



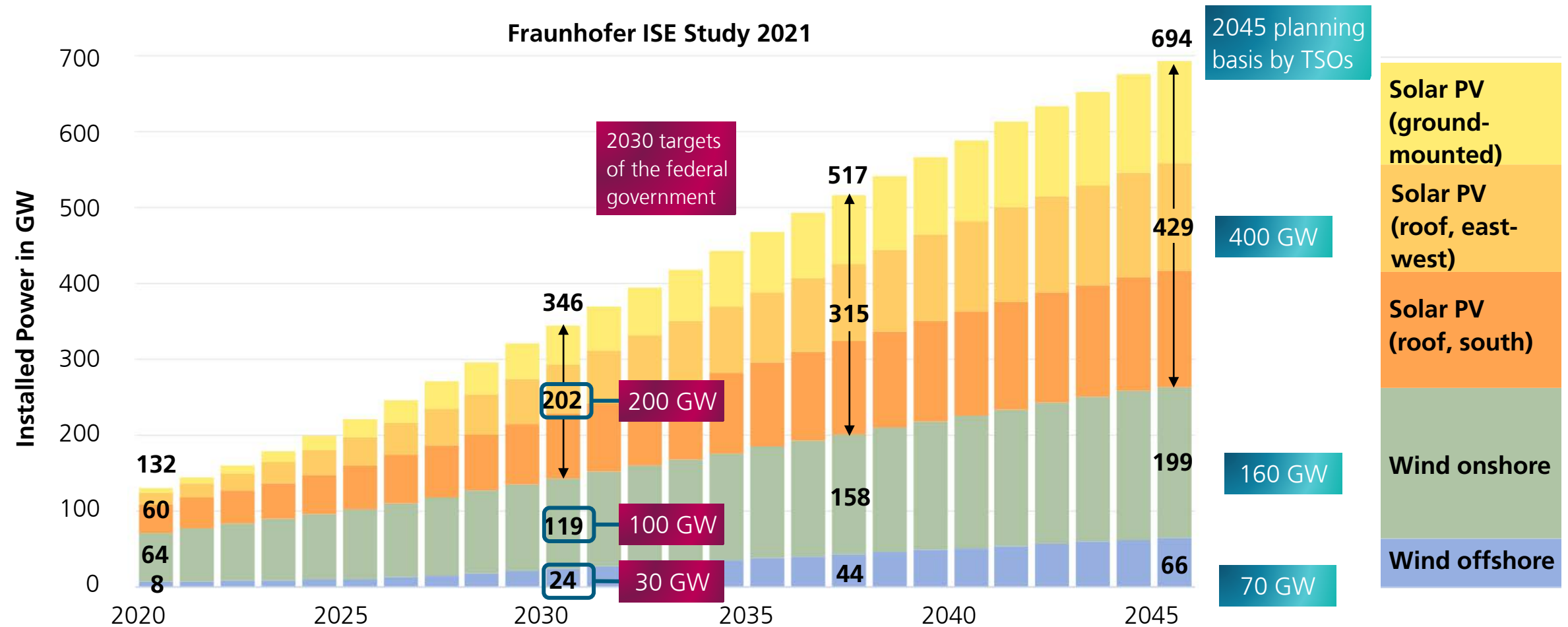
Germany's plans to decarbonize the energy system by 2045 seen in a global context

Soenke Rogalla

2nd Three Corners Power Electronics Extended Collaboration Workshop
Washington, DC – April 1st -2nd, 2023

Plans for Electricity Generation in Germany

Strong Expansion of Solar PV and Wind Energy



Sources: Fraunhofer ISE Study 2021: [Paths to a Climate-Neutral Energy System / www.energy-charts.info](https://www.energy-charts.info)

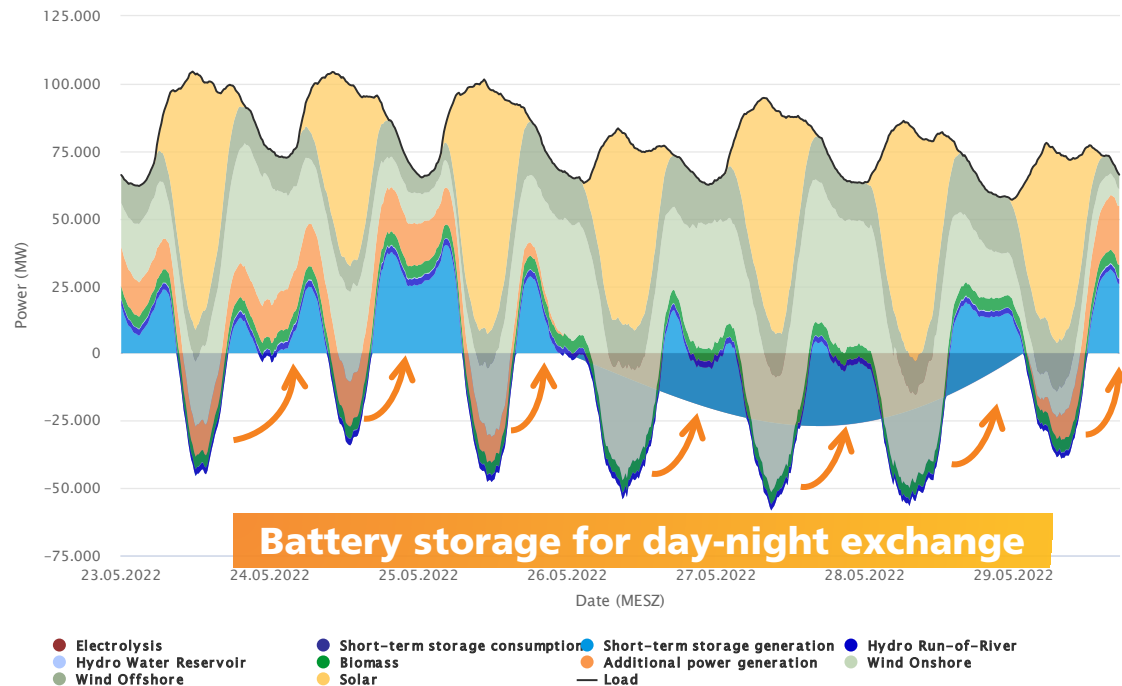
Eröffnungsbilanz Klimaschutz des BMWK (13.01.2022).

Szenariorahmen zum Netzentwicklungsplan Strom 2037 mit Ausblick 2045, Version 2023 (Januar 2022).

Flexibilities for a Volatile Energy System

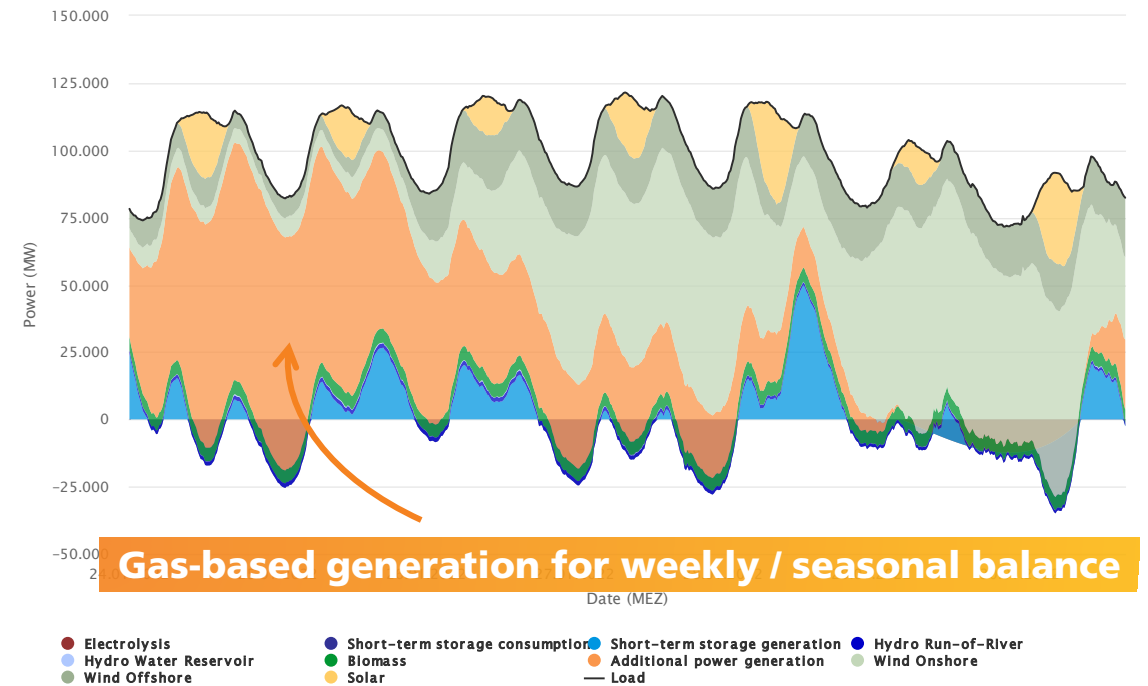
Battery Storage Systems and Emission-Free Gas-Fired Power Plants

Simulated Electricity Generation for 2030 (Week 21)



Required battery capacities:
175 GWh (stationary) + 275 GWh (mobil)

Simulated Electricity Generation for 2030 (Week 4)



Required gas-fired power plant capacities:
150 GW

Power Electronics for Generation, Storage and Transmission

Estimated German Demand for 2045 based on ISE study

Type	2022	Estimated cumulated installation until 2045
Solar	66 GW	430 GW
Wind onshore	58 GW	200 GW
Wind offshore	8 GW	66 GW
HVCD offshore	6 GW	46 GW
HVDC and FACTS	4 GW	25 GW
Stationary batteries	4 GW	180 GW
Electrolysers	0 GW	83 GW
Total	146 GW	1,030 GW

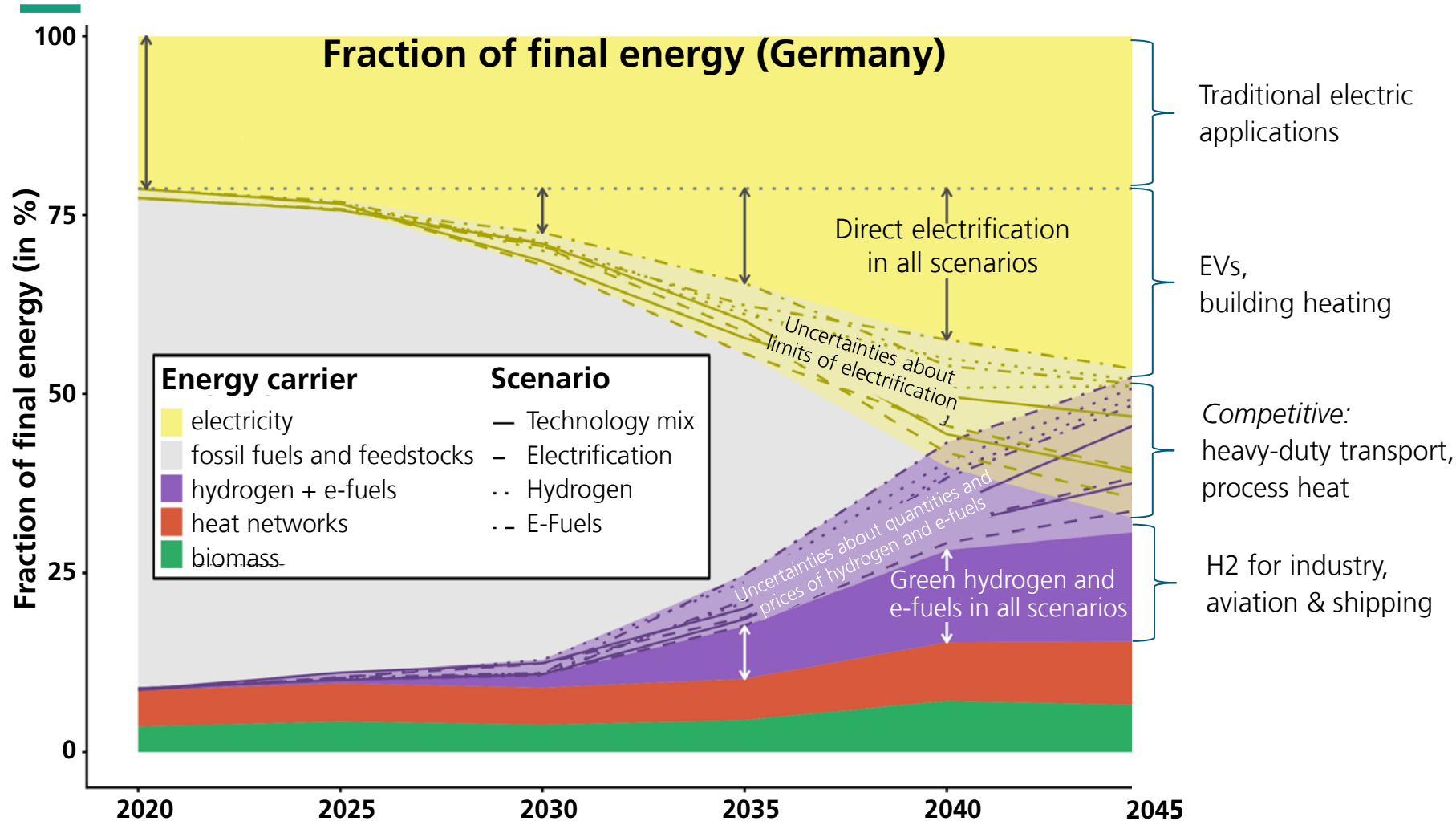
Note: additional demand in the sectors mobility, heat, IT and consumption loads!

1 TW

**Germany's needs for
power electronics by 2045**

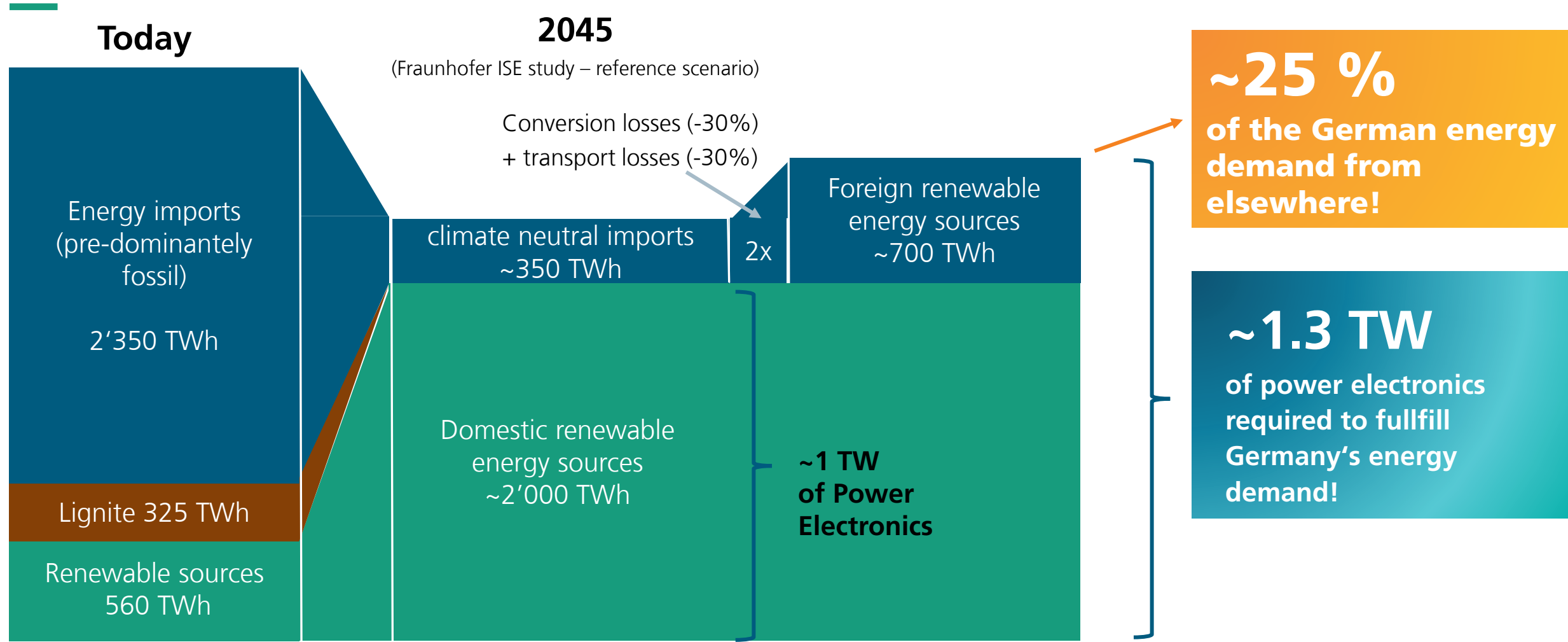
Sources: <https://energy-charts.info/> ,
<https://www.ise.fraunhofer.de/de/veroeffentlichungen/studien/wege-zu-einem-klimaneutralen-energiesystem.html>
https://de.wikipedia.org/wiki/Liste_der_HG%C3%9C-Anlagen#Inbetriebnahme_ab_2008

All Electric Society?



- Direct use of electricity strongly increasing
- Green hydrogen and fuels no regret solutions for industry and transport sectors
- About 20 % of final energy not yet clear → various options for future system design

Where Do Non-Electric Energy Carriers Come from?



Based on figures from these sources:

Fraunhofer ISE Study 2021: [Paths to a Climate-Neutral Energy System](#)

Umweltbundesamt: [Primärenergieverbrauch \(2022\)](#).

Acatech Position Paper: [Coupling the different energy sectors – options for the next phase of the energy transition](#)

Global Extrapolation of the German Szenario

We are talking about large amounts of terawatts!



	Germany	→	Worldwide
Economic output / GDP	~ \$ 4 bn	25x	\$ 100 bn
Energy consumption	~ 3.3 TWh	50x	~165 TWh
Population	~ 84 million	100x	~8,000 million
<u>Required resources:</u>			
Solar PV	~0.4 TW	25x ... 100x	10 ... 40 TW
Wind	~0.25 TW		6.3 ... 25 TW
Stationary Battery Storage	~0.175 TWh		4.4 ... 17.5 TWh
Power electronics	~ 1,3 TW		30 ... 130 TW

Outlook

What power electronics technology advances are necessary for the envisioned global energy system?

Challenges...

- Workforce
- Material and component availability
- Power system stability

Solutions...

1

“Electrification” of occupational profiles

activate the potential of women in power electronics, retraining for “losers of the electrification”/ R&D, manufacturing, installation, system technologies, O&M,...

2

R&D / Circular economy

New (semiconductor) materials, new circuit topologies, higher voltage levels, innovative system concepts, ..

Sensitivity for LCA, recycling, green products, ...

3

Grid-forming converters

inverter-based grid control without the need to rely on synchronous machines, smart grid applications, cyber security ...



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www.cines.fraunhofer.de/en/portfolio/power-electronics.html

Fraunhofer ISE's Multi-Megawatt Lab in Freiburg, Germany.