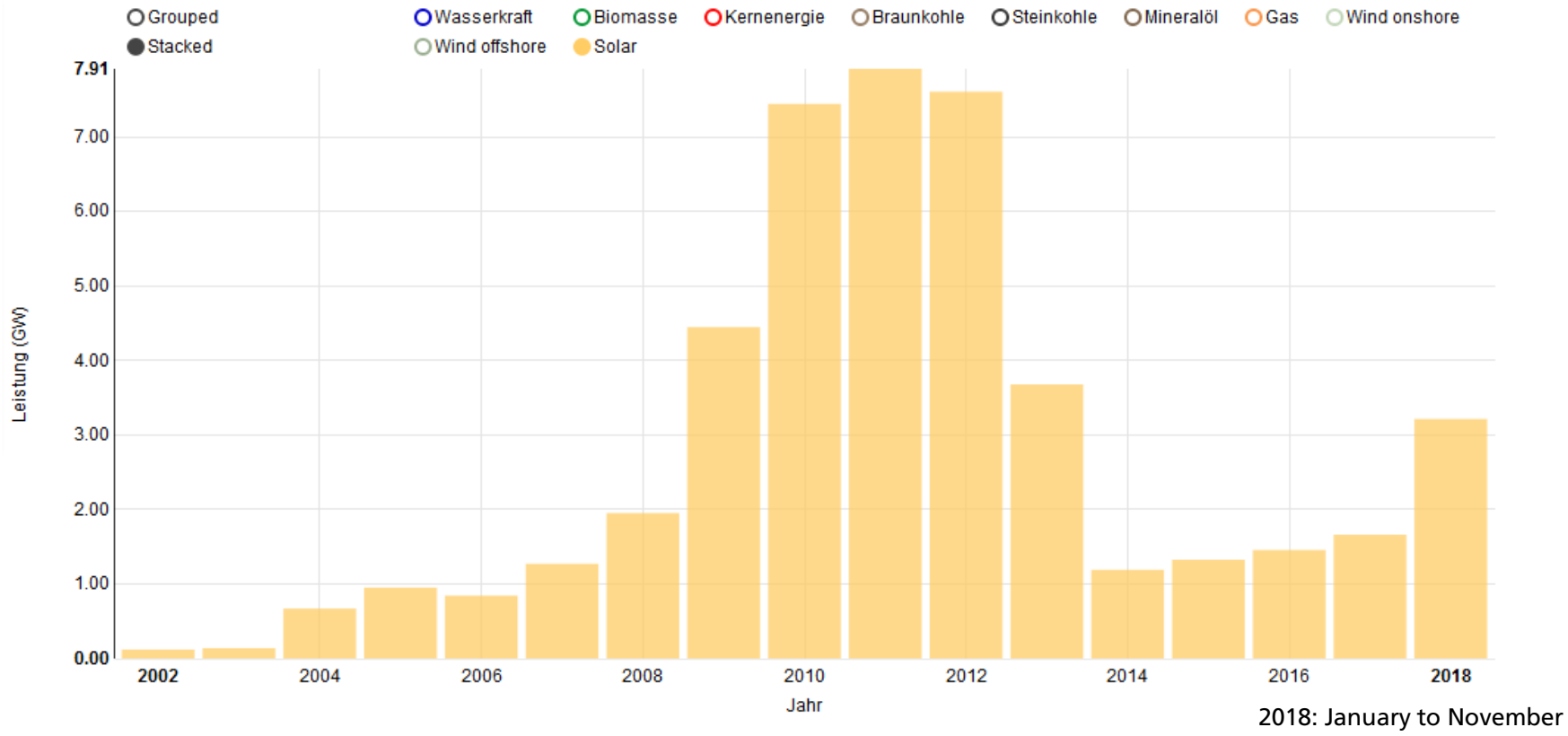
Annual increase of net installed generation capacity
Solar



2018: January to November

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

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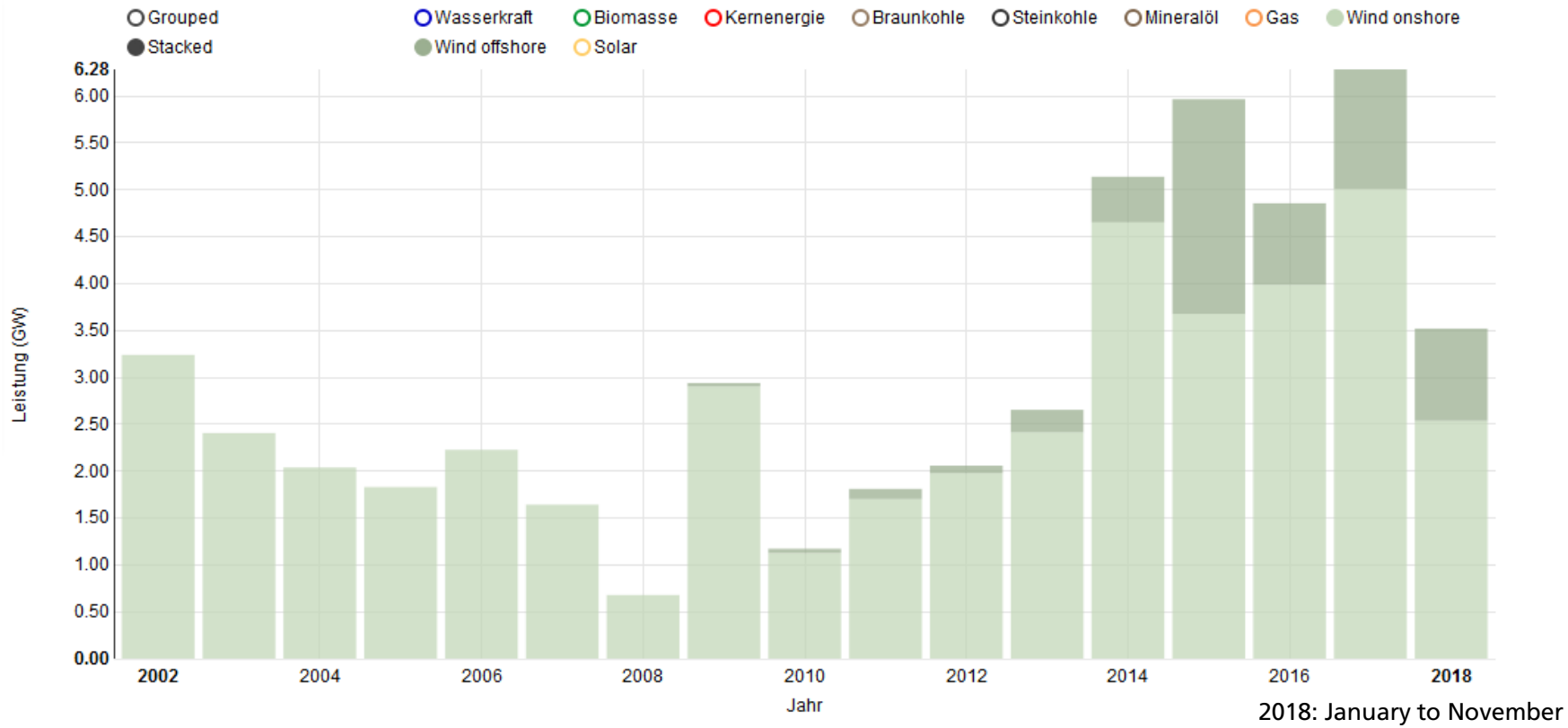
Annual increase of net installed generation capacity
Wind



2018: January to November

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

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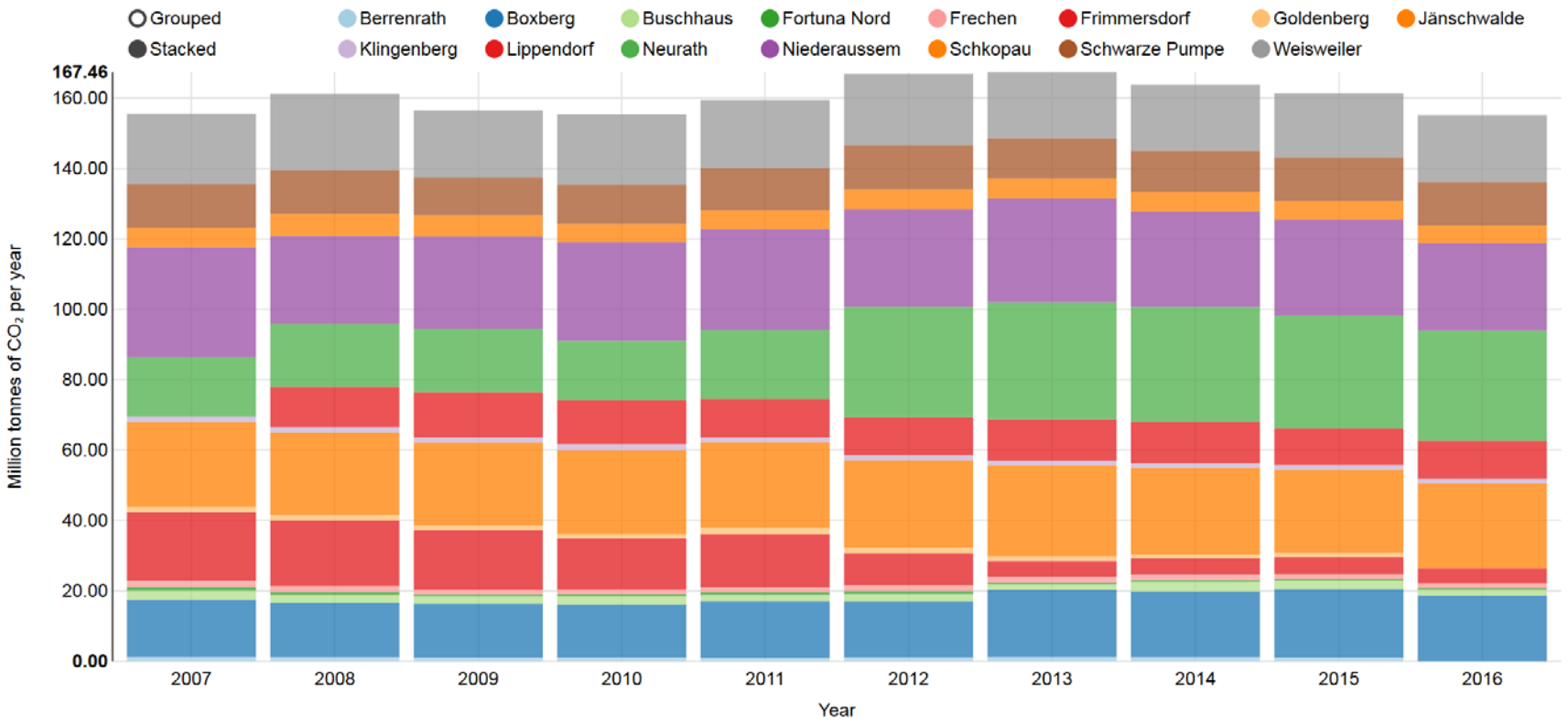
Annual carbon dioxide (CO_2) emissions of power plants

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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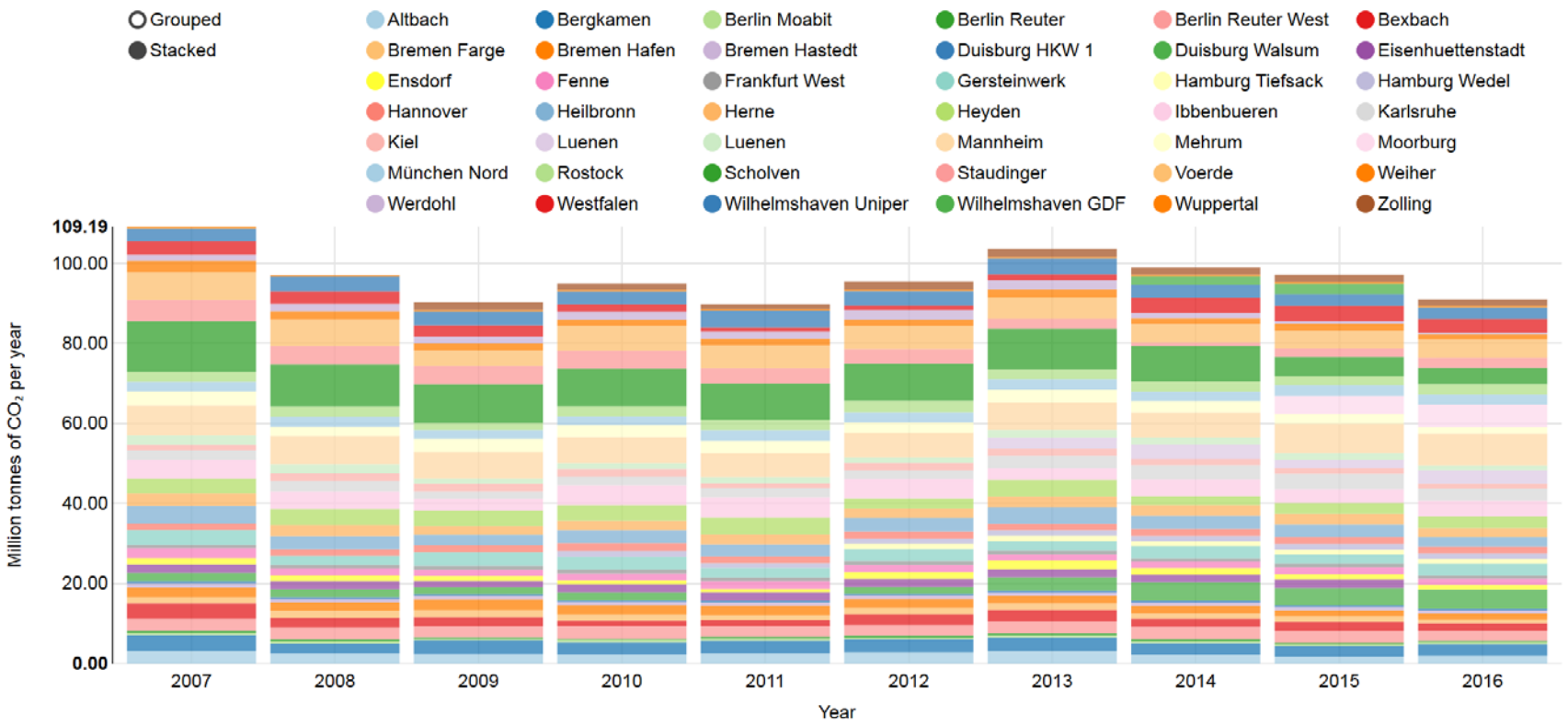
Annual carbon dioxide (CO_2) emissions of power plants

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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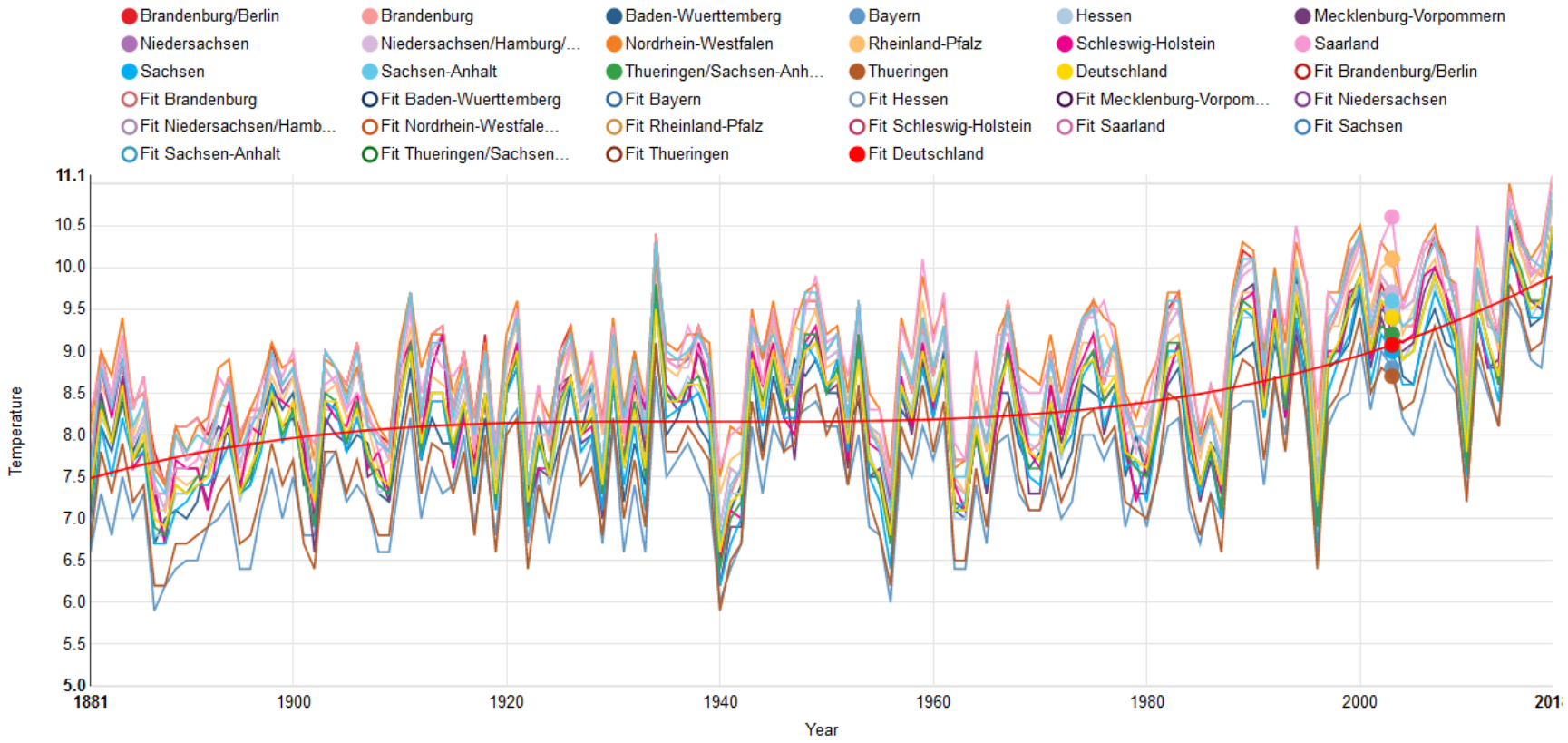
Average air temperature in Germany
1881 to 2018



Data source: Deutscher Wetterdienst (DWD)
Graphic: B. Burger, Fraunhofer ISE; Source: https://www.energy-charts.de/climate_y_avg.htm?source=airTemp_line

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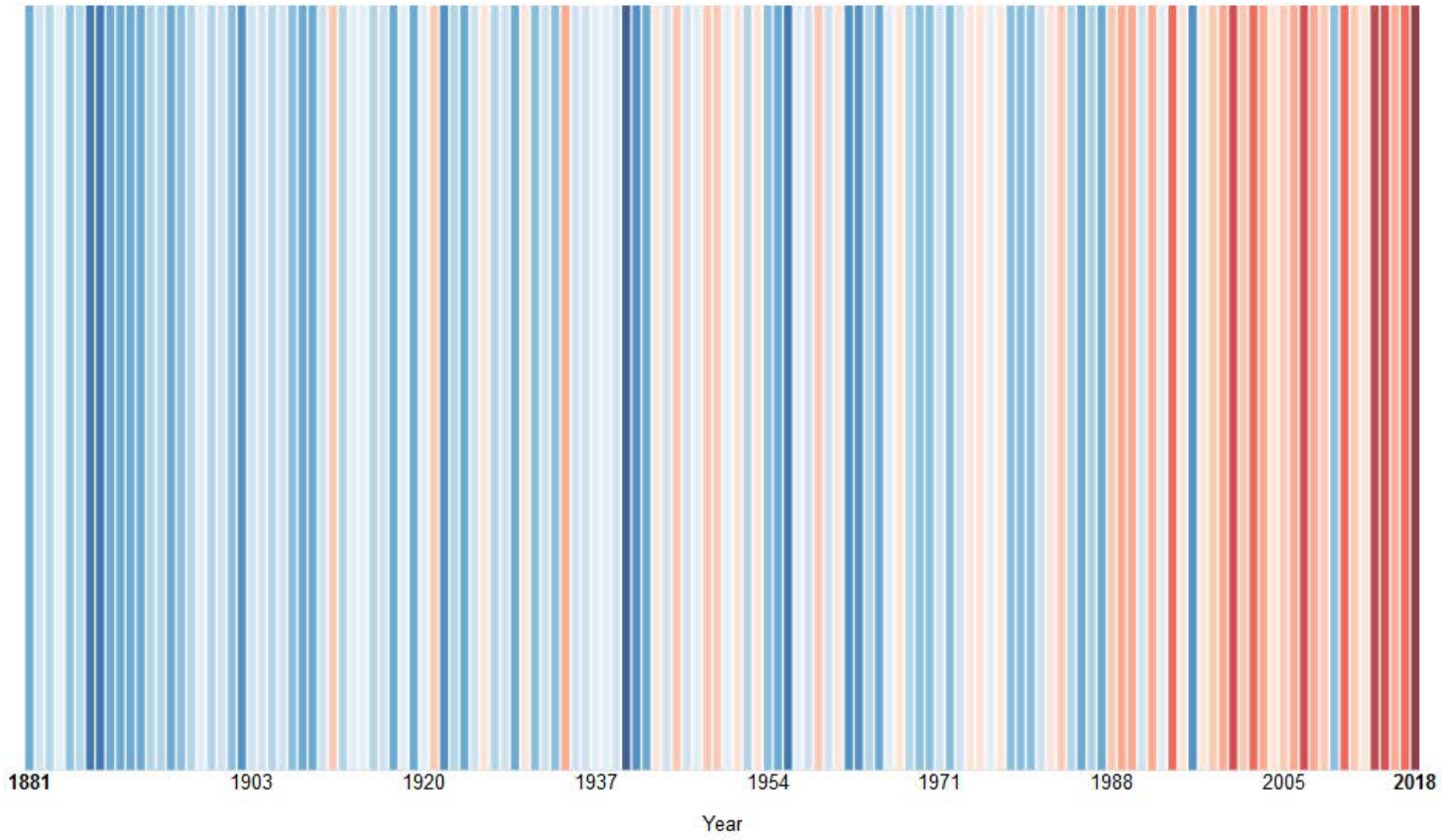
Average air temperature in Germany
Warming stripes from 1881 to 2018



Warming stripes according to an idea by Ed Hawkins.
The colour scale goes from 6.6°C in 1940 (dark blue) to 10.5°C in 2018 (dark red)
Datasource: Deutscher Wetterdienst DWD, Climate Data Center (CDC)

Grafik: B. Burger, Fraunhofer ISE; Quelle: https://www.energy-charts.de/climate_y_avg_de.htm

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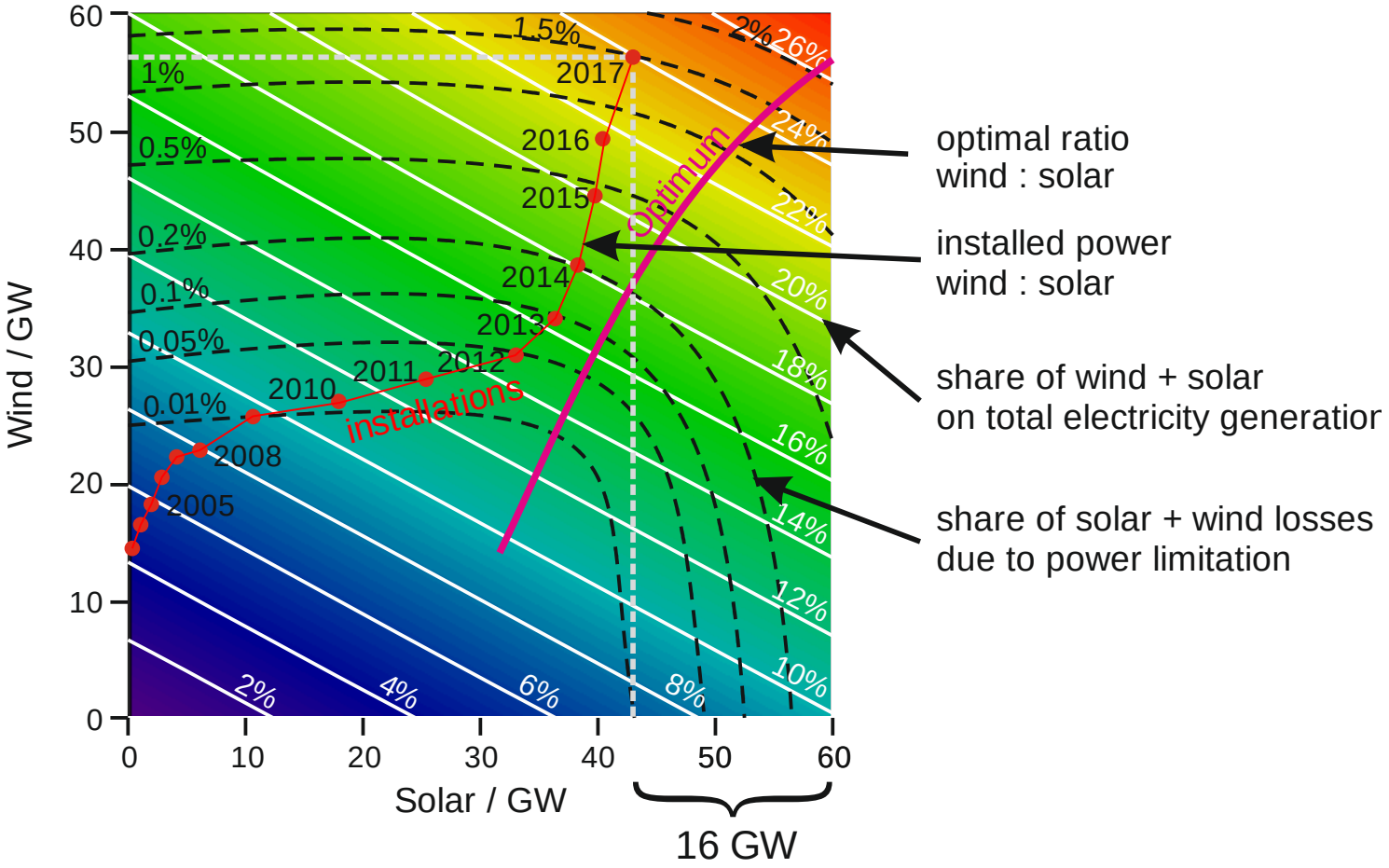
Optimum ratio of installed power

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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