EGAT
Power for Thai Happiness

Advanced Energy Business Management Training

ZIW e.V.
Center for Innovation and Further Education

Trier University of Applied Sciences
HOCHSCHULE TRIER

Bender-IS

Disruptive Technologies: PV, Batteries, Electric Vehicles

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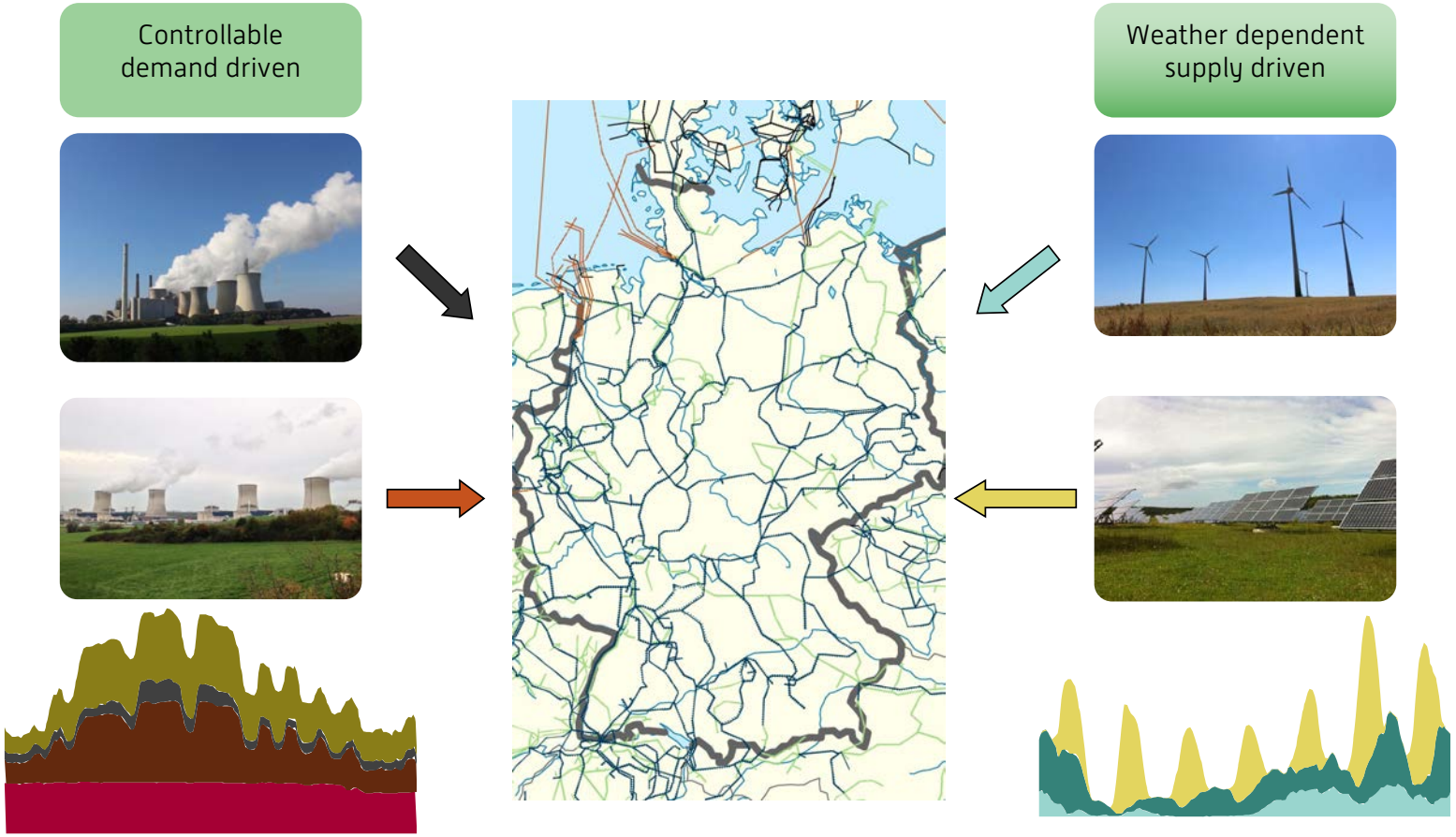
Trier, 27th May 2022

https://www.umwelt-campus.de/en/hteheesen/tebm

Different energy production systems participate in the electric grid



Map: Alexrk2. License: CC BY-SA 3.0. Netz: ENTSO-E https://www.entsoe.eu/map/Pages/default.aspx

Grid Use and Balancing Groups

$$\Sigma P_I = \Sigma P_O + P_V$$

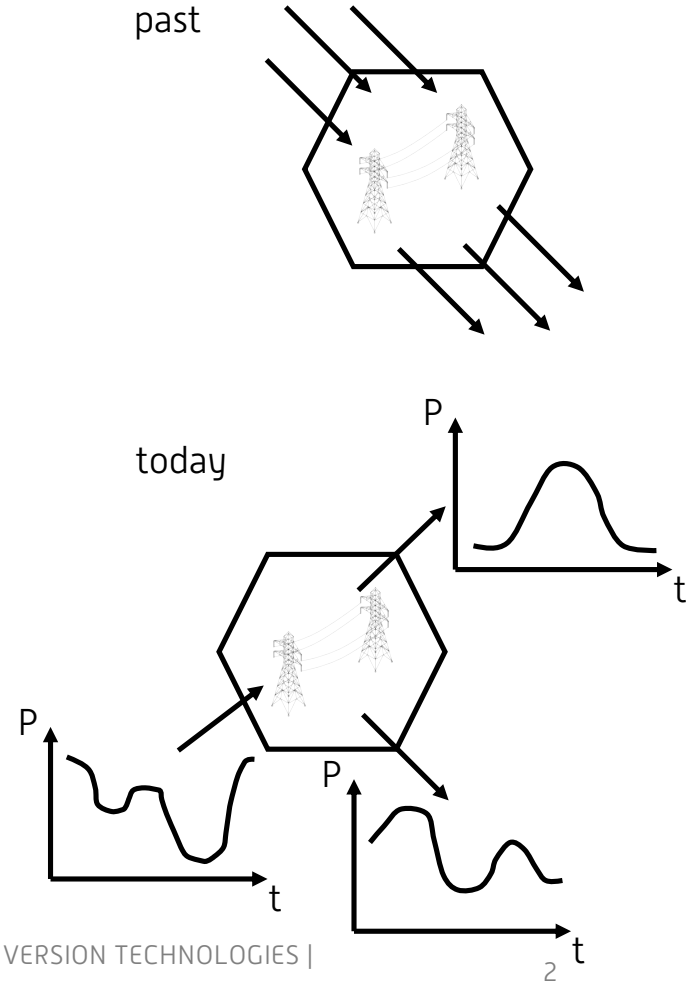
Inputs (P_I):

- Power generation
- Neighboring grids on same voltage level
- Returns from subordinate grids on smaller voltage level

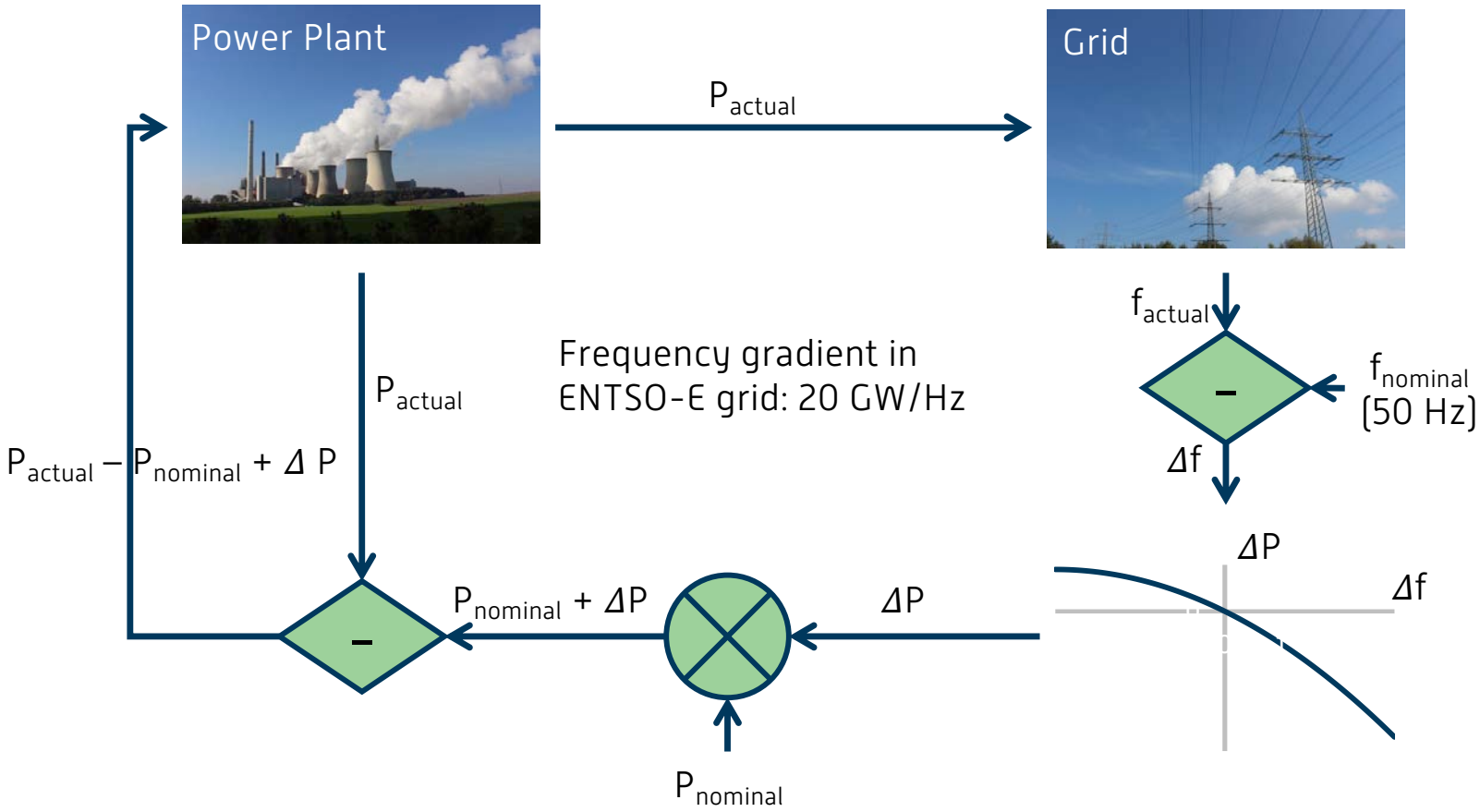
Output (P_O):

- Loads
- Subordinate grids on smaller voltage level
- Neighboring grids on same voltage level

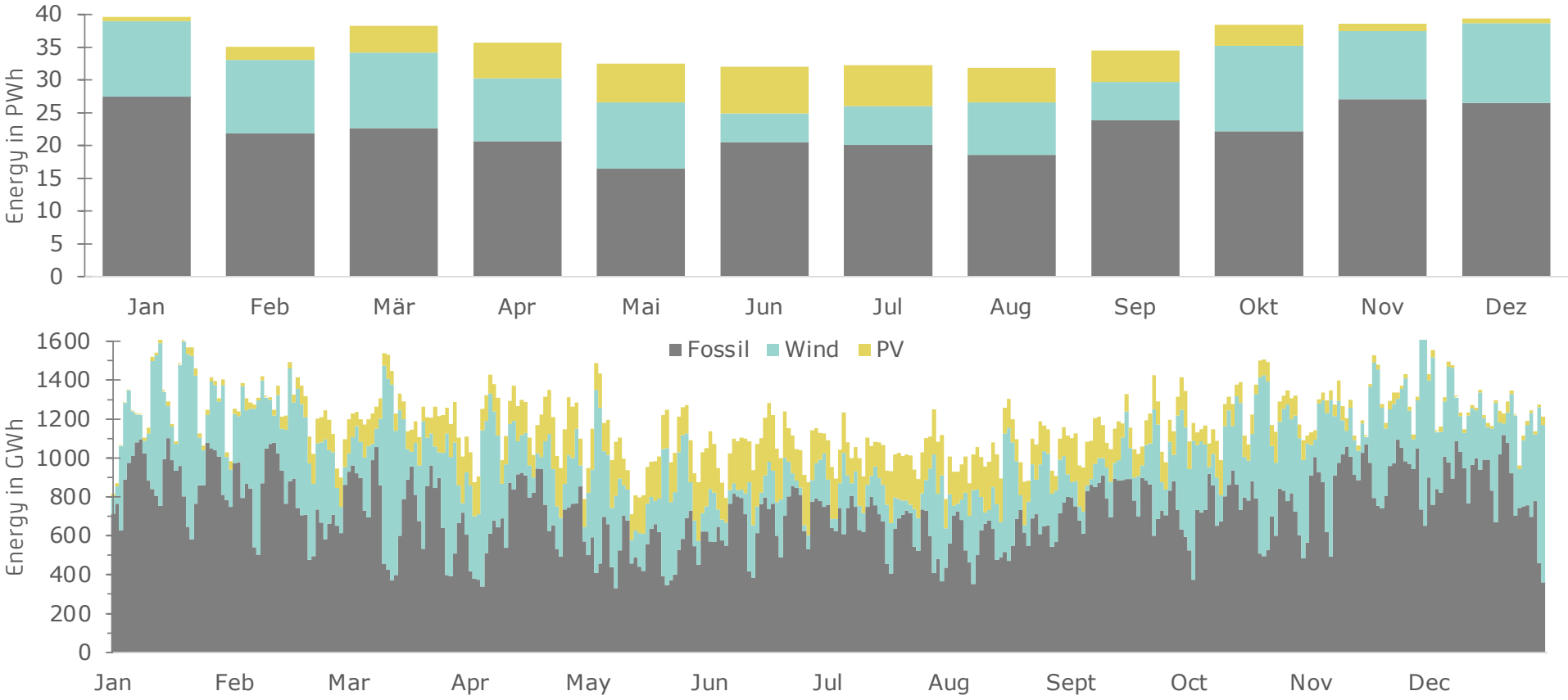
Grid losses (P_V)



Frequency Control

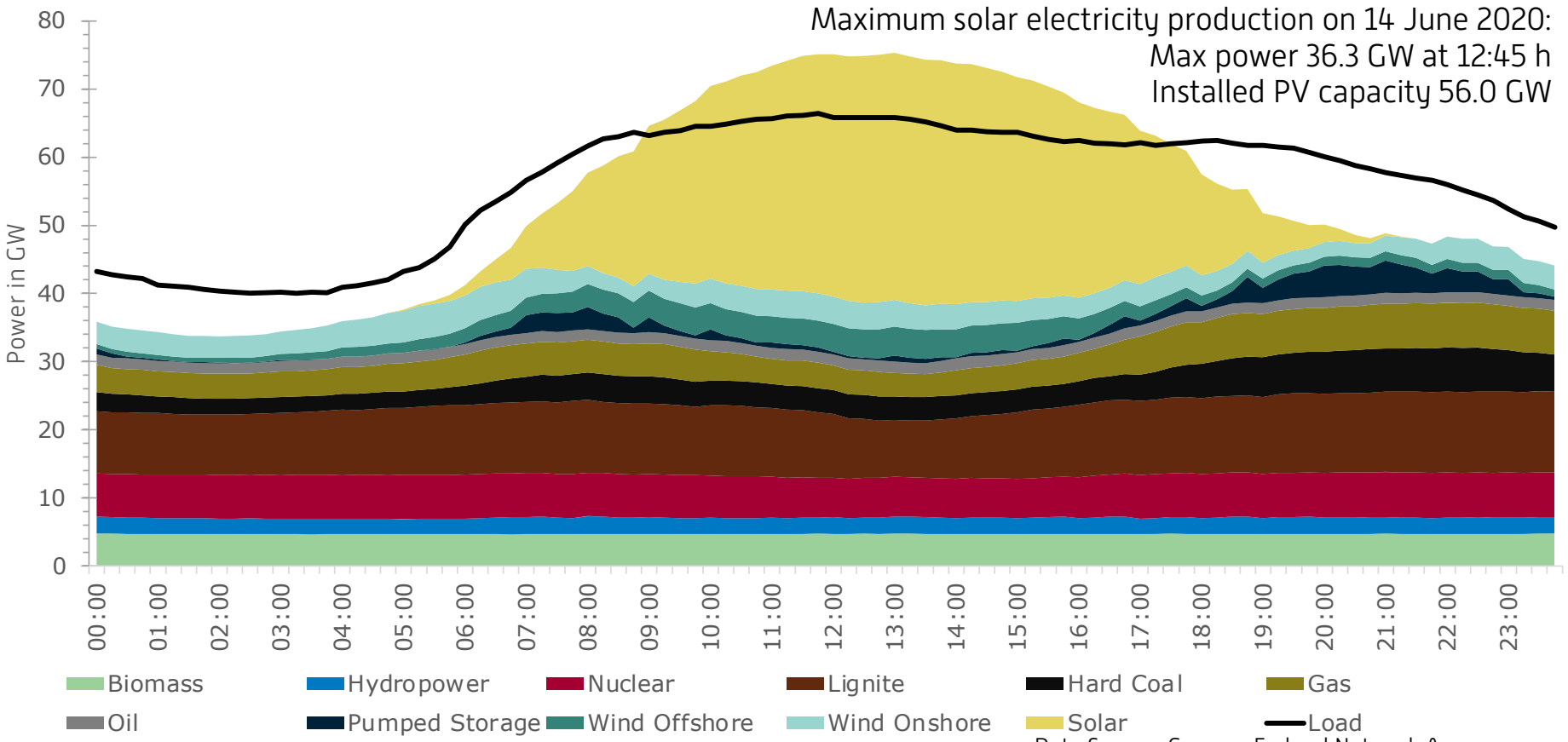


Power Generation by Fossil Power Plants, Wind, PV in Germany 2021



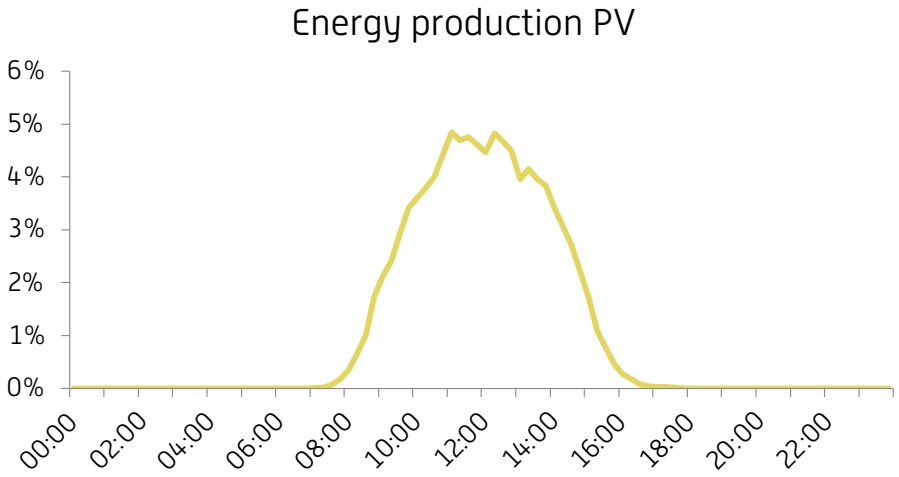
Data Source: German Federal Network Agency. smard.de

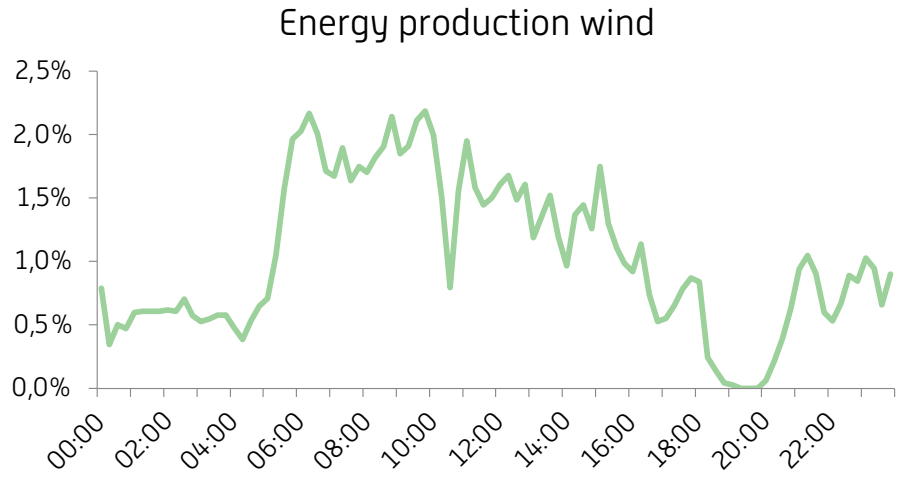
Largest Solar Electricity Production in Germany 14 June 2021

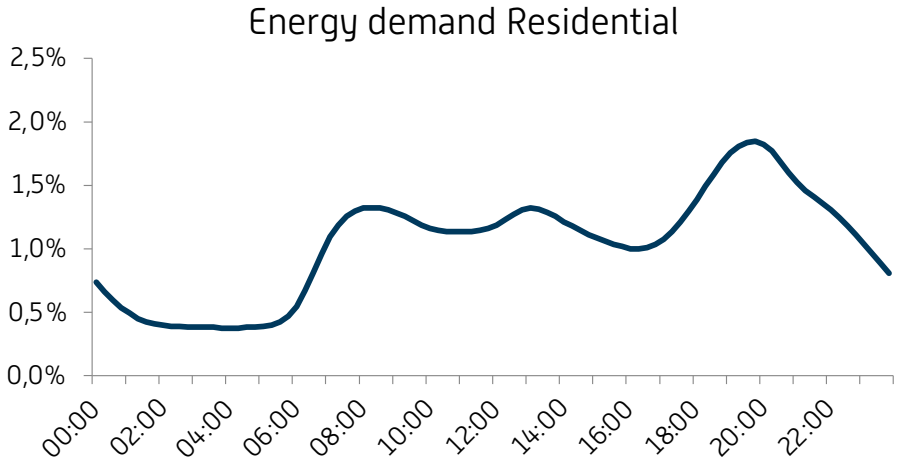


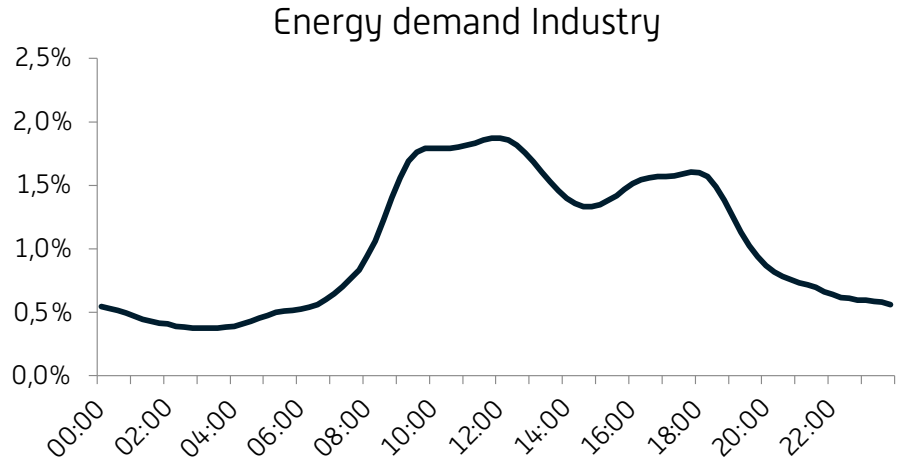
Data Source: German Federal Network Agency. smard.de

Energy Production and Demand Profiles

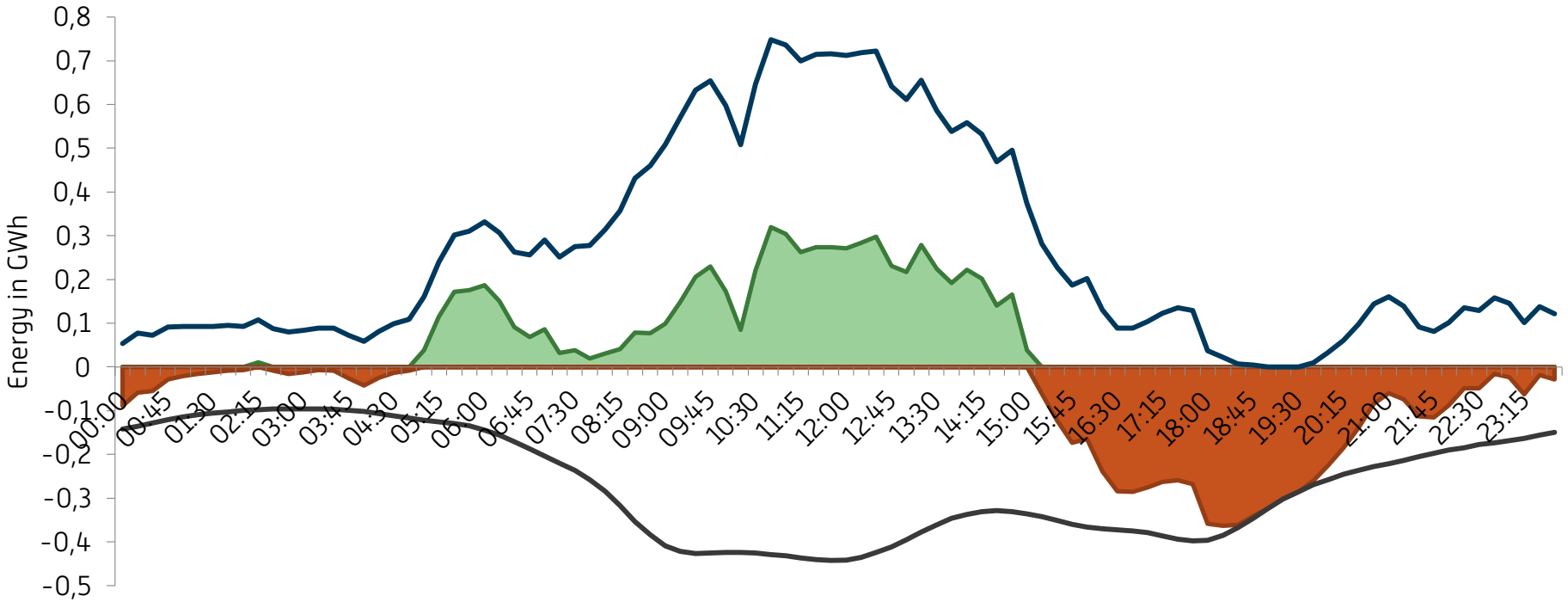






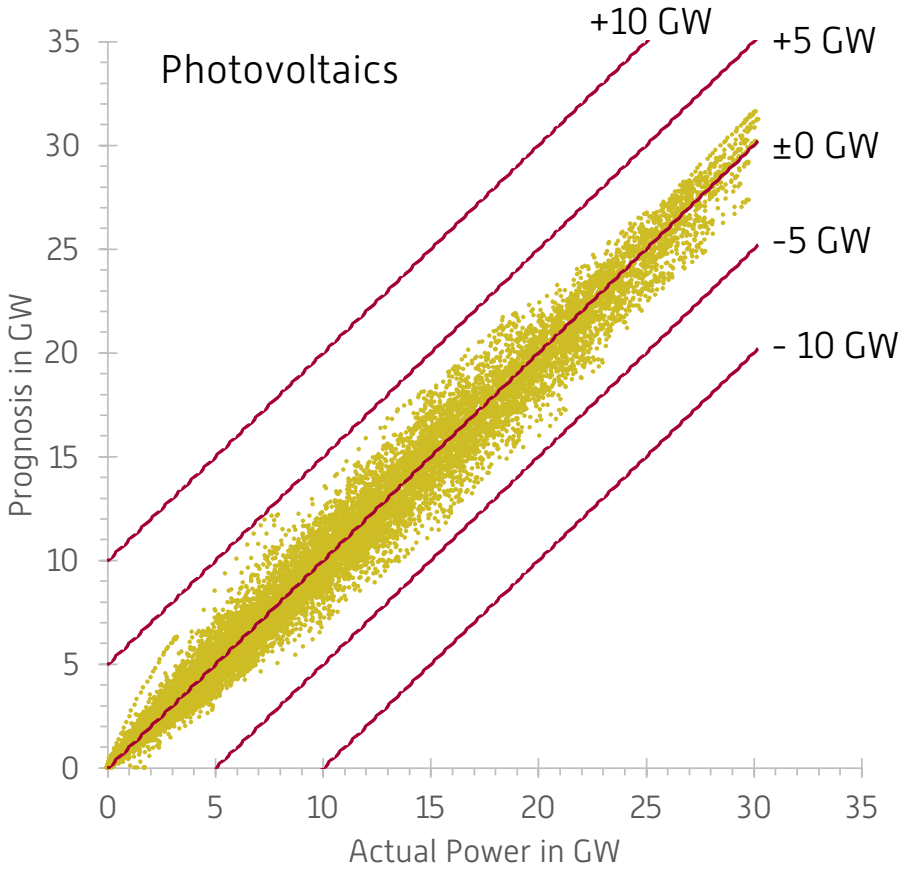


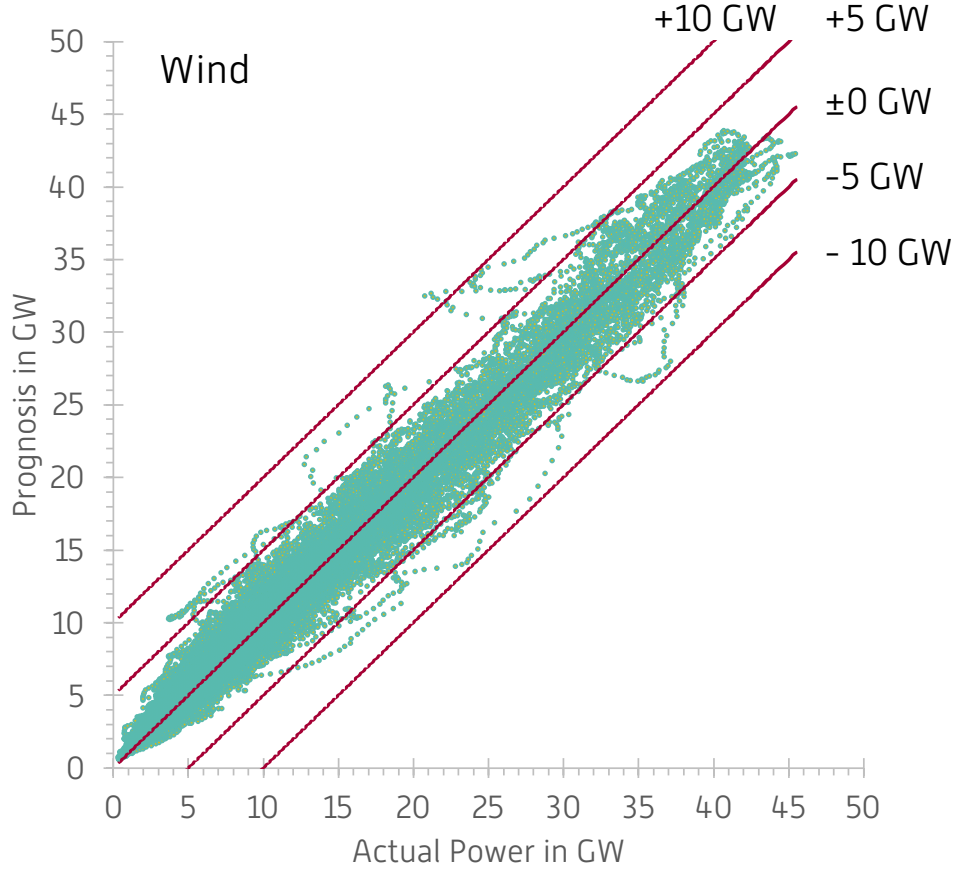
Resulting Electricity Production and Demand in Saarland



Assumptions: Characteristic day in winter
450000 households, 1.015 mio. inhabitants
Residential electricity demand: 5.1 GWh
Industrial electricity demand: 20.4 GWh

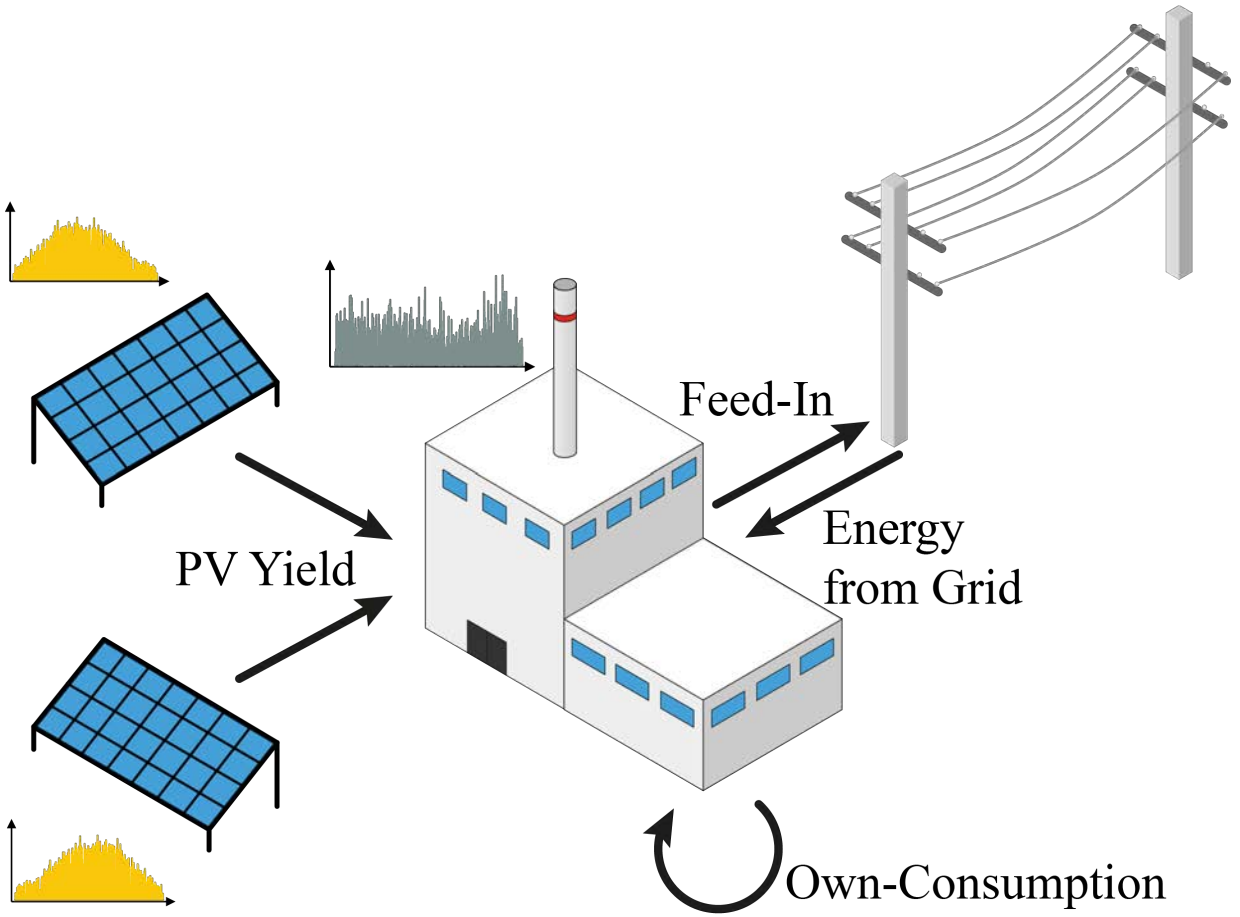
Comparison of actual and prognosed power of PV and wind shows a high accuracy and is comparable to the fossil power plant prognosis quality.



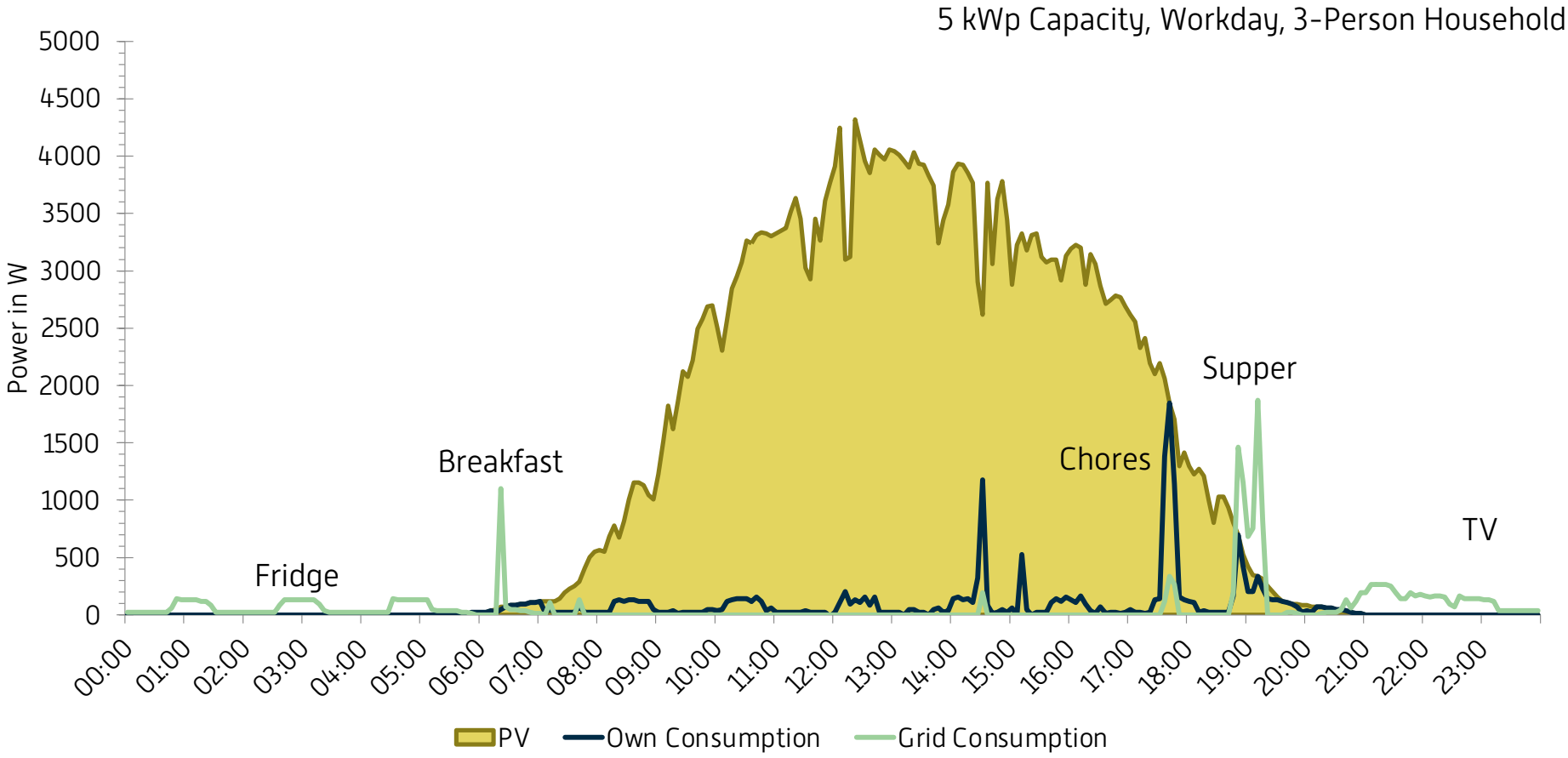


Data Source: German Federal Network Agency. smard.de

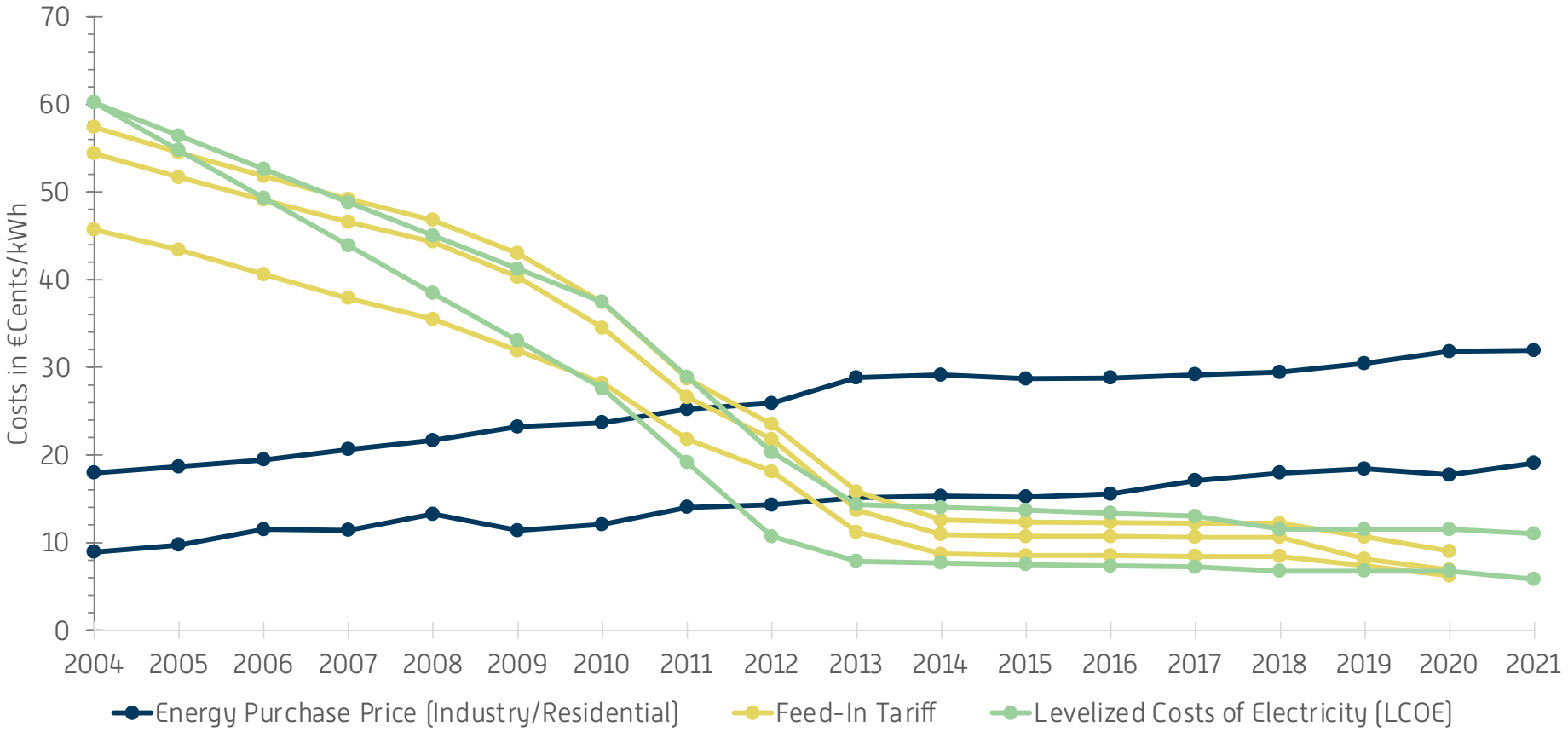
Concept of Self-Consumption



Self-Consumption Household



Cost Development of the German PV Sector



Sources: BDEW-Strompreisanalyse Juni 2021. Haushalte und Industrie. 10.06.2021. Bundesnetzagentur. Fraunhofer ISE. Stromgestehungskosten Erneuerbare Energien. Juni 2021.

Definition of Self-Consumption Rate and Energy Self-Sufficiency Rate

Definition of self-consumption rate SCR

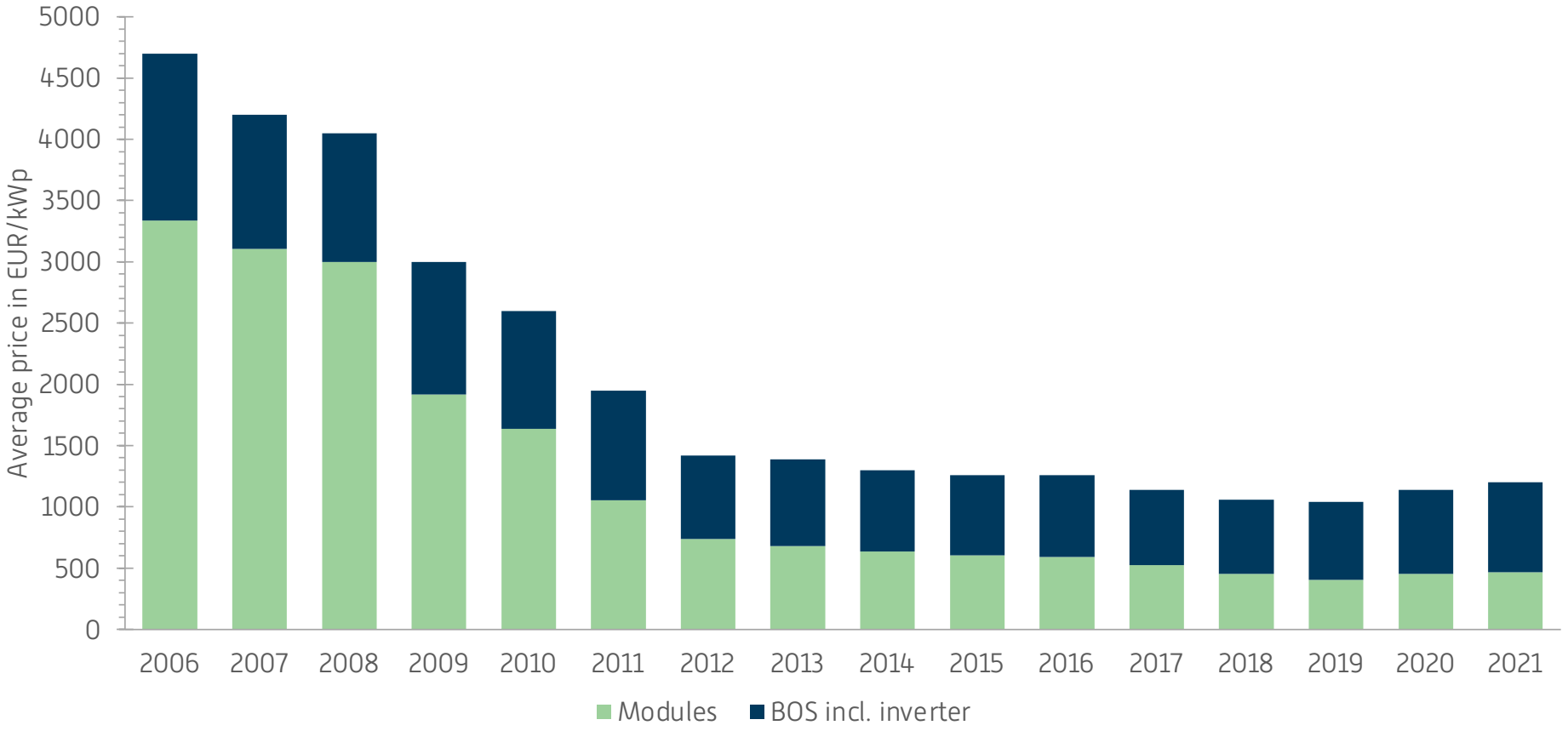
$$SCR = \frac{E_{\text{PV Consumed}}}{E_{\text{PV Yield}}}$$

Definition of energy self-sufficiency rate SSR

$$SSR = \frac{E_{\text{PV Consumed}}}{E_{\text{Total Consumption}}}$$

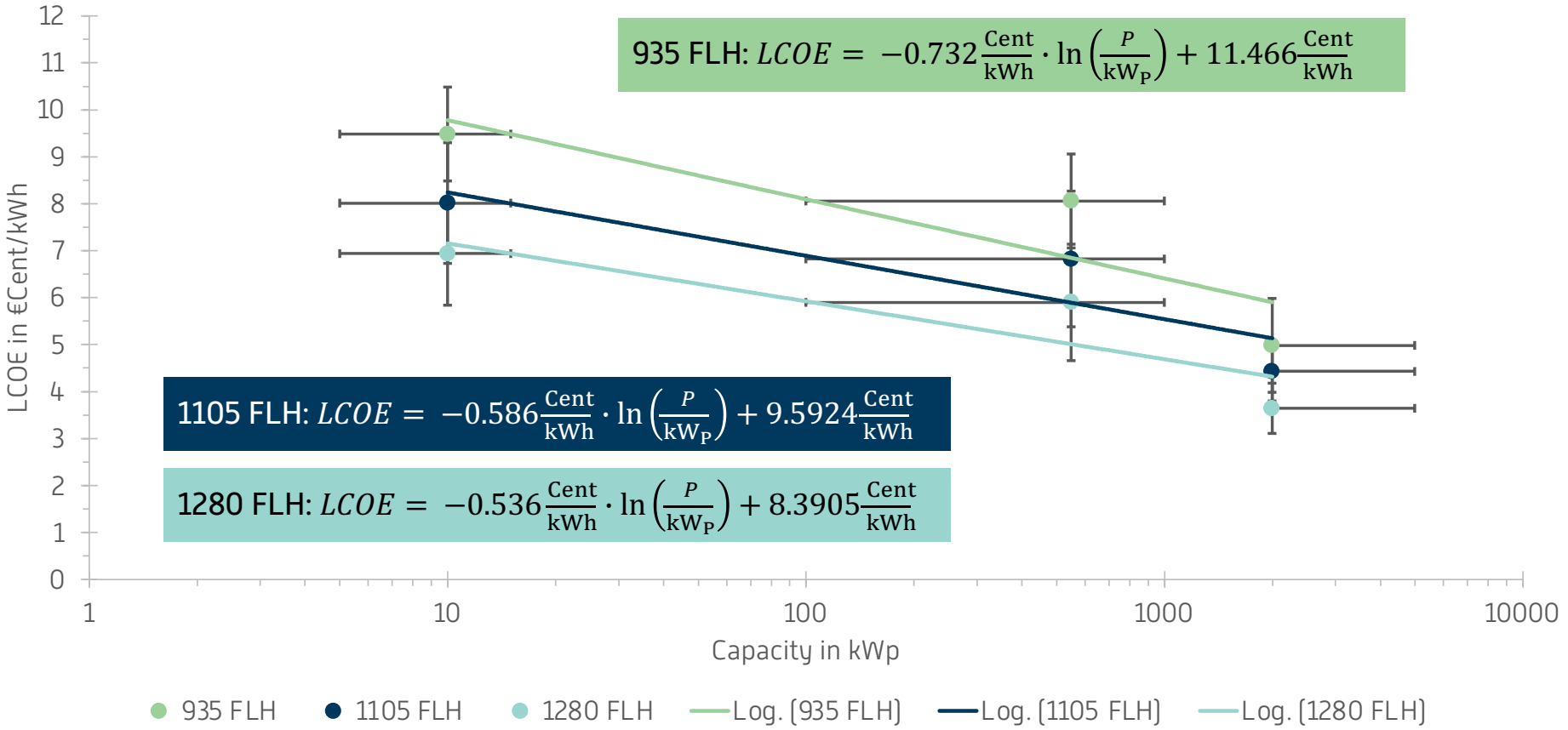
$E_{\text{PV Consumed}}$: Energy of PV system which is consumed within the building and is not fed into the grid
$E_{\text{total Consumption}}$: Electric energy consumption of the whole building

Development of the PV System Costs



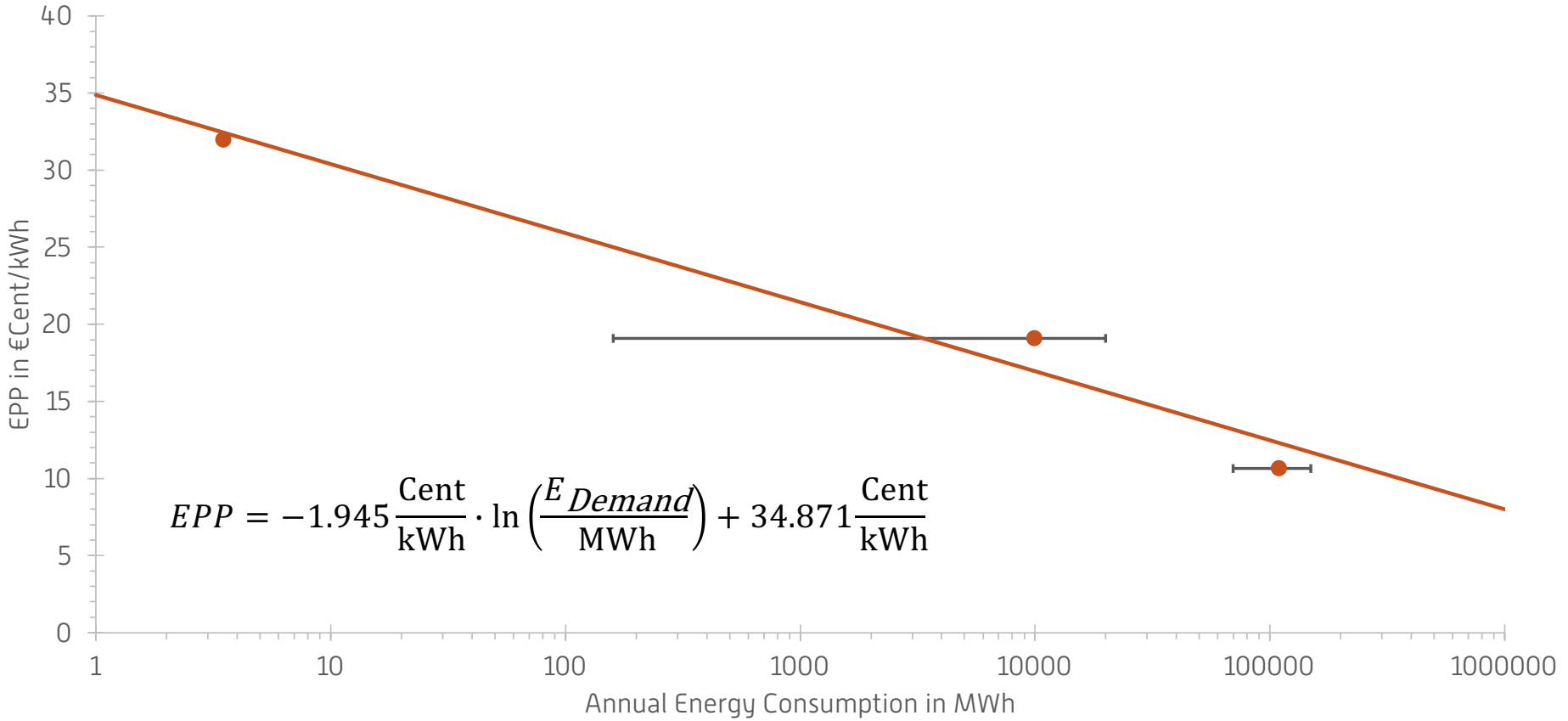
Source: Fraunhofer ISE. Photovoltaics Report. Feb. 2022. Slide 45

Levelized Costs of Electricity (LCOE) of Roof-Top and Ground-Mounted PV Systems depending on the location/full load hours (FLH)



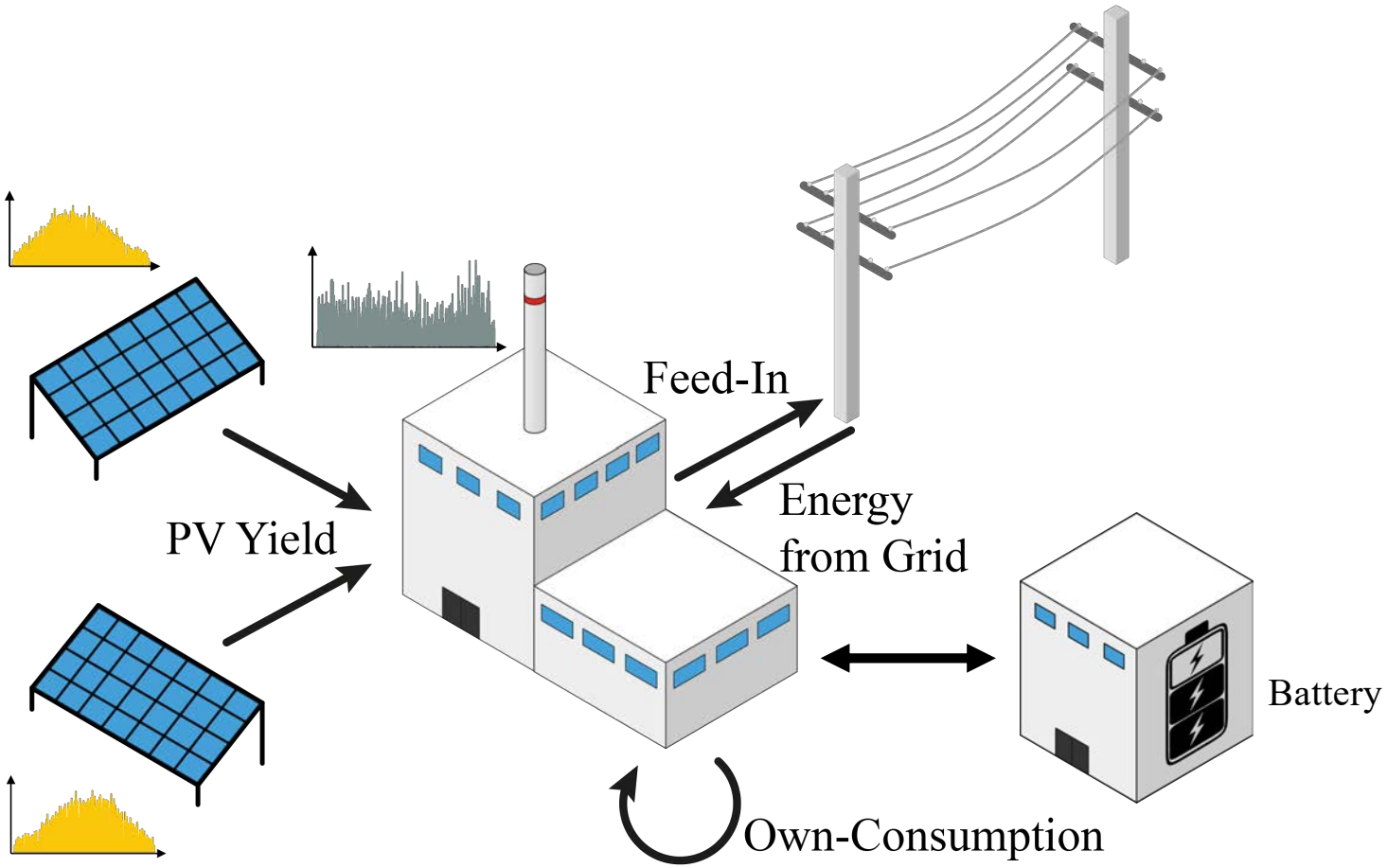
Source: Fraunhofer ISE. Stromgestehungskosten Erneuerbare Energien. Juni 2021.

Energy Purchase Price (EPP) of Industrial/Commercial Customer

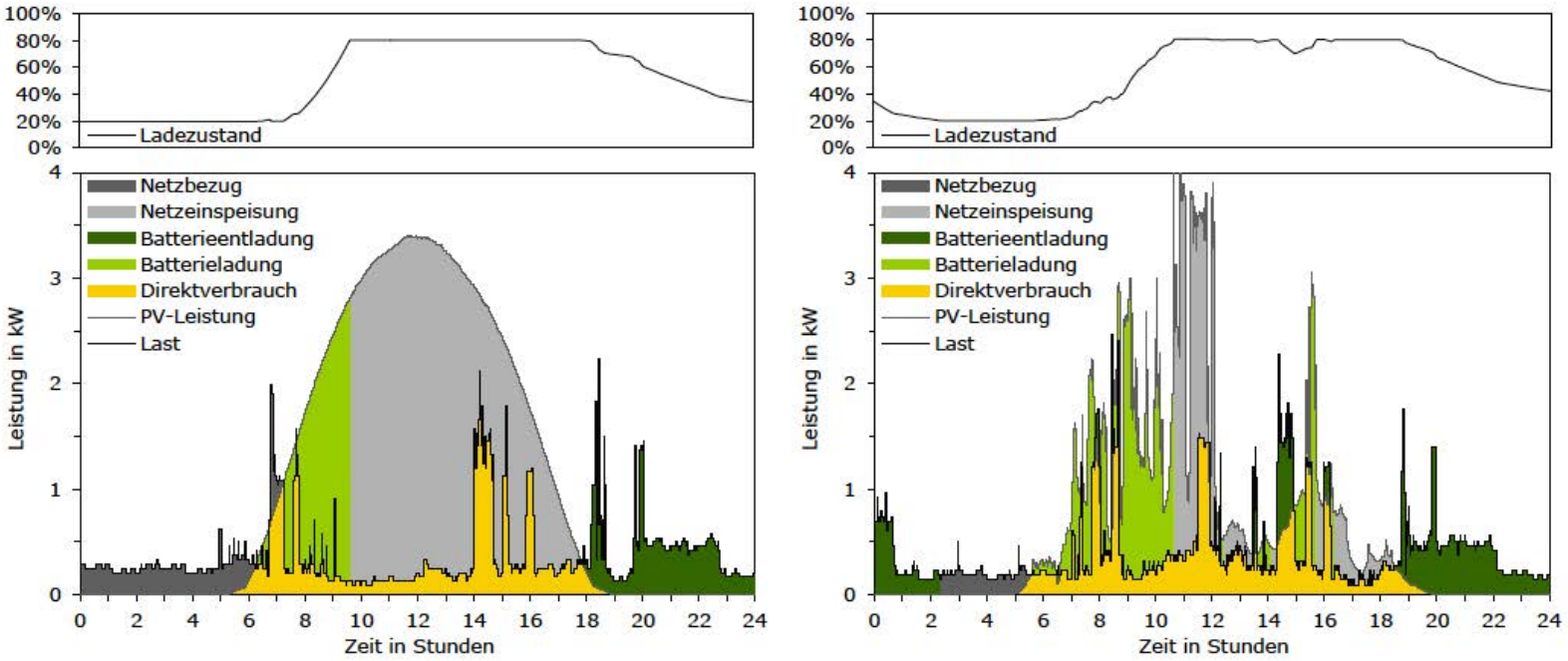


Source: BDEW-Strompreisanalyse Juni 2021. Haushalte und Industrie. 10.06.2021

Concept of Self-Consumption including a Battery



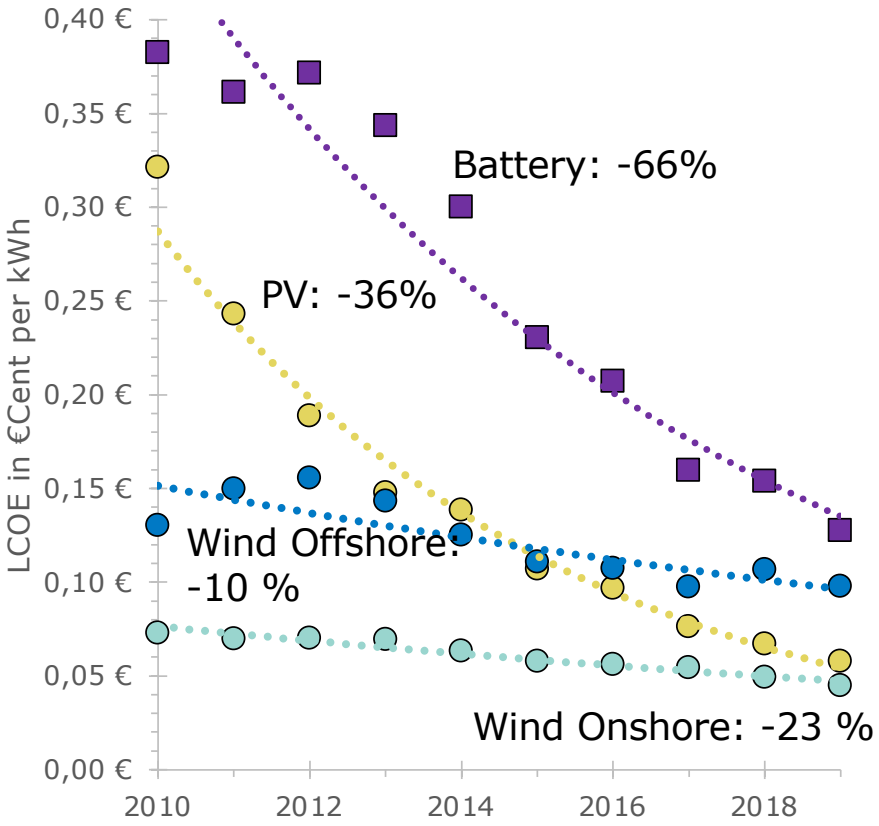
Self-Consumption with a Battery System

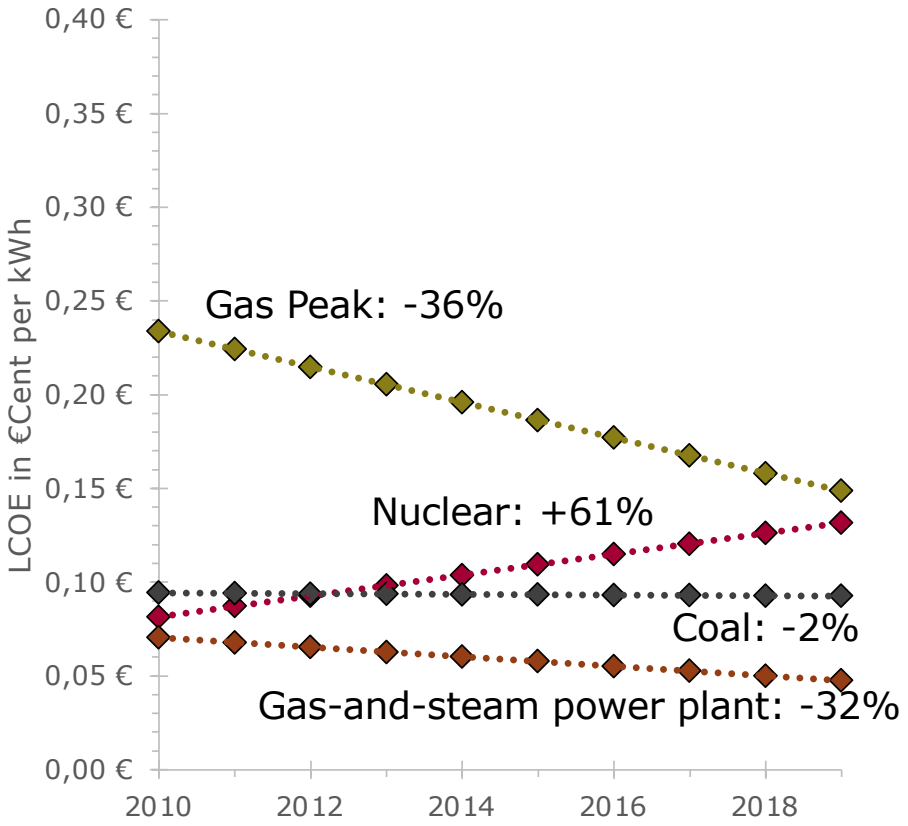


Hourly energy flows in a household with PV-storage system for self-consumption on a cloudless day (left) and partly cloudy day (right).

Source: HTW Berlin. Dezentrale Solarstromspeicher für die Energiewende. 2015. S. 24

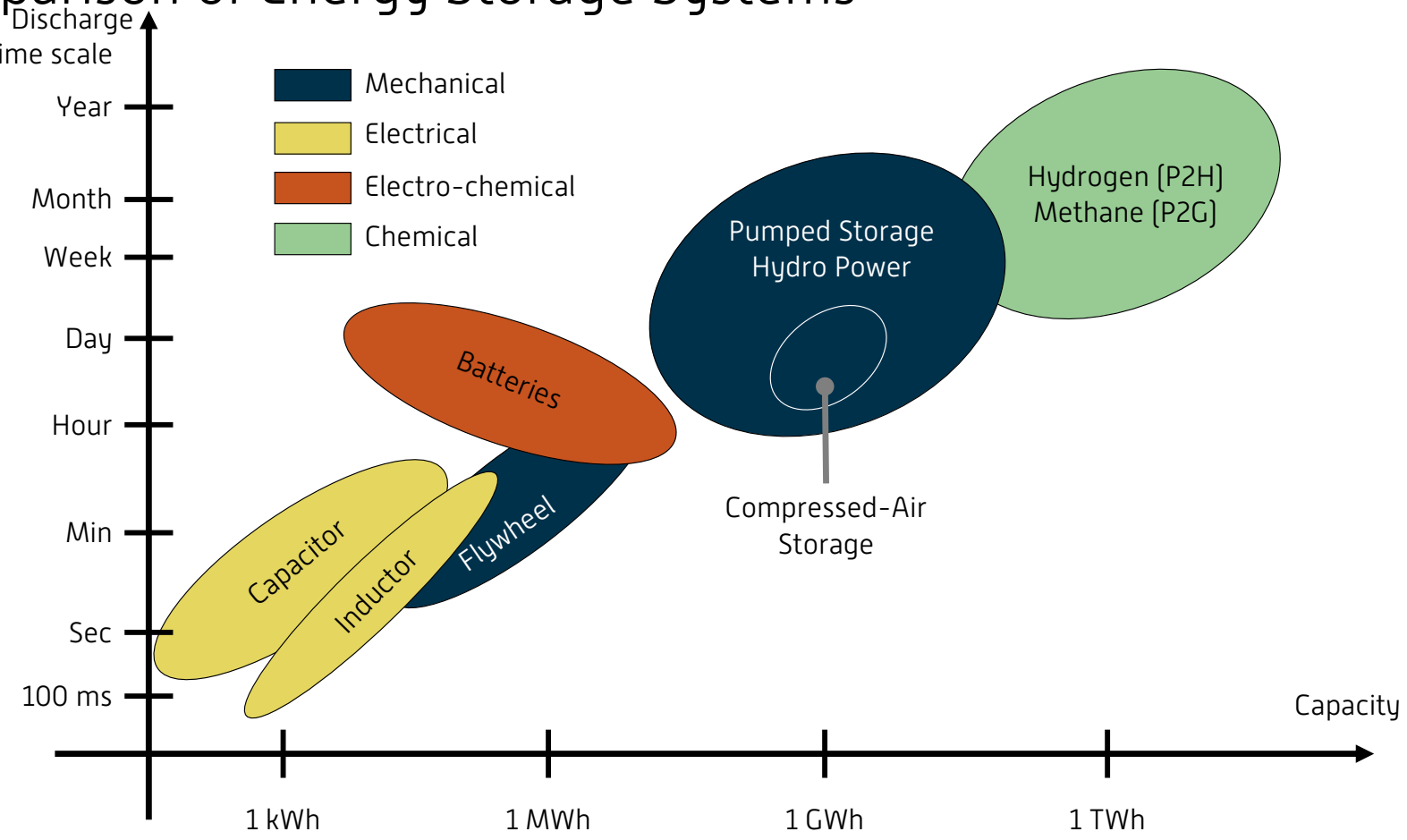
Renewable energy systems produce electricity more cheaply than newly built fossil fuel power plants.



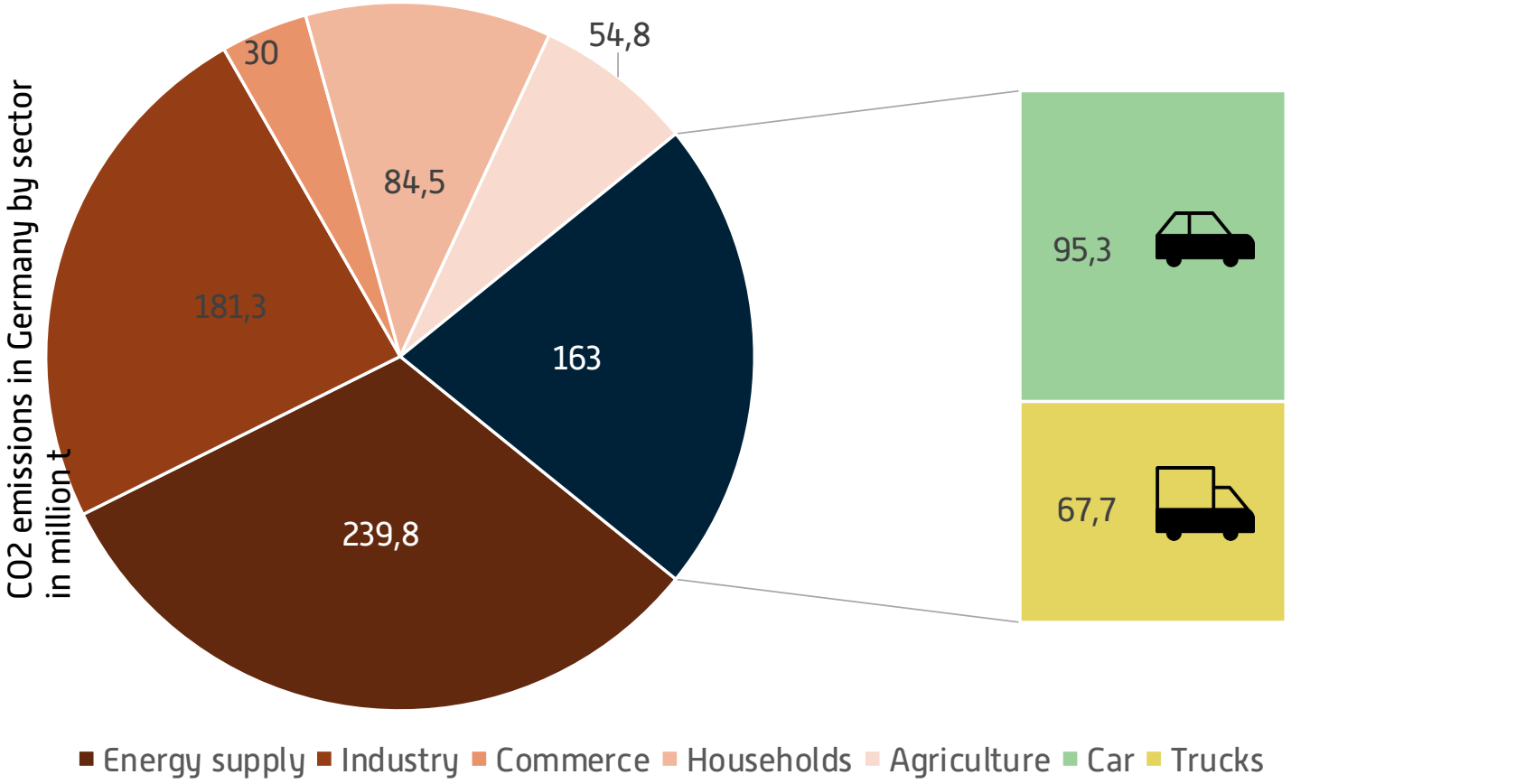


Data source: Max Roser (2020) - "Why did renewables become so cheap so fast?". Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/cheap-renewables-growth

Comparison of Energy Storage Systems



Road traffic accounts for 20 percent of CO_2 emissions in Germany.



Data Source: Umweltbundesamt

Estimation of power consumption and energy demand during refueling.

Power consumption when refueling with gasoline/diesel

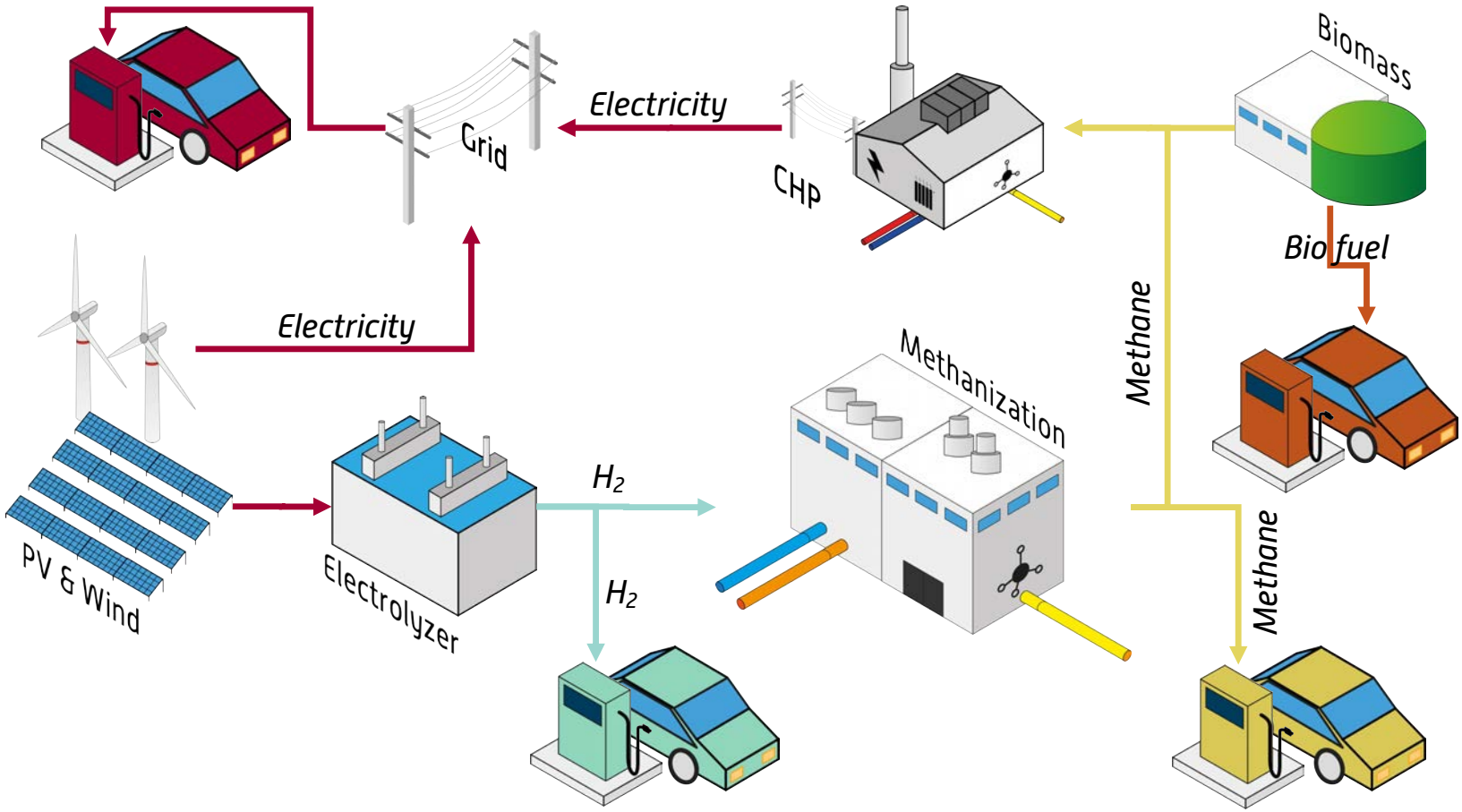
Assumptions:

- Tank volume 50 liters
- Refueling time 2 minutes
- Energy content of fuel around 10 kWh/liter

$$P = \frac{50l \cdot 10\,\frac{\mathrm{kWh}}{\mathrm{l}}}{\frac{2}{60}\,\mathrm{h}} = 15.000\ \mathrm{kW} = 15\ \mathrm{MW}$$

Power consumption corresponds to the nominal power at a wind speed of 15 m/s of a wind farm with 6 wind turbines.

Concept of sector coupling for decarbonization of the road transport sector

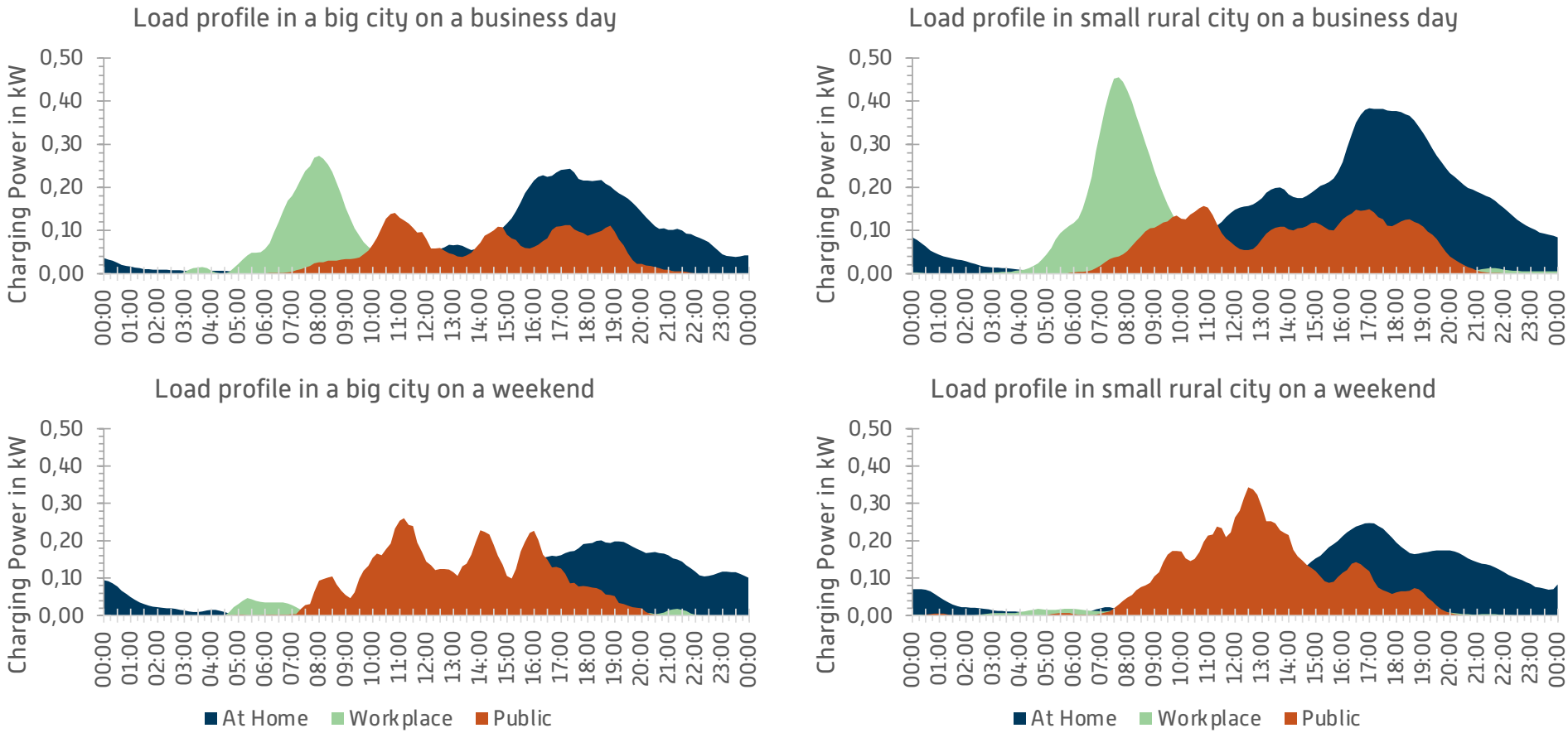


Comparison of fuel costs for different fuels in Germany

Vehicle type	Combustion	Battery	Natural Gas	Fuel Cell	H_2 Combustion
Comsumption per 100 km	7 Liter	15 kWh	6 kg	0.9 kg	3.6 kg
Fuel price	1.76 €/l	0.30-0.,45 €/kWh	1.20 €/kg	9.50 €/kg	
Costs for 100 km	12.32 €	4.50 – 6.75 €	7.20 €	8.55 €	34.20 €
Remark		Less range than gasoline/diesel		High self-discharge rate	

Data Sources: Umweltbundesamt, Verkehrsministerium, BMW

Charging profiles for electric vehicles.



Source: Daniel Heinz. Erstellung und Auswertung repräsentativer Mobilitäts-und Ladeprofile für Elektrofahrzeuge in Deutschland. KIT. 2018

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